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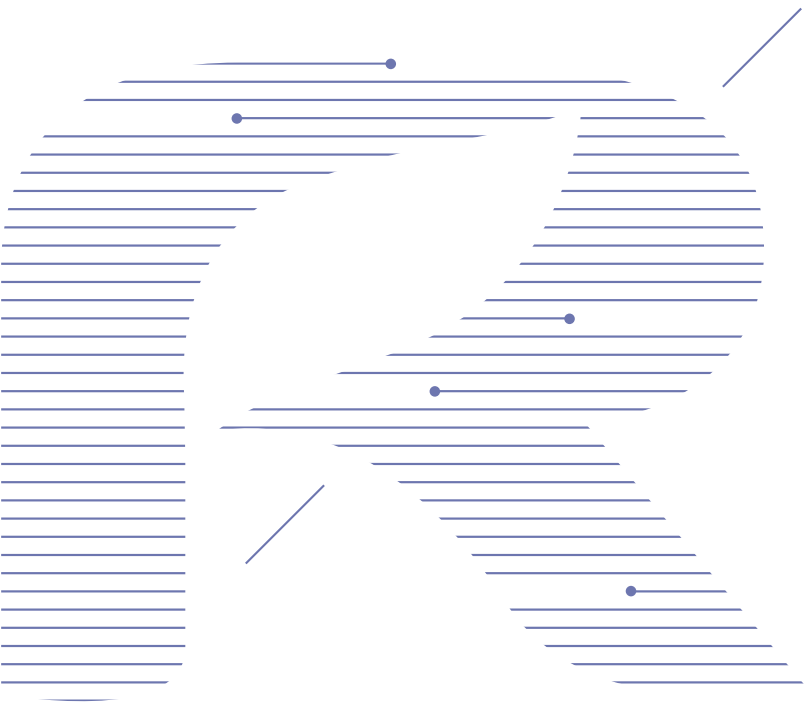
Current Status of Digital Transformation in the Agricultural Sector of Southeast Asian Countries

JEONG Hakkyun · CHA Wonkyu · AHN Kyumi · JOO Yeongseon · HEO Jang · Noer Azam Achisani · Edgar Allan Po · Chu Diem Hang · Manoluck Bounsihalath · Kong Thong



한국농촌경제연구원

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이용자를 위하여

1. 본 자료집은 동남아시아 국가의 농업 디지털 전환 현황 및 준비도 조사를 위하여 5개 연구대상국(인도네시아, 필리핀, 베트남, 라오스, 캄보디아)의 연구자들에게 위탁연구를 요청한 후 수령한 내용을 정리한 자료입니다.

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For Readers

1. This source book is a compilation of research received from researchers in five target countries (Indonesia, the Philippines, Vietnam, Lao PDR, and Cambodia) after requesting commissioned research to assess the status and readiness of agricultural digital transformation in targeted Southeast Asian countries.

2. This source book has been written based on the reports from commissioned researchers in Southeast Asia and includes their individual interpretations. Therefore, the content presented in this document does not represent the official views of our institution (KREI). Additionally, please note that some content may interpreted differently depending on the researchers' own viewpoint.

3. This source book will also be available through our research institute (www.krei.re.kr) website upon publication.

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1. Overview of Digital Transformation in Indonesia Agriculture

1.1. Background

The agricultural sector has long been the backbone of Indonesia's economy, contributing significantly to the nation's GDP and employing a substantial portion of the population. In 2023, agriculture accounted for approximately 12.5% of Indonesia's GDP and provided employment for 39.5% of the workforce (BPS, 2024). This sector is not only vital for economic stability but also for food security and rural development.

1) This chapter is written based on the final report written and submitted by Noer Azam Achsani internal data (2024) titled "Digital Transformation in the Agricultural Sector of Indonesia".

However, as the global landscape evolves, the agricultural sector in Indonesia faces the imperative of digital transformation to maintain its competitiveness and drive economic growth.

Digital transformation in agriculture refers to the integration of digital technologies into agricultural practices to enhance productivity, efficiency, and sustainability. Emerging technologies like IoT, AI, blockchain, and big data analytics are revolutionizing agriculture, addressing challenges such as climate change and resource scarcity (Saikanth et al., 2024). These technologies enable precision farming, smart irrigation, and improved supply chain management (Hussein et al., 2024). IoT sensors and AI-driven analytics facilitate real-time monitoring of farm conditions, crop disease prediction, and automated farming operations (Hussein et al., 2024; Obaid et al., 2024). Blockchain technology enhances transparency and traceability in the food supply chain (Obaid et al., 2024). The integration of these technologies optimizes resource use, improves crop management, and increases overall agricultural efficiency (Saikanth et al., 2024; Rathi & Gomathy, 2023). For instance, AI can analyze market trends and predict demand, helping farmers make informed decisions about what to plant and when to sell. However, challenges such as digital divides and data privacy concerns must be addressed to ensure equitable access and responsible adoption (Saikanth et al., 2024). As global food demand increases, these technological advancements play a crucial role in achieving sustainable agriculture and food security (Rathi & Gomathy, 2023). The adoption of these technologies can lead to better resource management, increased crop yields, reduced environmental

impact, and improved market efficiency.

The agricultural sector in Indonesia has witnessed a gradual embrace of digital technologies, albeit with varying degrees of adoption across the country (Ningrat & Nurzaman, 2019). Digital innovations such as precision farming, smart irrigation, and data-driven decision-making have the potential to enhance agricultural productivity, sustainability, and resilience (Finger, 2023). However, the integration of these technologies has been hindered by factors such as unequal distribution of subsidies, lack of infrastructure, and the predominance of small-scale farmers who may face barriers to adoption (Smidt & Jokonya, 2021; Dhillon & Moncur, 2023).

Despite the promising potential of digital technologies, the agricultural sector in Indonesia faces significant challenges in their adoption. One of the primary obstacles is the limited digital infrastructure in rural areas. Many regions still lack reliable internet connectivity, which is essential for the implementation of IoT devices and other digital solutions. Additionally, the cost of acquiring and maintaining digital technologies can be prohibitive for smallholder farmers, who constitute the majority of the agricultural workforce in Indonesia (Ministry of Agriculture, 2022).

Another critical challenge is the low level of digital literacy among farmers. Many farmers are not familiar with modern digital tools and lack the necessary skills to utilize these technologies effectively. This gap in knowledge and skills can hinder the widespread adoption of digital solutions and limit their impact on agricultural productivity. Therefore, there is a pressing need for educational programs and

training initiatives to enhance digital literacy and empower farmers to leverage digital technologies.

Furthermore, the current public policies and strategies related to digital transformation in agriculture are often fragmented and lack coherence. While there have been efforts to promote digital agriculture through various government programs, these initiatives are not always well-coordinated or aligned with the specific needs of the agricultural sector (OECD, 2019). A more integrated and comprehensive approach is required to create an enabling environment for digital transformation.

Given these challenges and opportunities, this research aims to provide a thorough review of the current state of digital transformation in the agricultural sector of Indonesia. It seeks to introduce public policies and strategies that support digital transformation at both the national and sectoral levels and to identify specific challenges that could benefit from international development cooperation. By addressing these issues, the research aims to contribute to the development of a more competitive and sustainable agricultural sector in Indonesia.

1.2. Definition

Digital transformation in agriculture refers to the integration of digital technologies to enhance agricultural practices by collecting, processing, analyzing, and disseminating data, thereby enabling

data-driven decision-making and improving overall efficiency, productivity, and sustainability. Various definitions and perspectives on digital transformation in agriculture have been provided by multiple scholars, each highlighting different aspects and dimensions.

Khanna (2020) defines digital transformation in agriculture as the use of digital technologies to collect detailed, location-specific data about growing conditions and automate the application of agricultural inputs in a spatially variable manner. The goal of this approach is to improve production efficiency, reduce waste and environmental impact, and increase farm profitability. Similarly, Nehrey (2023) describes it as the adoption and use of digital tools, such as data collection systems, decision support technologies, and data-driven farming methods, to optimize agricultural processes and achieve higher efficiency, productivity, and profitability.

Abashidze (2023) extends this definition by emphasizing the role of digital transformation in enabling real-time, data-driven decision-making in response to changing external factors. This involves establishing robust decision-support systems that leverage digital technologies to monitor and adapt agricultural operations dynamically. According to Dayioglu & Turker (2021), digital transformation is seen as the process of integrating digital technologies to address agricultural and sectoral needs, leading to the evolution and improvement of workflows and organizational culture. They highlight that this transformation includes innovations such as Precision Farming, Smart Farming, and Agriculture 4.0, which are crucial for transforming agri-food production systems.

Paraforos & Grientrog (2021) and Fountas et al. (2020) collectively describe digital transformation in agriculture as the integration of data-driven technologies like the Internet of Things (IoT), cloud computing, and big data analytics. These technologies enable precision farming and revolutionize agricultural practices, often referred to as "Agriculture 4.0" or "Digital Farming." Alahmadi et al. (2022) further support this view by defining digital agriculture (or smart agriculture/farming) as the use of various digital devices, such as sensors, GPS, robotics, and drones, to monitor, assess, and manage environmental parameters that affect food production, with the aim of increasing food production with minimal human intervention.

Hrustek (2020) offers a broader perspective, defining digital transformation as a key paradigm that drives the transformation of agricultural activities and processes through five key determinants: strategic orientation, customer centricity, ICT and process infrastructure, talent and capacity building, and innovation and organizational culture. Digital transformation is viewed as an inevitable process for businesses seeking growth, expansion, quality, and sustainability. It has a transformative impact on the global economy and society by changing business models through digital strategies, fostering an innovative culture, and leveraging digital technologies.

Lastly, Kosior (2018) discusses digital transformation in the agri-food sector as the adoption and use of technologies like big data, IoT, and artificial intelligence to improve agricultural productivity and address environmental challenges. However, Kosior also emphasizes that this digital transformation faces significant barriers and raises

ethical and social concerns that need careful consideration.

In conclusion, digital transformation in agriculture encompasses the adoption and integration of various digital technologies and tools, such as IoT, AI, big data analytics, precision farming techniques, and digital devices. These technologies aim to optimize agricultural practices, improve efficiency and productivity, reduce environmental impact, and enable sustainable growth. However, the process also presents challenges, such as ethical, social, and infrastructural barriers, that must be addressed to fully realize its potential.

1.3. Strategic Importance to The Sector

Digital transformation in agriculture represents a significant shift in how farming is conducted, driven by the integration of advanced technologies and innovative practices. This transformation is not merely a technological upgrade; it fundamentally reshapes production processes, resource management, and responses to market demands, enhancing efficiency across the entire agricultural value chain. It is a strategic imperative for the agricultural sector, aimed at addressing contemporary challenges such as food security, sustainability, and economic viability.

At its core, digital transformation in agriculture encompasses a variety of technologies such as precision farming, data analytics, the Internet of Things (IoT), artificial intelligence (AI), and blockchain. These technologies enable farmers to gather and analyze data on crop

health, soil conditions, weather patterns, and market trends. For instance, precision farming allows for the targeted application of water, fertilizers, and pesticides, increasing yields and reducing environmental impact. Through the use of sensors and drones, farmers can monitor their fields in real-time, make informed decisions, and optimize their practices to enhance productivity and sustainability.

One of the critical factors in the implementation of agricultural digitalization is internet accessibility. Farmers can utilize the internet to access weather forecasts, which are crucial components in determining the success of agricultural activities. Additionally, the internet enables farmers to seek information on pests and plant diseases, facilitating more effective management and preventing crop failure. Various studies have been conducted on the implementation of agricultural digitalization, including research by Munawaroh (2022), which emphasizes the essential role of agricultural digitalization in the highly digital modern era. Agricultural digitalization not only helps farmers but also facilitates the government in monitoring agricultural systems and making fair, honest, and wise decisions to meet the needs of its citizens.

The study by Munawaroh (2022) shows that strengthening citizen engagement through agricultural digitalization programs is carried out through socialization and workshops. These activities aim to increase citizens' knowledge and understanding of the benefits and objectives of agricultural digitalization programs, as well as how to manage agriculture more effectively. A follow-up study by Johan et al.

(2022) found that farmers' perceptions, characteristics, and the role of facilitators have a significant influence on the implementation of agricultural digitalization.

The strategic importance of digital transformation in agriculture cannot be overstated. As highlighted by Beksultanova et al. (2023), restructuring production processes through digital technologies is essential for modernizing the agricultural sector, requiring both technological and managerial innovations alongside government support. Glyzina (2023) also underscores the potential for growth and improvement in productivity through digitalization, particularly given the current low index of digitalization in agriculture. Furthermore, Zheng et al. (2024) emphasizes that digitalization serves as a crucial driver for high-quality agricultural development and rural revitalization, especially within the EU context.

Digital transformation facilitates the implementation of precision agriculture, which optimizes resource use and minimizes environmental impacts. According to Macpherson et al. (2022), integrating digital tools is vital for achieving sustainability goals, as it allows for more informed decision-making and resource management. Usenko (2024) further discusses the necessity of expanding digital technology markets to enhance agricultural productivity and sustainability, while Rasyid (2024) points to the application of smart farming techniques as a means to increase efficiency and transform traditional agricultural practices into more data-driven and responsive systems.

Moreover, digital transformation plays a crucial role in addressing

sustainability challenges, particularly in the context of climate change. Technologies such as AI and machine learning can help predict weather patterns and assess the impact of environmental changes on crop production, enabling farmers to adapt their practices and ensure food security while minimizing their ecological footprint. This proactive approach supports the agricultural sector in becoming more resilient to environmental and market conditions.

Government policies and support are also vital in facilitating digital transformation. Stender et al. (2024) analysis of European agricultural policy highlights the need for strategic frameworks that support digitalization efforts, ensuring that agricultural policies are aligned with technological advancements. Similarly, Cook et al. (2021) identify the challenges posed by inadequate infrastructure and skills shortages, which necessitate targeted government interventions to foster a conducive environment for digital agriculture. By creating an enabling environment, governments can encourage investment in technology and infrastructure, provide training for farmers, and promote research and development. This partnership between the public and private sectors is crucial for fostering innovation and making sure that all farmers, no matter their size or location, can access the advantages of digital transformation.

In conclusion, the digital transformation of agriculture is a multifaceted process that includes the adoption of advanced technologies, the restructuring of production processes, and the formulation of supportive policies. Its strategic importance lies in its potential to enhance productivity, ensure food security, and promote sustainability in

the face of growing global challenges. As the agricultural sector continues to evolve, embracing digital transformation will be key to building a resilient and sustainable future for farming, positioning agriculture to meet the demands of a rapidly changing global landscape.

2. National and Sectoral Agricultural Digital Transformation Policies

2.1. National Policies on Agricultural Digital Transformation

In the broader context of digital transformation in agriculture, it is crucial to recognize how these policies facilitate and drive the modernization of agricultural practices through digital means. Digital transformation in agriculture involves integrating advanced technologies into every facet of farming, from crop management to livestock health, with the ultimate goal of enhancing productivity, sustainability, and efficiency. This shift is not just about adopting new tools but also about fundamentally rethinking and restructuring traditional agricultural processes to harness the full potential of digital innovations.

An examination of the regulations established by the Ministry of Agriculture, which serve as the basis for policy-making related to electronic systems, can be described as follows:

Minister of Agriculture Regulation No. 41/2023 governs the Minutes of Handover (Berita Acara Serah Terima or BAST). This regulation aims to manage the procedures for drafting, signing, and documenting BAST digitally. E-BAST (Electronic Minutes of Handover) includes features such as Digital Signatures, Online Monitoring and Reporting, and an Integrated Database. This regulation is expected to improve efficiency and transparency in managing government aid within the Ministry of Agriculture.

Minister of Agriculture Regulation No. 33 of 2023 on the implementation of the Electronic-Based Government System (Sistem Pemerintahan Berbasis Elektronik or SPBE) within the Ministry of Agriculture focuses on SPBE Governance, SPBE Management, Information and Communication Technology (ICT) Audit, ICT Operations, and Monitoring and Evaluation. This regulation is expected to enhance the effectiveness, efficiency, and accountability of public services and government administration within the Ministry of Agriculture through the use of information and communication technology.

Minister of Agriculture Regulation No. 17 of 2023 on the National Animal Health Information System (Isikhnas) aims to strengthen the management of animal health data and information in Indonesia. It features a Web and Mobile-Based Platform, Real-Time Data Integration, Integrated Data Analysis, Interoperability, and the Use of GIS Technology. This regulation is expected to improve the efficiency and effectiveness of animal health management in Indonesia through a more integrated and data-driven digital approach.

Minister of Agriculture Regulation No. 20 of 2022 on the

Documentation and Legal Information Network (JDIH) regulates the management and development of JDIH within the Ministry of Agriculture. The regulation aims to provide quick, easy, and accurate access to legal information managed by the Ministry of Agriculture. It emphasizes the importance of digitalization in the management of legal information and public transparency.

Minister of Agriculture Regulation No. 10 of 2022 governs the Electronic System for the Allocation of Subsidized Fertilizers to Farmers (e-Alokasi). This regulation was created to enhance transparency, efficiency, and accuracy in the distribution of subsidized fertilizers to eligible farmers and reduce the potential for misuse.

Minister of Agriculture Regulation No. 40 of 2021 is a regulation issued by the Ministry of Agriculture of the Republic of Indonesia governing the "One Data Agriculture Initiative." The regulation aims to improve data management in the agricultural sector through the preparation, collection, processing, storage, presentation, and utilization of integrated and accurate data.

Minister of Agriculture Regulation No. 35 of 2021 on Synergy Between Various Programs and Policies within the Ministry of Agriculture aims to increase the effectiveness and efficiency of program and policy implementation within the Ministry of Agriculture. The primary goal of this regulation is to ensure that various programs and policies within the Ministry of Agriculture can support each other and operate more efficiently, thereby maximizing benefits for the agricultural sector in Indonesia. It also emphasizes the importance of digitalization as part of efforts to enhance the

efficiency and effectiveness of program and policy implementation.

Key aspects related to digitalization in this regulation include:

- Information System Integration
- Use of Information and Communication Technology (ICT)
- Data and Document Digitalization
- Digital Collaboration Platforms
- Digital-Based Monitoring and Evaluation

Utilization of Big Data and Analytics With advanced analytics, the Ministry of Agriculture can predict future trends and needs, enabling more targeted policy responses.

Minister of Agriculture Regulation No. 21 of 2021 on the Agricultural Extension Management Information System (SIMLUHTAN) is a regulation issued by the Ministry of Agriculture of Indonesia to manage the use of information systems in agricultural extension activities. Its main goal is to improve efficiency, effectiveness, and transparency in conducting agricultural extension through the use of information and communication technology.

Minister of Agriculture Regulation No. 15 of 2021 on Online Single Submission (OSS) for Licensing in the Agricultural Sector is a policy established by the Ministry of Agriculture of the Republic of Indonesia to expedite and simplify the licensing process in the agricultural sector through digital transformation.

Minister of Agriculture Regulation No. 15 of 2021 on the Animal Health Record Management Information System is a regulation governing the digital system for managing animal health data in Indonesia. This regulation is a step forward in the modernization and

digitalization of animal health management in Indonesia, supporting animal health and welfare and contributing to the livestock and public health sectors as a whole.

Minister of Agriculture Regulation No. 15 of 2021 on the Animal Health Management Reporting Information System (SIMPOL PKH) aims to regulate and facilitate systematic and integrated animal health reporting in Indonesia. This regulation aims to improve efficiency, effectiveness, and accuracy in managing animal health in Indonesia.

Minister of Agriculture Regulation No. 39 of 2019 and No. 2 of 2020 regulates the Online Recommendation for the Import of Horticultural Products (RIPH), aiming to increase efficiency and transparency in the import process of horticultural products in Indonesia. The objectives of these regulations are:

- **Enhancing Administrative Efficiency:** Streamlining the administration process related to horticultural product import recommendations through an online system.
- **Ensuring Compliance and Quality:** Ensuring that imported horticultural products meet established quality and safety standards.
- **Transparency and Accountability:** Increasing transparency in the import recommendation process and facilitating oversight by relevant parties.
- **Cost and Time Reduction:** Reducing the costs and time required for the import recommendation process through a digital system.

The online implementation of these regulations is expected to make the import recommendation process for horticultural products more structured, efficient, and accessible to all relevant parties.

Minister of Agriculture Regulation No. 50 of 2018 on the Supervision and Reporting System of Activities within the Ministry of Agriculture aims to increase the effectiveness and efficiency of supervision and reporting in the agricultural sector. This regulation is expected to make the supervision and reporting systems within the Ministry of Agriculture more efficient, accurate, and transparent.

Minister of Agriculture Regulation No. 45 of 2018 on the Electronic Performance Accountability System for Government Agencies (E-SAKIP) aims to enhance transparency, accountability, and performance of government agencies through the use of information technology. This regulation emphasizes the role of technology in improving the efficiency and effectiveness of performance accountability in the government sector.

Minister of Agriculture Regulation No. 39 of 2018 on the Planting Calendar (KATAM) in Indonesia aims to improve the effectiveness and efficiency of agricultural management activities by utilizing accurate data and information, such as meteorological data.

Minister of Agriculture Regulation No. 41 of 2017 on the Management and Evaluation Reporting Information System (SIMPEL) in Indonesia aims to improve the effectiveness and efficiency of reporting and evaluation activities in the agricultural sector. The regulation aims to optimize data and information management in the agricultural sector, and enhance the accuracy and efficiency of reporting and evaluation.

Minister of Agriculture Regulation No. 1 of 2016 on the Electronic Procurement Service (LPSE) within the Ministry of Agriculture has the

following objectives, key points, and specifications.

Objectives are as follows:

- Improving Transparency: Ensuring that the procurement process for goods and services in the Ministry of Agriculture is conducted openly and is accessible to the public.
- Efficiency and Effectiveness: Streamlining the procurement process, reducing bureaucracy, and increasing budget efficiency.
- Accountability: Enhancing accountability in the procurement of goods and services through a digital trail.
- Improving Service Quality: Providing better procurement services to all stakeholders.
- Use of Electronic Systems: The procurement of goods and services must be conducted through an integrated electronic system, namely LPSE, for all types of procurement.
- Registration and Qualification: Suppliers of goods/services must be registered with LPSE and meet the established qualification requirements.
- Procurement Process: The procurement process must follow the stages set out in the LPSE system, from announcement, registration, bidding, evaluation, to winner determination.
- Documentation: All procurement documentation must be stored in digital format and accessible to authorized parties.

This regulation is designed to support more modern and transparent procurement reforms, and to enhance budget management within the Ministry of Agriculture.

Minister of Agriculture Regulation No. 41 of 2014 on the Electronic

Planning System (E-Planning) aims to improve efficiency and effectiveness in the planning process within the Ministry of Agriculture. This regulation is expected to support the Ministry of Agriculture in achieving better and more sustainable agricultural development goals through more structured and integrated planning.

Minister of Agriculture Regulation No. 98 of 2013 on the Sustainable Plantation Information System (Siperibun) is a regulation designed to govern and facilitate the implementation of information systems in the plantation sector in Indonesia. The objectives of this regulation are:

- Increasing Transparency and Accountability: Ensuring that information about plantation activities is available openly and can be accounted for.
- Supporting Sustainable Plantation Management: Optimizing environmentally, socially, and economically friendly plantation practices.
- Facilitating Monitoring and Evaluation: Providing accurate and up-to-date data to monitor and evaluate the implementation of plantation policies and programs.

Minister of Agriculture Regulation No. 32 of 2011 Jo. Minister of Agriculture Regulation No. 25 of 2016 on the Portal for Information and Documentation Management Officers (PPID) within the Ministry of Agriculture aims to increase transparency and accountability in public information management within the Ministry of Agriculture. This regulation seeks to create a more open and easily accessible public information system through the use of information technology.

Minister of Agriculture Regulation No. 05 of 2007 on the Product Certification Agency for Agricultural Tools and Machinery (LS-Pro Alsintan) is an important regulation in the agricultural sector in Indonesia. It aims to ensure that agricultural tools and machinery available in the Indonesian market meet established quality and safety standards. With this regulation, it is expected that the quality of agricultural tools and machinery products will be guaranteed, thereby increasing productivity and efficiency in the agricultural sector. The implementation of digitalization is expected to make the certification process for agricultural tools and machinery faster, more accurate, and transparent, ultimately supporting the achievement of the regulation's primary objectives.

Minister of Agriculture Decree No. 559 of 2022 on the Identification and Registration of Animals in the Animal Health Program (Identik PKH) has several objectives, as follows:

- Ensuring Animal Health: The main goal of this decree is to ensure that livestock in Indonesia are healthy and free from contagious diseases that could affect the health of other animals as well as human health.
- Enhancing Transparency and Accountability: With standardized registration and identification, the government can more easily track and monitor the health conditions of animals throughout Indonesia.
- Supporting the National Animal Health Program: Animal identification and registration will help in the effective and efficient implementation of animal health programs.

Directorate General of Plantation Decree No. 105 of 2018 on the

Electronic Plantation Cultivation Registration Certificate (eSTDB) is a regulation issued by the Directorate General of Plantations that governs the electronic registration system for plantation cultivation.

- Administrative Efficiency: Simplifies and speeds up the registration process for plantation cultivation using an electronic system.
- Transparency and Accuracy: Increases transparency in the registration process and ensures that the obtained data is more accurate and up-to-date.
- Monitoring and Supervision: Facilitates the monitoring and supervision of plantation cultivation by the relevant authorities.
- Reducing Unofficial Fees: Reduces the potential for illegal fees or corrupt practices in the administrative registration process.

This regulation aims to modernize plantation administration, enhance efficiency and transparency, and facilitate access to and management of plantation cultivation data electronically.

Currently, there are 23 regulations related to digitalization policies in the agricultural sector. However, the primary focus of these regulations is on electronic governance aspects such as reporting, evaluation, data management, and budget allocation. These regulations are part of a larger strategy to build a digitally integrated agricultural sector that leverages technology to address modern challenges. By creating frameworks for digital certification, registration, and data management, these policies contribute to a more streamlined, transparent, and responsive agricultural system. They represent critical steps towards a comprehensive digital transformation, where technology is not only an enabler but a core component of agricultural practice. Through these regulatory measures,

the agricultural sector can better align with the demands of a digital economy, improve operational efficiencies, and drive sustainable growth in an increasingly complex global landscape. While these areas are crucial for improving internal government processes and enhancing administrative efficiency, they fall short of addressing the broader application of digital technologies within agriculture. The existing policies are mainly inward-looking, concentrating on streamlining government operations rather than enabling comprehensive digital transformation across the agricultural value chain.

The limited scope of these regulations highlights a significant gap in the current policy framework. At present, there are no regulations that explicitly or implicitly cover full-scale agricultural digitalization, from upstream activities like pre-production to downstream processes such as post-harvest management, processing, distribution, and marketing. This narrow regulatory focus restricts the potential benefits that digitalization can bring to the agricultural sector. The absence of comprehensive policies means that many opportunities to enhance productivity, sustainability, and economic viability through digital means remain underutilized.

To truly harness the potential of digital technologies, there is an urgent need for integrated policies that support a holistic digital transformation across the entire agricultural value chain. Such policies should not only cover internal government processes but also facilitate the adoption and integration of digital technologies at every stage, from pre-production planning, resource allocation, and planting to harvesting, post-harvest processing, and market access. By promoting

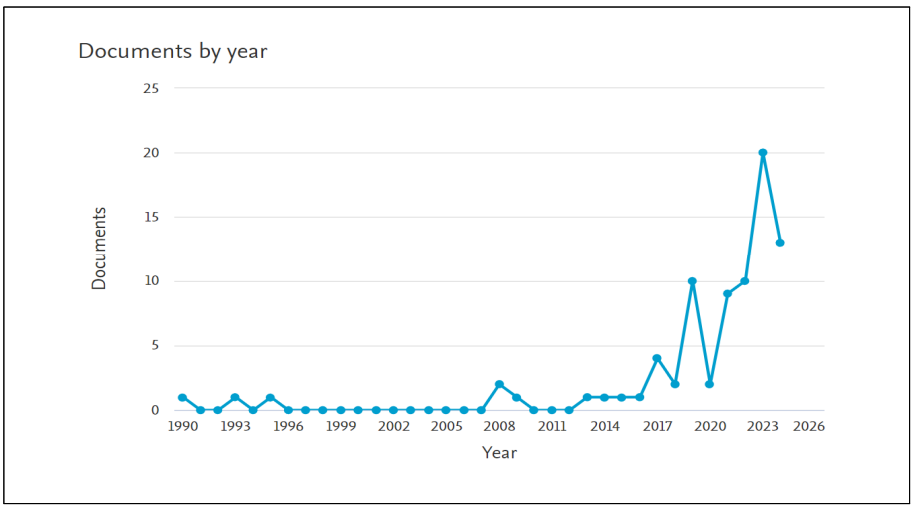
digitalization at all stages of agricultural production, the sector can better respond to challenges such as climate change, market volatility, and resource management, ensuring more resilient and sustainable agricultural practices.

Therefore, developing a regulatory framework that fosters digital innovation throughout the agricultural ecosystem is critical. This includes creating incentives for technology adoption, providing training and support for farmers, and encouraging public-private partnerships to drive digital advancements. By addressing the gaps in the current regulatory landscape and developing comprehensive policies that cover the entire agricultural value chain, the government can play a pivotal role in enabling a more efficient, productive, and sustainable agricultural sector.

3. Technological Applications in the Indonesian Agriculture

Research on digital transformation in Indonesia has been conducted by several scholars. A literature search in the Scopus database, using the keyword combination “digital transformation” OR digitalization OR “technology adoption” AND agriculture OR “agriculture sector” OR farming AND Indonesia, resulted in the identification of 80 documents. The distribution of publication years is illustrated in 〈Figure 1-1〉. This figure also indicates that the trend of studies discussing digital transformation in the agricultural sector in Indonesia has shown a general increase from the early 1900s to 2023.

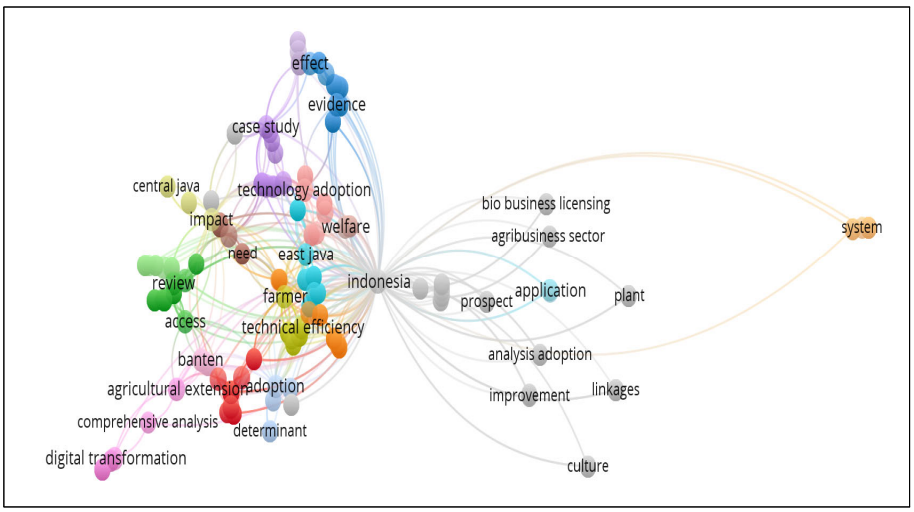
〈Figure 1-1〉 Document trends related to digital transformation in Indonesia



Source: SCOPUS(https://www.scopus.com/home.uri), Accessed date: 2024. 8. 10.

Upon analyzing the keyword trends of the 80 documents using VOSviewer, a visual network was generated, as illustrated in Figure 2. The colors in this visualization correspond to distinct discussion clusters. The cluster identified as follows: (1) Green Cluster: the adoption of agricultural practices, (2) Blue Cluster: the efficiency of farmers, particularly in Indonesia, and their adoption of new agricultural technologies, (3) Red Cluster: factors influencing the adoption of technology in agriculture, (4) Purple Cluster: the role of digital transformation in agriculture, (5) Yellow Cluster: frameworks for agribusiness or bio-business licensing systems, (6) Brown Cluster: regional impacts, (7) Gray Cluster: licensing and business aspects of agriculture, and (8) Light Blue Cluster: practical applications of technology, with a focus on improvements and outcomes.

〈Figure 1-2〉 Visualization of Keyword Network on Digital Transformation in the Agricultural Sector in Indonesia



Source: Internal Document from Noer Azam Achisani.

After evaluating the documents and conducting further analysis of their content, the researchers found that relying solely on a single database did not provide a sufficiently comprehensive perspective. To gain a deeper understanding of digital transformation in Indonesia's agricultural sector, the researchers incorporated multiple databases and carefully analyzed their content.

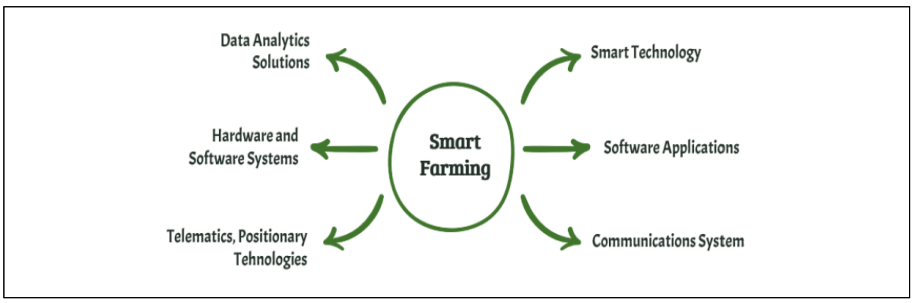
The evolving literature presents various interpretations of digital transformation in the agricultural sector. However, the majority of the literature highlights the integration of technology in agriculture (Rasyid & Ningsih, 2024; Johan et al., 2024; Suswadi & Irawan, 2023; Fahmi & Mendrofa, 2024; Sudaryanto et al., 2022). The implementation of technology is aimed at increasing productivity (Dewi et al., 2023), improving operational efficiency (Sudaryanto et al., 2022), and enhancing product competitiveness (Rasyid & Ningsih, 2024; Dewi et al., 2023) to sustainably improve farmers' welfare (Johan et al., 2024; Fahmi & Mendrofa, 2024). In summary, Sudaryanto et al. (2022) describe these efforts as various initiatives to digitize the agricultural sector through the use of technology.

Digital transformation in Indonesian agriculture refers to the utilization of digital technologies for smart farming, aimed at enhancing productivity, operational efficiency, and product competitiveness through improved communication, supply chain management, and product quality (Rasyid & Ningsih, 2024). This digital transformation serves as a mechanism for transitioning agriculture from traditional systems to modern agricultural frameworks (MoA, 2020a), making it more responsive to market

demands, environmental challenges, and improving national food security (Sudaryanto et al., 2022). This concept aligns with the Fourth Industrial Revolution (Industry 4.0), where agricultural development is characterized by the production of high-value, productive, and environmentally friendly agricultural outputs tailored to specific needs (Sudaryanto et al, 2022).

The implementation of smart farming involves the use of tools (such as drones, sonic bloom technology, remote sensing, soil and weather sensors, smart irrigation systems, etc.) and information technology-based systems (including big data, mobile internet, cloud computing, and the Agriculture War Room (AWR), among others) to support integrated and intelligent agriculture. Sizan et al. (2021) comprehensively illustrates the areas of smart farming implementation, as shown in 〈Figure 1-3〉.

〈Figure 1-3〉 Implementation Areas of Smart Farming



Source: Sizan et al. (2021).

Several IT-based tools and information systems in the agricultural sector have been implemented in various regions of Indonesia by the Ministry of Agriculture of the Republic of Indonesia (Izzuddin et al., 2021). According to Suswadi & Irawan (2023) and Shaleh et al. (2024),

the use of mobile applications, IoT sensors, and digital platforms has been piloted in rice farming, horticulture, plantations, livestock, fisheries, and forestry. Some regions that have served as pilot areas for the utilization of these tools and systems include several cities, districts, and provinces, such as Karawang, Sragen, and Ngawi (Suswadi & Irawan, 2023), Surabaya (Izzuddin et al., 2021), West Sulawesi (Adha et al., 2024), Central Java (Wijaya et al., 2020; Permatasari et al., 2024), West Sumatra (Ngadi & Nagata, 2022), Karawang, Bekasi, and Purwakarta (Sholihah et al., 2024), Cianjur (Sholihah et al., 2024; Wijayanto et al., 2024), and Bogor Regency (Sholihah et al., 2024; Harnowo et al., 2023).

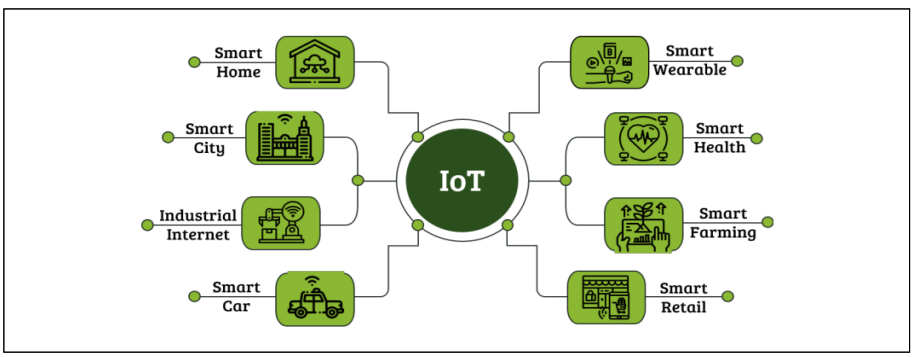
The presence of technology-based tools has been beneficial to farmers. Izzuddin et al. (2021) reported that the use of Internet of Things (IoT) technology, specifically through Smart Urban Farming (SUFI) to monitor environmental parameters using sensors such as plant temperature, air humidity, soil moisture levels, and light intensity, has been implemented in Surabaya. Ngatindriatun et al. (2024) highlighted that internet-based applications and information systems are also used in horticulture cultivation. Shofiyati (2022) added that the use of remote sensing tools (e.g., Sentinel-1, Landsat 8) helps estimate crop areas, monitor growth, assess soil fertility, detect stress, and support precision agriculture, thereby increasing crop yields in Indonesia. Hugeng et al. (2023) emphasized real-time monitoring of environmental conditions and automation of irrigation processes, ensuring optimal water use and better plant health. Other digital tools, such as Sonic Bloom and monochromatic light, stimulate plant growth through electroculture, resulting in a 40.08%

increase in pakcoy yields (Prasetyo & Wicaksono, 2021).

The use of technology is not limited to on-farm agricultural activities (Rakhmadi & Junaidi, 2022). Farmers also leverage technology to support record-keeping and the marketing of agricultural products. Rakhmadi & Junaidi (2022) identify e-commerce as one of the tools that helps broaden the market for agricultural products and facilitate direct sales to consumers. Rusdiyanto et al. (2019) highlight the use of automated data recording applications as an example of technological adoption. These practices demonstrate the high level of digital adoption aimed at realizing smart farming.

In the context of supporting the development of smart farming, several studies highlight the utilization of the Internet of Things (IoT). IoT is recognized as a set of networking devices that can interconnect, analyze sensor data, and assess current conditions (Sizan et al. 2021). IoT is applied across a variety of application areas, as outlined by Sizan et al. (2021), and illustrated in 〈Figure 1-4〉.

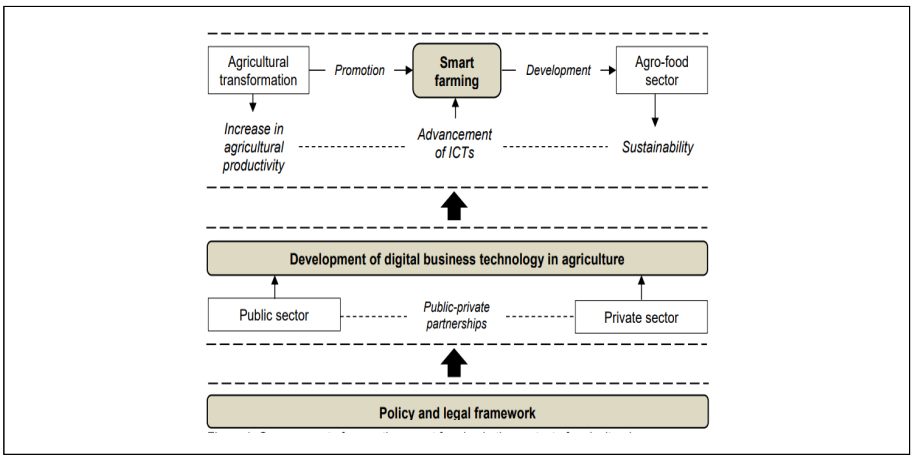
〈Figure 1-4〉 Areas of the application of IoT.



Source: Sizan et al. (2021).

Farmers recognize the numerous benefits provided by the introduction of technology, as discussed above. However, widespread implementation still faces significant challenges. Johan et al. (2024) identify key challenges in Indonesia, including regulatory issues, infrastructure limitations, and farmer education, which require integrated efforts from stakeholders to ensure success. Sudaryanto et al. (2022) emphasize the need for public-private partnerships, supported by appropriate policies and legal frameworks. The framework proposed by Sudaryanto et al. (2022) for realizing this concept is illustrated in Figure 5.

〈Figure 1-5〉 Framework of Agricultural Transformation in Indonesia



Source: Sudaryanto et al. (2020).

The digital transformation of Indonesia's agricultural sector necessitates the involvement of multiple stakeholders, including central and local governments, farmer groups, cooperatives, agricultural businesses, and academic institutions. At present, the digital transformation in agriculture primarily serves social objectives rather than structural

change, though it holds the potential for significant future impacts (Fahmi & Mendrofa, 2024). According to Suswandi (2023) and Ilham et al.(2023), the government's role includes overseeing policy implementation, supporting the integration of digital technology within the agricultural sector, establishing regulations, and providing essential infrastructure. Farmers and farmer groups are responsible for the practical implementation of technology in the field, as well as offering feedback for further refinement (Suswandi, 2023; Ilham et al., 2023). Agricultural businesses contribute by providing financial capital (Ilham et al., 2023), while universities are expected to drive new, research-based innovations (Lumbantobing et al., 2023). An essential factor for fostering stakeholder collaboration is the development of an agricultural innovation ecosystem, which facilitates continuous interaction among stakeholders to support collective prosperity (Bocean, 2024).

International experiences demonstrate that the integration of digital technologies into agricultural businesses can improve productivity, enhance market competitiveness, and help businesses adapt to evolving market conditions (Bocean, 2024). Giannakopoulos et al. (2024) discuss the use of artificial intelligence (AI) in agricultural data analysis, which includes applications such as data integration, predictive analytics, market forecasting, targeted marketing, price optimization, personalized campaigns, supply chain efficiency, and data-driven decision-making (Giannakopoulos et al., 2024). However, the full implementation of these technologies in Indonesia remains challenging. 〈Table 1-1〉 highlights the key challenges and opportunities encountered by Indonesian farmers.

〈Table 1-1〉 Digital Transformation Challenges and Opportunities in Indonesia

No	Sources	Commodity	Forms of Digital Transformation	Location	Challenges and Opportunity
1	Suswadi & Irawan (2023)	Rice Farming, Horticulture, Plantations, Livestock, Fisheries, Forestry	IoT	Karawang,Sragen and Ngawi	**Challenges:** Digital transformation in Indonesian agriculture faces limited infrastructure, low digital literacy, lack of supporting regulations, and farmers' hesitation to adopt new technologies. **Opportunities:** Digital tech can boost efficiency, provide real-time info, and foster collaboration with tech companies, educators, and government, driving innovation and productivity in the sector.
2	Ilham et al (2023)	Smart agriculture	Smart agriculture, smart infrastructure, smart service, smart innovation, smart institution, Smart supply chain management, Smart Financing, Smart Environment (Sustainability)	Indonesia	**Challenges:** Uneven internet infrastructure, especially in rural areas, limits the adoption of smart technologies. Despite efforts to improve access, many villages still face poor network quality, hindering the effective use of advanced digital tools. **Opportunities:** Smart agriculture and villages offer a chance to boost rural productivity and sustainability. Technologies like sensors, IoT, and data analytics help farmers manage crops in real-time, improve resource use, reduce climate risks, and enhance market access, empowering rural economies and promoting eco-friendly practices.

(continued)

No	Sources	Commodity	Forms of Digital Transformation	Location	Challenges and Opportunity
3	Shaleh et al (2024)	Potato Farm, Smart Agriculture	Smartphone, ICT (Information and Communicatiom Technology)	Indonesia	**Challenges:** Many farmers struggle to adapt to using ICT, and the high investment costs can be a barrier. Quick adaptation is needed, as not all farmers can adopt new technologies rapidly. **Opportunities:** Increased productivity as farmers can benefit from ICT to monitor land conditions, weather, nutrient needs, and pesticide requirements in real–time.
4	Izzuddin et al (2021)	Urban Farming	Internet of Things	Surabaya, Jawa Timur, Indonesia	**Challenges:** Limited local IoT hardware production and the need for more development to suit urban farming needs. **Opportunities:** IoT can enhance automation and efficiency in urban agriculture.
5	Ngatindriatun et al. (2024)	Horticulture	Technology based application	Indonesia	**Challenges:** Climate change causes unpredictable weather, affecting crops and their resistance to pests. Agriculture also heavily depletes natural resources, like water, and unsustainable practices harm the environment. Additionally, many small farmers lack access to the digital tools and training needed to improve efficiency. **Opportunities:** Technological advances like IoT, AI, and blockchain can boost agricultural productivity and sustainability. Digital tools can help farmers adopt better practices, reduce waste, and use resources more efficiently.

(continued)

No	Sources	Commodity	Forms of Digital Transformation	Location	Challenges and Opportunity
6	Adha et al. (2024)	Cocoa	Development Strategy in Digital Marketing for Cocoa Products	Sulawesi Barat, Indonesia	**Challenges:** Cocoa product entrepreneurs face difficulties in accessing international markets and navigating the international marketing mix. Enhancing competitiveness is challenging in a global economy marked by uncertainty. **Opportunities:** Digital technology offers potential for improving the competitiveness of agricultural commodities like cocoa for those who can effectively leverage it.
7	Rachmawati (2021)	Not specific	Smart agriculture	Indonesia	**Challenges:** Low adoption by farmers, high costs of smart farming equipment, and doubts about the credibility of tech companies hinder progress. Farmers' reluctance to change perceptions about machinery, along with limited internet access in parts of Indonesia, and the need for extensive data input into software, add to the difficulties.
8	Lumbantobing et al. (2023)	agriculture in general (supply chain)	IoT, Big Data, Machine Learning, Block Chain	Indonesia dan Norwegia	**Challenges:** uncertain principles and structured approaches for driving digital transformation in Indonesia **Opportunities:** Technologies like IoT, blockchain, and data mining are key to advancing digital transformation in the agricultural supply chain.

(continued)

No	Sources	Commodity	Forms of Digital Transformation	Location	Challenges and Opportunity
8	Lumantobing et al. (2023)	agriculture in general (supply chain)	IoT, Big Data, Machine Learning, Block Chain	Indonesia dan Norwegia	**Challenges:** uncertain principles and structured approaches for driving digital transformation in Indonesia **Opportunities:** Technologies like IoT, blockchain, and data mining are key to advancing digital transformation in the agricultural supply chain.
9	Cahyana et al. (2024)	Modern Agriculture	Chat GPT for Digital Soil Mapping, Precision Farming, Morphological Sensing Analysis	Central Java, Indonesia	**Challenges:** Despite high expert ratings, soil scientists perceive ChatGPT's accuracy as lower, showing a gap between its quality and their confidence. **Opportunities:** AI technologies like ChatGPT offer valuable tools for soil science education and research, assisting in creating formulas and indices for analysis.
10	Wijaya et al. (2020)	Traditional Farming, Modern Farming, Organic Farming, Agricultural Diversification	The use of ICT for information access, modernization of agricultural tools such as tractors, implementation of organic farming, economic diversification by utilizing technology for promotion, and efforts to improve digital infrastructure in rural areas to support small farmers.	Central Java, Indonesia	**Challenges:** - Limited Infrastructure: Minimal access to internet and technology. - Digital Divide: Differences in access between small and large farmers and between regions. - Lack of Skills: Small farmers lack technological knowledge. - Limited Resources: Limited funds and tools. - Climate Change: Negative impacts on agricultural output. **Opportunities:** - Technology Access: Infrastructure investment increases farmer access. - Training: Training programs improve farmers' technological capabilities.

(continued)

No	Sources	Commodity	Forms of Digital Transformation	Location	Challenges and Opportunity
10					– Sustainable Agriculture: Market Opportunities from organic practices. – Collaboration: Synergy between farmers, government, and the private sector. – Utilization of ICT: Improve marketing and production efficiency.
11	Ngadi & Nagata (2022)	Palm oil and rice	The PIR-Trans project is to analyze and monitor land use changes, such as the shift from agricultural land to oil palm plantations, as well as to increase rice production in the modern era.	South Sumatra, Indonesia	**Challenges:** the conversion of rice fields into oil palm plantations, has the potential to disrupt food security. Additionally, environmental changes caused by the expansion of oil palm plantations may impact the quality of water resources and land productivity. **Opportunities:** include the enhancement of agricultural productivity driven by digital technologies such as IoT, AI, and drones, which assist in monitoring and improving the efficiency of natural resource use. These technologies enable data-driven decision-making to optimize sustainable agricultural practices, applicable on both small and large scales.
12	Ngadi et al. (2023)	Rural Agriculture	Internet of Things (IoT), artificial intelligence (AI), and data analytics are being adopted to increase productivity and efficiency in the agricultural sector.	Indonesia	Aging human resources who have difficulty accepting new technology.

(continued)

No	Sources	Commodity	Forms of Digital Transformation	Location	Challenges and Opportunity
13	Permatasari et al. (2024)	Organic Farming	utilization of websites and social media to attract tourists to organic farming locations, and digital platforms can be used to organize events, festivals, and promote organic farming products.	Karanganyar, Central Java, Indonesia	**Challenges:** Declining interest of young generation in agriculture due to urbanization and changing career preferences. **Opportunities:** Synergy between tourism and organic farming can increase interest and participation of young generation in both sectors, as well as create new business Opportunities and increase local income.
14	Sholihah et al. (2024).	Rice Cultivation	The use of remote sensing technology (satellite data from Landsat 8 and 9) to obtain Land Surface Temperature (LST) data. This technology helps monitor climate fluctuations and predict drought-prone areas as part of Climate Smart Agriculture (CSA).	Central Citarum, West Java, Indonesia. Covering the areas of Bogor, Cianjur, Karawang, Bekasi, and Purwakarta Regencies	**Challenges:** Land surface temperatures are rising above optimal levels for rice production, leading to an increased risk of drought and potential crop failure. **Opportunities:** Leveraging LST data from remote sensing provides a valuable tool for drought early warning and strategic planning in agriculture, improving the resilience and sustainability of food production in drought-prone areas.
15	Wijayanto et al. (2024)	Rice farming, especially in the context of controlling bacterial leaf blight (BLB) in rice plants.	The use of drone technology with multispectral and thermal sensors for monitoring and analyzing rice plant health and the application of machine learning techniques for disease detection.	Cianjur, West Java, Indonesia	**Challenges:** Data imbalance in disease classification, high cost of drone sensors and related technologies, and limitations in field measurement accuracy. **Opportunities:** Improved disease detection accuracy can help farmers make better decisions, Potential to improve agricultural yields and food security through more efficient technologies, Opportunities for further collaboration between academics and practitioners in agriculture

(continued)

No	Sources	Commodity	Forms of Digital Transformation	Location	Challenges and Opportunity
16	Johan et al. (2024)	Agriculture in general	Data-driven agriculture, drones, satellites, and precision agriculture using GPS and GIS.	Indonesia	**Challenges:** lack of regulation, limited ICT infrastructure, limited internet and low digital literacy and technological skills. Opportunities: the existence of e-commerce and private digital trading platforms can help farmers improve their bargaining position.
17	Musyaffa et al. (2023)	Rice, corn, soybeans	Agricultural technology innovation using drones and IoT	West Java, North Sumatra, South Sulawesi, East Kalimantan	**Threats:** Technology gap and understanding in the use of technology **Opportunities:** Acceleration of digitalization due to Covid-19 which makes the agricultural chain distribution scheme shorter and farmers get bigger profits
18	Harnowo et al. (2023)	Soybean Precision Farming	Implementation of precision agriculture using IOT 4.0: satelit, remote sensing, crop-monitoring, drone, GIS Software dalam Soil Mapping, dan big data.	Cibinong Science Center – Botanical Garden	**Challenges:** In its implementation requires farmer perception and requires support from the government including promotion (dissemination) of precision agriculture. Opportunities: Increasing agricultural productivity, increasing agricultural profits, reducing the use of agricultural facilities (especially chemicals), reducing agricultural production costs, time, and human resources.
19	Imam et al. (2022)	Salt	transform with IoT-based digital web system to optimize salt farming production	Indonesia	**Challenges:** Unpredictable weather fluctuations to measure salt levels, temperature, and humidity in the sea. Availability of traditional farmers to use the digital web that has been innovated. Most traditional farmers do not understand technology and are more accustomed to doing things traditionally.

(continued)

No	Sources	Commodity	Forms of Digital Transformation	Location	Challenges and Opportunity
19					**Opportunities:** If this innovation can be well received and implemented well, it can increase the potential for salt production in Indonesia and has the opportunity to export salt commodities abroad to improve the Indonesian economy.
20	Rachmawati (2021)	Agriculture in general	Agri Drone, Blockchain, Agriculture War Room (AWR)	Indonesia	**Challenges:** 1. Low level of farmer adoption 2. High investment costs for smart farming equipment 3. Uncertainty about the credibility of technology companies developing smart farming equipment products 4. Difficulty in changing farmers' perceptions about the usefulness of agricultural machinery, and the convenience that will be obtained by using smart farming equipment, 5. Limited internet access in several areas in Indonesia and the need to input a lot of data and information into software.

Source: Written by author.

〈Table 1-1〉 presents a comprehensive overview of various digital transformation initiatives in Indonesia's agricultural sector, emphasizing both the challenges and opportunities. The key challenges in implementing digital transformation in this sector encompass several critical factors. First, the limited internet infrastructure, particularly in rural areas, poses a significant barrier to the adoption of smart farming

technologies and digital tools. Many regions lack access to reliable, high-speed networks, Internet of Things (IoT) devices, and modern technological infrastructure. Second, low levels of digital literacy among farmers hinder the adoption of new technologies, compounded by a reluctance to abandon traditional farming practices. Additionally, the high costs associated with implementing digital solutions, such as IoT systems, drones, and precision agriculture tools, present significant financial burdens, particularly for smallholder farmers. Furthermore, challenges such as climate change, unpredictable weather patterns, and the depletion of natural resources complicate crop management and agricultural sustainability efforts. Lastly, the absence of supportive regulatory frameworks, a structured approach, and robust government backing further impedes the smooth implementation of digital transformation initiatives in agriculture.

Despite these challenges, digital transformation in Indonesia's agricultural sector presents substantial opportunities. Digital tools such as IoT, artificial intelligence (AI), drones, and precision agriculture offer significant potential for enhancing productivity and efficiency. These technologies enable real-time monitoring, reduce resource wastage, and improve crop yields. Furthermore, digital transformation supports sustainability by promoting environmentally friendly agricultural practices, mitigating the risks posed by climate change, and enhancing resource efficiency. Additionally, the expansion of market access through digital platforms and marketing tools improves farmers' bargaining power, facilitates access to broader markets, and creates opportunities for international trade.

Collaborative efforts between farmers, technology companies, educational institutions, and government agencies can further drive innovation and help address the digital divide. Moreover, smart technologies like IoT and data analytics have the potential to empower rural economies by enhancing productivity, promoting sustainability, and attracting younger generations to re-engage with the agricultural sector. However, to fully realize these opportunities, it is essential to address the existing barriers related to infrastructure, digital literacy, and the costs associated with technological adoption.

Digital transformation in Indonesia's agricultural sector is crucial for enhancing efficiency and competitiveness. The implementation of precision agriculture technologies requires effective training programs for farmers and agribusiness actors to ensure optimal adoption (Michailidis et al., 2024). Identifying training needs for those involved in the precision agriculture ecosystem is a critical first step. The utilization of artificial intelligence (AI) in agricultural marketing data analysis, including data integration, predictive analysis, supply chain efficiency, and data-driven decision-making, can significantly enhance agribusiness performance (Šermukšnyte-Alešiuniene & Melnikiene, 2024). Recent studies also suggest that digital technologies can reduce labor costs, improve customer relations, enhance investment planning, and redesign agricultural processes.

A major challenge is ensuring that these advancements do not exacerbate inequalities and are effectively implemented in small-scale farming and rural areas. According to Sari & Diana (2024), digital transformation in rural agricultural sectors contributes not only

to the economic aspects of farming but also to communication, education, healthcare, and community culture. Thus, a holistic, thoughtful, and proactive approach is necessary to realize the full benefits of digital transformation in agriculture.

4. Readiness and Adoption Challenges for Digital Transformation

To grasp the potential effects of digital transformation in agriculture, it's important to evaluate the current level of preparedness across different areas. This includes evaluating the availability and quality of critical infrastructure, such as internet connectivity and digital hardware, particularly in rural areas where most agricultural activities occur. Additionally, understanding the readiness and willingness of farmers to embrace digital technologies is key, as their engagement and adoption are crucial for any digital initiatives to succeed. By exploring these factors, we can gain insights into the challenges and opportunities that lie ahead in the journey toward a more digitally integrated agricultural sector.

4.1. Gadget Usage in Indonesia

〈Table 1-2〉 Gadget Usage in Indonesia

Year	Total Population	Population Proportion (%)		
		Owns a Mobile Phone	Uses a Computer	Uses the Internet
2015	254,896,941	51.87	15.01	20.03
2016	257,891,669	53.24	15.73	23.16
2017	261,088,526	54.25	17.32	29.44
2018	264,226,891	56.82	17.39	36.33
2019	267,303,490	57.96	13.20	43.51
2020	270,311,824	57.48	12.97	49.84
2021	271,585,334	60.71	10.77	58.29
2022	274,201,549	62.67	10.98	62.70
2023	276,789,454	62.32	11.39	65.87

Source: SUSENAS March (2023), processed.

The data in Table 2 illustrates clear growth, proceeding from the adoption of digital technology within Indonesia from the years 2015 to 2023. Over this period, the whole population grew at a rate of 254.9 million in 2015 to 276.8 million in 2023. With such rising population change, there exists a huge shift in the percentage of the population that own mobile phones, use computers, and have access to the internet over the years, pointing out significantly changed grounds of digital connectedness in the country.

Ownership of mobile phones has continued an upward trend from 51.9% in 2015 to 62.3% in 2023. This would imply that the price and accessibility of mobile phones became cheaper, making them the principal means of communication and access to other digital services. The acquisition of mobile technology becomes part of daily

life with changes in features in mobile products and widening telecommunications networks.

In contrast, the proportion of computer use has been on a decrease from 15.0% recorded back in 2015 to 11.4% in the year 2023. This fact shows that mobile phones are the new wave computers since they even perform better than the previous desktops, the personal computers. Moving from traditional computers to more recent hand-held ones illuminates a preference for technology that is easily portable, user-friendly, and that is accessible from various locations.

By far, the greatest growth was in internet use: from 20.0% in 2015 to 65.9% in 2023. This increase, by no small means, demonstrates enormous improvements in internet infrastructure, greater smartphone adoption, and the fact that such digital connectivity has become a critical need both personally and professionally. Basically, this explains how fast Indonesia is moving with respect to digital inclusion among the general public.

Over the years, the data reflects a trend change toward digital connectivity on a mobile-first basis in Indonesia. These include increased ownership and use of mobile phones and the internet, and decreased use of computers. This could be attributed to technological advancement, investment in infrastructure, and increasing digital literacy among the Indonesian populations—the country's dynamism as a player in this era of digitization.

4.2. Purposes of Internet Use

Table 3 provides an understanding of the purposes for internet usage in Indonesia for the years 2019 to 2021 and shows a trend in using the internet for such purposes. This data presents trends in changed patterns of using the internet by populations over these three years.

It is consistent with the fact that most popularly, 87.21% in 2019, the use of the internet, and slightly increased to be 88.24% in 2021, is for social media and networking purposes. It means that the majority of Indonesians have gotten used to having a daily routine with social media platforms like Facebook, Twitter, WhatsApp, among others. These are the channels which offer primary communication, social interaction, and content sharing among Indonesians.

The second most ranked reason why people use the internet is Getting Information and News. This, however, decreased slightly from 69.87% in 2019 to 64.85% in 2021 but still remains one of the major key activities on the internet, meaning that the said use of the internet remains an important source of obtaining timely information and news for most of the population.

Entertainment activities — What people spend their time on, such as downloading and playing games, watching TV, and more — all have varying interest. These almost rose from 62.06% in 2019 to peak at 68.58% in 2020, likely because of the COVID-19 pandemic and associated lockdowns, before receding just a little to 63.28% in 2021. This pattern shows the role of the internet in providing entertainment and leisure options, especially when movements are limited.

Acquiring Information for Learning Purposes increased significantly from 25.86% in 2019 to 32.45% in 2021, showing that the use of the internet for educational purposes has been growing in recent years. The rise might be a result of online learning due to the pandemic, which made many people turn to the internet as a place to glean most of their education.

Purchasing Goods and Services increased from 12.83% in 2019 to 15.93% in 2021, depicting the growth in comfort and familiarity with e-commerce platforms among Indonesians. This proportionate increase is directly correlated with a similar trend noted within the digital transformation of retail, as more individuals take up the practice of shopping online for convenience and variety.

The uptake of E-Banking in Financial Services rose gradually from 6.46% in the year 2019 to 7.63% at the end of the year 2021, pointing toward an upward trend in adopting digital financial services. This indicates a move away from cash transactions and greater societal acceptance of digital banking offerings.

Finally, the data made it clear that internet use in Indonesia has been dominated by social, information search, and entertainment functions, with rising shares of education and commercial functions. These patterns are indicative of larger trends toward digital engagement and point to the expanding role of the Internet in social networking and learning and commerce.

〈Table 1-3〉 Purposes of Internet Use in 2019-2021

Purposes of Internet Use	Percentage (%)		
	2019	2020	2021
Getting Information/News	69.87	68.45	64.85
Getting Information for Learning Purposes	25.86	24.72	32.45
Sending/Receiving Emails	13.93	12.17	12.74
Social Media/Networking (Facebook, Twitter, BBM, WhatsApp, Skype, etc.)	87.21	87.88	88.24
Purchasing Goods/Services	12.83	14.12	15.93
Selling Goods/Services	5.08	4.97	5.23
Entertainment (Downloading/Playing Games, Watching TV, Downloading/Watching Movies/Videos, Listening to Radio, Downloading Images and Music)	62.06	68.58	63.28
Financial Services (E-Banking)	6.46	7.00	7.63
Getting Information About Goods/Services	13.69	13.78	12.87
Others	3.25	3.98	4.67

Source: SUSENAS (2024), processed.

〈Table 1-3〉 illustrates the purposes of internet use in Indonesia during March 2022 and March 2023, highlighting shifts in user behavior over this period. The data shows a diverse range of activities for which people utilize the internet, with notable trends in both increases and decreases across various purposes.

Getting Information/News remains one of the primary reasons for internet use, increasing from 73.25% in March 2022 to 78.09% in March 2023. This growth indicates the continued reliance on the internet as a key source of news and information, reflecting its role as a critical platform for staying updated on current events.

Social Media/Networking saw a significant increase, rising from 72.56% in 2022 to 78.35% in 2023. This demonstrates the pervasive role of social media in daily life, as users engage in communication, content sharing, and networking across various platforms like

Facebook, Instagram, and WhatsApp. Social media remains a dominant force in how people connect and interact online.

Purchasing Goods/Services also saw a notable rise from 16.12% in March 2022 to 19.97% in March 2023. This trend reflects the growing acceptance and convenience of e-commerce, as more users turn to online platforms for their shopping needs. The increase suggests a broader shift towards digital transactions and the continued expansion of online retail.

Financial Services (E-Banking) usage increased from 6.79% to 9.71%, indicating that more individuals are embracing online banking and digital financial services. This trend highlights the ongoing digital transformation of the financial sector, with users increasingly opting for online solutions for their banking needs.

Digital Content Creation experienced a significant increase from 1.28% in March 2022 to 4.72% in March 2023, reflecting a growing interest in producing and sharing digital content such as videos, blogs, and social media posts. This rise could be linked to the increasing popularity of platforms that allow users to monetize content creation, fostering a new wave of digital entrepreneurs.

Online Learning experienced a decline from 18.70% in March 2022 to 10.37% in March 2023. This reduction could be attributed to the gradual return to traditional in-person learning as pandemic restrictions ease, leading to a decreased reliance on online educational platforms.

Work From Home (WFH)/Working Online from Home also saw a decrease, from 3.45% in 2022 to 2.05% in 2023, suggesting a shift back

to physical workplaces as the impact of COVID-19 wanes. The decline indicates that while remote work remains an option, it is not as widely utilized as it was during the height of the pandemic.

Entertainment shows a significant increase from 70.35% in 2022 to 85.32% in 2023, underscoring the internet's role as a primary source of leisure and entertainment. This surge highlights how users continue to engage with streaming services, gaming, and other online entertainment options, making it a vital aspect of internet use.

Overall, the data reveals evolving internet usage patterns in Indonesia, with increased engagement in social networking, online shopping, and digital financial services, while activities such as online learning and remote work are seeing declines. These trends reflect broader shifts in digital behavior as users adapt to post-pandemic realities, with continued reliance on the internet for communication, information, and entertainment.

〈Table 1-4〉 Purposes of Internet Use in 2022-2023

Purposes of Internet Use	Percentage (%)	
	Mar-22	Mar-23
Getting Information/News	73.25	78.09
Getting Information About Goods/Services	20.05	24.10
Sending/Receiving Emails	10.48	12.91
Social Media/Networking	72.56	78.35
Purchasing Goods/Services	16.12	19.97
Selling Goods/Services	4.52	5.22
Financial Services (E-Banking)	6.79	9.71
Online Learning	18.70	10.37
Work From Home (WFH)/Working Online from Home	3.45	2.05
Entertainment	70.35	85.32
Digital Content Creation	1.28	4.72
Others	4.82	5.90

Source: SUSENAS (2024), processed.

The data from the previous tables (Table 3 and Table 4) illustrate the evolving patterns of internet use in Indonesia from 2019 to 2023, highlighting key activities driving digital engagement among users. Social Media/Networking consistently remains the most popular internet activity, with usage rates slightly increasing over the years, reflecting the dominant role of social media in connecting people and facilitating communication. Getting Information/News also stands out as a major purpose, though it showed a slight decline from 2019 to 2021 but rebounded significantly by 2023, highlighting the internet's role as a critical source of information.

Entertainment activities, including gaming and streaming, saw notable fluctuations, peaking during the pandemic years as people sought leisure activities online, but have generally remained a strong driver of internet use. Online Learning surged during the pandemic but started to decline as in-person learning resumed. E-commerce activities such as purchasing and selling goods/services have steadily increased, indicating growing comfort with digital transactions and the expanding digital economy. Similarly, Financial Services (E-Banking) usage has gradually risen, showcasing a shift towards digital banking solutions.

Overall, Table 3 and Table 4 reveal a growing reliance on the internet for communication, information, shopping, and financial transactions, while trends like remote work and online learning have adjusted post-pandemic. These insights underscore the dynamic nature of internet use in Indonesia, shaped by technological advancements and evolving user needs.

4.3. Digital Infrastructure in Indonesia: Internet Connectivity

The terms in the context of the infrastructure for connectivity to the internet describe how high the reception of internet signals is in a certain area. This is very contributive to how the people within this area receive digital services. They include explanations for each term:

Using Base Transceiver Station (BTS) Towers: BTS is a telecommunications infrastructure that enables wireless communication between user devices, such as mobile phones or modems, and the network of the operator. The availability of BTS towers in any place is very important for proper cellular and internet signals to reach there. Generally, areas having a good number of BTS towers will have better access to most digital services, including internet connectivity.

4G/LTE Internet Signal Reception: A 4G/LTE (Long-Term Evolution) display indicates that high-speed internet is available in an area. This technology is tailored to support very fast, seamless data services and can therefore be used for digital applications that require the use of vast bandwidth, which includes video streaming, teleconferencing, and the application of IoT in agriculture.

With 3G/H/H+/EVDO Internet Signal Reception: If an area gets signals for 3G, H (HSDPA), H+ (HSPA+), or EVDO, then this means the place is getting a lower-speed internet connection other than 4G/LTE but good enough for normal internet access—meaning browsing, emailing, and social networking. The speed and stability proffered by these networks are good enough for basic digital applications but comparatively less than ideal for services requiring high bandwidth.

2.5G/E/GPRS Internet Signal Reception: When it receives 2.5G, E

(EDGE), or GPRS signals, it means that the internet network the device connects to is of a very low speed. These kinds of networks are only able to support applications based on text and simple communication like SMS or basic texting. For digitalizing agriculture, this kind of connectivity is not enough for the farmer to advance further in the use of more advanced stages of digital applications.

Without Internet Signal Reception: Without internet signal reception, this implies a total lack of the internet service in a region. This is a big challenge under digital transformation; a place without the internet may not have access to digital information that could improve efficiency and productivity in agriculture, through farming applications and many other digital technologies.

In the context of digital transformation in agriculture, normally speaking, the availability and quality of Internet signal reception form the important foundation in determining how well digital technology can be implemented and accessed by farmers, especially in rural settings.

Table 5 is the summary of internet infrastructure by all provinces of Indonesia, in villages or sub-districts with different quality levels of the internet signal: 4G/LTE, 3G/H/H+/EVDO, 2.5G/E/GPRS, and zero internet signal. Most provinces display a large share of their villages with 4G/LTE signals, which makes most of their areas equipped with modern internet facilities. For instance, Central Java has the highest number of villages with this coverage: thousands of them. East Java has 7,597, while West Java has thousands.

To a great extent, BTS towers also determine the course of internet connectivity. The provinces with the highest numbers of BTSs include

East Java, 4,826 towers; Central Java, 4,642 towers; and West Java, 4,601 towers. In these respective areas, the internet coverage may largely be considered to be effective since there is appropriate infrastructure in place to serve the large population within their jurisdictions.

In some pockets, the availability of an internet signal remains to be 3G or 2G. Provinces like East Nusa Tenggara, West Kalimantan, and Central Kalimantan have a slightly higher dependency on 3G and 2.5G signals. This translates to the need for more upgrades in that region to better its connectivity. That is a reflection of the unequal technological adoption in the country, with regions falling far behind in this form of modern internet infrastructure.

Even with the gains made, there are still some provinces that have villages where no internet signal is being received at all. These problem regions include many in Papua, West Papua, and East Nusa Tenggara, each totaling 271, 213, and 172 villages, respectively. This kind of lack of connection within remote or rural areas in general poses some challenges to digital inclusion.

Table 5 evidently indicate discrepancies in internet infrastructures whereby most provinces with high density and urbanization such as Jakarta have a high level of 4G coverage, while the remote areas, including Papua and Maluku, have a challenge in connectivity. These discrepancies point to a much deeper digital divide pervading Indonesian society when the effects are felt in access to information, services, or opportunities.

In general, Table 5 reveals how Indonesia has been able to move up the ladder of internet access; however, it also shows that more continued

investments are required to reduce the remaining connectivity gap further, especially in rural and remote areas. Expanding the infrastructure of the internet in each province has a strategic importance so that people in every corner of the country gain proper access to digital services, thus enabling economic and social development.

Limited internet connectivity and a lack of supporting infrastructure in rural regions pose significant challenges to the adoption of digital technologies in sectors like agriculture. Many rural areas still struggle with inadequate access to reliable internet, which is crucial for implementing modern agricultural practices that rely on real-time data, online marketplaces, and remote monitoring systems. Without proper connectivity, farmers in these regions are unable to fully benefit from advancements in digital agriculture, such as precision farming, automated systems, and access to online agricultural advisory services.

Furthermore, the shortage of digital devices and the technical know-how to use them effectively also hinder progress. Many villages lack access to affordable and suitable digital devices, which prevents farmers from using apps, platforms, and services designed to enhance agricultural productivity. This digital divide contributes to inefficiencies and limits farmers' ability to access new markets, resources, and information that could improve their yields and livelihoods.

There are, however, opportunities for improvement. A collaborative effort between the government and the private sector is needed to enhance digital infrastructure in rural areas. Investment in expanding internet coverage, improving signal quality, and providing affordable digital tools and training can help bridge the gap. By fostering such

collaborations, rural communities can gain the necessary tools and resources to participate in and benefit from the digital transformation of the agricultural sector.

〈Table 1-5〉 Distribution of Internet Infrastructure

Province	Total Number of Villages/ Sub-districts	Number of Villages/Sub-districts				
		with Base Transceiver Station (BTS) Towers	with 4G/LTE Internet Signal Reception	with 3G/H/H+/EVDO Internet Signal Reception	with 2.5G/E/GPRS Internet Signal Reception	with No Internet Signal Reception
Aceh	6,434	1,593	5,024	1,202	176	32
North Sumatra	5,982	2,625	4,467	1,018	349	148
West Sumatra	1,264	940	1,075	132	40	17
Riau	1,848	1,263	1,511	241	92	4
Jambi	1,523	748	1,240	183	86	14
South Sumatra	3,271	1,501	2,492	596	145	38
Bengkulu	1,502	449	1,187	220	73	22
Lampung	2,651	1,401	2,167	407	67	10
Bangka Belitung Islands	393	348	373	16	4	-
Riau Islands	428	307	319	66	37	6
DK Jakarta	267	244	265	1	-	1
West Java	5,952	4,601	5,517	404	26	5
Central Java	8,562	4,642	7,765	735	57	5
Yogyakarta	438	348	382	49	6	1
East Java	8,495	4,826	7,597	777	104	17
Banten	1,549	1,106	1,225	289	33	2
Bali	716	575	660	53	3	-
West Nusa Tenggara	1,150	917	1,053	79	13	5
East Nusa Tenggara	3,378	1,087	2,030	803	373	172
West Kalimantan	1,958	959	948	448	304	258
Central Kalimantan	1,407	554	635	341	293	138
South Kalimantan	1,973	862	1,496	380	84	13
East Kalimantan	997	638	713	159	78	47
North Kalimantan	459	216	227	35	76	121
North Sulawesi	1,799	703	1,542	156	58	43
Central Sulawesi	1,871	706	1,466	197	114	94
South Sulawesi	2,977	1,682	2,527	335	65	50
Southeast Sulawesi	2,231	625	1,717	330	84	100
Gorontalo	726	302	605	72	33	16
West Sulawesi	554	235	356	80	44	74
Maluku	1,156	583	800	100	60	196
North Maluku	1,138	435	681	149	121	187
West Papua	1,433	432	934	135	93	271
Papua	2,456	609	930	228	360	938
Indonesia	78,938	39,062	61,926	10,416	3,551	3,045

Source: PODES (2021), processed.

4.4. Evaluating Farmers' Readiness

4.4.1. Average Age of Farmers in Indonesia

Table 6 provides an overview of the population, number of farmers, and the average age of farmers across various provinces in Indonesia, highlighting significant aspects of the agricultural workforce in the country. Indonesia has a total population of approximately 276.8 million people, with around 42.2 million engaged in farming, which highlights the significant role of agriculture in the country's economy. Provinces with large populations, such as West Java, Central Java, and East Java, also have the highest number of farmers, indicating a strong agricultural base in these regions. East Java leads with about 7.7 million farmers, followed by Central Java with 5.7 million, and West Java with 4.3 million.

The average age of farmers in Indonesia is 47 years, indicating an aging workforce in the agricultural sector. This raises challenges regarding the sustainability of the labor force in the sector, especially in terms of adopting digital technology. Older farmers, particularly in provinces with higher average ages, such as Yogyakarta (57 years) and Central Java (52 years), tend to be less familiar with and more reluctant to adapt to new technologies. Digital transformation in agriculture, such as the use of data-driven applications, Internet of Things (IoT), and automation tools, requires good digital literacy. With the older age of farmers, the adoption of technology may be hindered by limited understanding and a lack of technical skills.

Papua has the youngest average farmer age at 38 years, suggesting

that the agricultural workforce in this region is relatively younger compared to the national average. Similarly, West Papua and East Nusa Tenggara also have younger farmers, with average ages of 41 and 43 years, respectively. These regions have great potential to lead in the adoption of digital agricultural technologies. Younger farmers are generally more adaptable to new technologies, which can enhance productivity and efficiency in farming. By integrating technologies such as drones for land mapping, sensors for monitoring crop conditions, and digital platforms for marketing, the younger generation can transform farming practices to be more modern and sustainable.

There are clear regional disparities in the number of farmers and their ages, reflecting different agricultural dynamics across Indonesia. Provinces with a high number of farmers but an older workforce, such as East Java, face the dual challenge of maintaining agricultural productivity while preparing for generational shifts. In contrast, regions with younger farmers, like Papua, have opportunities to innovate and sustain agricultural activities in the long term.

The aging farming population highlights the importance of initiatives to attract younger generations to agriculture through training, technology integration, and support programs. Ensuring the sustainability of Indonesia's agricultural sector will require addressing these demographic challenges to enhance productivity and secure food security for the future. Overall, the data emphasizes the critical role of agriculture in Indonesia and the urgent need to support the sector's workforce, particularly in regions with an older farming population.

〈Table 1-6〉 Characteristic of Farmers

Province	Population	Number of Farmers	Average Age
Aceh	5,582,184	1,043,997	44
North Sumatra	15,219,996	2,636,707	44
West Sumatra	5,723,121	1,005,464	46
Riau	7,267,255	1,230,501	43
Jambi	3,704,372	828,209	45
South Sumatra	8,877,552	1,960,058	44
Bengkulu	2,054,218	520,968	45
Lampung	8,736,562	2,032,994	45
Bangka Belitung Islands	1,520,110	188,395	45
Riau Islands	2,503,105	96,649	46
DK Jakarta	10,759,455	36,739	44
West Java	51,039,000	4,345,267	50
Central Java	35,216,579	5,688,731	52
DI Yogyakarta	4,060,892	463,638	57
East Java	40,484,793	7,737,009	51
Banten	13,383,057	781,058	51
Bali	4,557,870	534,355	51
West Nusa Tenggara	5,423,409	1,207,871	44
East Nusa Tenggara	5,718,108	1,482,081	43
West Kalimantan	5,262,450	1,224,313	43
Central Kalimantan	2,783,881	545,619	43
South Kalimantan	4,408,243	667,895	46
East Kalimantan	3,785,055	370,734	46
North Kalimantan	743,689	117,965	44
North Sulawesi	2,560,820	290,375	48
Central Sulawesi	3,188,520	647,843	44
South Sulawesi	9,071,061	1,566,998	45
Southeast Sulawesi	2,812,474	408,130	46
Gorontalo	1,212,450	207,157	45
West Sulawesi	1,428,679	326,030	43
Maluku	1,837,568	277,159	45
North Maluku	1,297,642	170,586	44
West Papua	1,048,833	188,091	41
Papua	3,516,451	1,391,905	38
Indonesia	276,789,454	42,221,491	47

Source: SUSENAS March (2023), processed.

4.4.2. Education Level of Farmers in Indonesia

〈Table 1-7〉 provides an overview of the educational level of farmers across various provinces in Indonesia, categorized into those who did not complete elementary school, elementary school graduates, junior high school graduates, senior high school graduates, and those with diploma or university education. The data highlights the educational background of the agricultural workforce, which has important implications for digital transformation in the sector.

The majority of Indonesian farmers have relatively low educational attainment, with a significant number only completing elementary school. Nationwide, about 15.8 million farmers (37.41%) have elementary school education, and around 10 million farmers (23.72%) did not complete elementary school. Provinces like Central Java, East Java, and West Java have the highest number of farmers with low educational levels, reflecting the broader trend across the country.

The low educational levels among farmers pose a substantial challenge for the adoption of digital technologies in agriculture. Farmers with limited education may struggle with digital literacy, making it difficult for them to effectively use advanced tools like smartphones, agricultural apps, IoT devices, and data-driven decision support systems. For instance, provinces such as Central Java and East Java, which have a high number of farmers with elementary or lower education, may face significant barriers in embracing digital transformation fully.

However, there is also a notable number of farmers with higher education, including 7.6 million (18.02%) who completed senior high

school and over 1.2 million (2.87%) with diplomas or university degrees. These farmers represent an important demographic that could lead the way in adopting digital technologies. Provinces like Jakarta, Yogyakarta, and Bali, which have relatively higher numbers of educated farmers, are better positioned to leverage digital tools in agriculture.

To harness the potential of digital transformation in agriculture, targeted educational and training programs are essential. Efforts should focus on improving digital literacy among farmers, particularly those with lower educational backgrounds, to enable them to access and utilize digital technologies. Training programs that simplify technology use, provide hands-on experience, and highlight the direct benefits of digital tools can help bridge the gap.

Government policies and support systems play a crucial role in promoting digital transformation among farmers. Providing access to affordable digital tools, enhancing connectivity in rural areas, and offering subsidies or incentives for digital adoption can significantly improve the readiness of the agricultural workforce. Collaboration between government, private sector, and educational institutions can create a comprehensive approach to empower farmers with the necessary skills.

In conclusion, while the current educational profile of Indonesian farmers presents challenges to the widespread adoption of digital technologies, it also highlights key opportunities. By investing in education, training, and support systems, Indonesia can drive digital transformation in agriculture, enhancing productivity, sustainability, and the overall resilience of the sector.

〈Table 1-7〉 Education Level of Farmers

Province	Number of Farmers by Education Level (People)				
	Did Not Complete Elementary School	Elementary School Equivalent	Junior High School Equivalent	Senior High School Equivalent	Diploma/ University
Aceh	148,505	296,812	249,115	287,585	61,980
North Sumatra	387,348	642,320	560,236	938,306	108,497
West Sumatra	245,545	297,562	192,261	229,829	40,267
Riau	182,983	401,059	248,241	336,874	61,344
Jambi	112,766	310,126	185,051	196,106	24,160
South Sumatra	363,920	741,693	385,019	423,260	46,166
Bengkulu	99,775	173,895	104,549	122,187	20,562
Lampung	367,803	651,524	506,527	458,945	48,195
Bangka Belitung Islands	50,196	66,388	26,320	40,948	4,543
Riau Islands	24,822	40,828	10,766	18,777	1,456
DK Jakarta	4,534	5,191	6,356	11,468	9,190
West Java	759,549	2,403,439	609,646	493,825	78,808
Central Java	1,600,536	2,361,537	918,846	699,798	108,014
DI Yogyakarta	161,642	135,805	75,226	76,007	14,958
East Java	2,128,960	2,964,033	1,323,848	1,128,484	191,684
Banten	193,005	422,829	77,794	80,053	7,377
Bali	135,887	177,793	92,085	103,158	25,432
West Nusa Tenggara	334,053	379,399	236,218	223,337	34,864
East Nusa Tenggara	416,970	597,978	230,195	185,537	51,401
West Kalimantan	357,964	432,978	211,597	191,939	29,835
Central Kalimantan	82,727	219,130	128,636	94,026	21,100
South Kalimantan	147,072	284,477	116,937	100,665	18,744
East Kalimantan	48,031	138,042	80,092	94,912	9,657
North Kalimantan	23,832	38,670	25,427	25,812	4,224
North Sulawesi	53,526	91,672	67,339	68,746	9,092
Central Sulawesi	97,164	267,981	142,916	114,084	25,698
South Sulawesi	403,541	496,357	283,457	334,050	49,593
Southeast Sulawesi	85,065	144,334	89,893	69,597	19,241
Gorontalo	87,660	66,069	26,678	22,012	4,738
West Sulawesi	93,581	107,915	41,197	64,877	18,460
Maluku	37,926	100,104	64,438	63,258	11,433
North Maluku	32,941	62,334	33,342	36,041	5,928
West Papua	44,777	48,708	37,303	45,536	11,767
Papua	700,664	224,439	204,505	229,776	32,521
Indonesia	10,015,270	15,793,421	7,592,056	7,609,815	1,210,929

Source: SUSENAS March (2023), processed.

4.4.3. Literacy and Digital Access Characteristics of Farmers

〈Table 1-8〉 provides data on the literacy levels, mobile phone ownership, and internet access among farmers in various provinces in Indonesia. It highlights critical aspects of digital accessibility within the agricultural sector, which plays a significant role in the broader context of digital transformation. The data shows that approximately 2.9 million farmers in Indonesia cannot read, with the highest numbers in East Java (857,500), Central Java (563,733), and West Nusa Tenggara (199,140). The presence of a large number of illiterate farmers presents a significant challenge to digital transformation in agriculture. Literacy is a fundamental barrier to accessing and effectively using digital tools, such as smartphones and internet-based applications that can improve farming practices and productivity.

Despite literacy challenges, a considerable number of farmers own mobile phones, with nearly 22.9 million farmers across Indonesia having access to these devices. Provinces like East Java (3.7 million), Central Java (2.5 million), and West Java (2.0 million) have the highest mobile phone ownership among farmers. This high level of mobile penetration indicates a substantial opportunity to leverage mobile technology for digital transformation initiatives in agriculture, such as providing market information, weather updates, and access to agricultural services through mobile platforms. As noted earlier, Tables 3 and 4 highlight an increasing dependence on the internet for various activities such as communication, accessing information, online shopping, and financial transactions. Currently, the majority of mobile phone usage among farmers does not yet involve the adoption of technology.

Access to the internet is relatively high among farmers, with approximately 18.8 million farmers using the internet across Indonesia. East Java leads with over 3.1 million internet users among farmers, followed by Central Java with 2.3 million, and West Java with 1.7 million. Internet access enables farmers to connect to valuable resources, including e-commerce platforms, online education, and digital farming solutions that can significantly enhance agricultural productivity and market reach.

The data reflects both the challenges and opportunities for digital transformation in the agricultural sector. On the one hand, high mobile phone ownership and internet access among farmers present a strong foundation for implementing digital solutions. On the other hand, the significant number of illiterate farmers suggests that digital literacy programs are urgently needed to ensure that these technologies are accessible and beneficial to all farmers, regardless of their education level.

To effectively bridge the digital divide, targeted interventions are necessary, including basic digital literacy training, the development of user-friendly digital tools that cater to farmers with lower literacy levels, and the promotion of audio-visual content that can bypass reading barriers. Digital transformation efforts must consider the unique needs of these farmers to ensure inclusivity and maximize the impact of digital solutions.

Supportive policies and programs that focus on improving connectivity in rural areas, providing affordable digital tools, and facilitating farmer training are essential to drive the adoption of digital technologies in agriculture. Collaboration between the government, private sector, and non-governmental organizations can help create an

enabling environment for digital transformation, ultimately enhancing the livelihoods of millions of farmers across Indonesia.

Overall, the data underscores the critical need to address literacy and connectivity barriers to fully realize the benefits of digital transformation in agriculture. By empowering farmers with the necessary skills and access, Indonesia can foster a more resilient, efficient, and sustainable agricultural sector.

〈Table 1-8〉 Literacy and Digital Access Characteristics of Farmers

Province	Numbers of Farmers (People)		
	Cannot Read	Owns a Mobile Phone	Accesses the Internet
Aceh	24,099	682,391	486,204
North Sumatra	30,121	1,841,922	1,564,145
West Sumatra	7,162	656,710	501,752
Riau	11,207	1,016,521	805,403
Jambi	16,609	587,732	466,165
South Sumatra	23,989	1,264,475	983,957
Bengkulu	11,078	321,235	252,198
Lampung	54,130	1,334,374	1,193,170
Bangka Belitung Islands	4,590	131,615	100,830
Riau Islands	2,432	76,330	54,882
DK Jakarta	0	32,759	31,413
West Java	125,760	2,008,865	1,728,531
Central Java	563,733	2,455,111	2,385,694
DI Yogyakarta	56,801	174,864	194,957
East Java	857,500	3,685,946	3,113,684
Banten	34,305	311,789	235,410
Bali	48,372	285,227	226,220
West Nusa Tenggara	199,140	685,927	523,924
East Nusa Tenggara	98,157	701,909	508,914
West Kalimantan	84,945	719,781	614,086
Central Kalimantan	2,993	392,011	331,305
South Kalimantan	11,542	397,143	351,740

(continued)

Province	Numbers of Farmers (People)		
	Cannot Read	Owns a Mobile Phone	Accesses the Internet
East Kalimantan	6,014	308,828	242,048
North Kalimantan	4,318	94,320	74,549
North Sulawesi	1,058	161,357	111,090
Central Sulawesi	16,589	350,698	259,654
South Sulawesi	156,385	1,015,738	741,087
Southeast Sulawesi	27,017	283,192	180,708
Gorontalo	5,356	110,948	76,508
West Sulawesi	28,343	193,646	151,822
Maluku	3,273	150,916	93,677
North Maluku	2,076	96,060	60,319
West Papua	9,763	108,920	77,214
Papua	375,258	309,376	113,444
Indonesia	2,904,115	22,948,636	18,836,704

Source: SUSENAS March (2023), processed.

4.5. Identification of International Cooperation Needs

Identification of challenges and gaps in meeting strategic goals is important for the furtherance of digital transformation in agriculture. Among the most common obstacles are lack of access to proper digital infrastructure, lack of technical support, and the requirement of capacity building among farmers. Obstacles and challenges of this sort indicate where international cooperation may be possible. International partners can bring resourceful collaboration, best practices, and important technological solutions to overcome such barriers. Some possible areas for international collaboration include developing digital infrastructure, improving training programs, and creating platforms for knowledge exchange. These partnerships can be

instrumental in setting the stage for more efficacious and inclusive digital transformation, eventually leading to sustainable agricultural development on a global scale. A summary of the international cooperation needs is contained in the 〈Table 1-9〉.

〈Table 1-9〉 International Cooperation Needs

No	Challenges and gaps	Specific goal(s) from the assistantship	Sub-theme	Potential collaborating parties
1	Provision of renewable energy in rural areas for enhancing agricultural sector and attractiveness of rural areas	Exploration of renewable energy resources to support food production	Demonstration the effectivity of micro grid renewable energy for triggering automatic or remotely controlled sensors for mitigating bird, grasshopper and rats' infestation	KLES, SPSA
			Demonstration of full scale agriphotovoltaic systems as a driving force for attractive rural agriculture and rural aquaculture	Envelops, KLES, Kyungpook National University, DSSLR, SB
			Research on the planting strategies under agriphotovoltaic systems	Seoul National University, DSSLR
			Demonstration of environmentally friendly greenhouses or plant factories for high-valued horticulture	Gyeongsang National University, N.Thing, DSSLR
			Research on business models for controlled environment agriculture (CEA)	KDI School of Public Policy and Management, SB
			Development of Smart Village	Hanyang University, SB, FEM, DSSLR
			Advancing Rural Training Center (ARTC) as a show case for all visitors (especially farmers) to gain some insight and hands on experience. Proposed site is DSSLR for the showcase and Jasinga Field Station (~15 Ha) for hands on training of the development of marginal lands	KLES, Envelops, N.Thing, Infoworks, KAIST, DSSLR, SB

(continued)

No	Challenges and gaps	Specific goal(s) from the assistantship	Sub-theme	Potential collaborating parties
2	Supports for telecommunicatio n gap	Achieving stability of signal reception	Wide range WiFi extender, powered by renewable energy sources	KAIST, SPSA
3	Data capture and farmers' assistantships	Joint research and development on the effective strategies for local data capture, storage, recommendation and policy making	Remote assistantship platforms for farmers, similar to halodoc, for pest and disease and soil health	Kangwon National University, SPSA, DPP
			Market reviewer for agricultural produces	Seoul National University, SB, SPSA
			Research and Development of affordable environmental sensors and their networks	KAIST, DSSLR, SPSA
			Design and development of soil-related information systems and platforms for public use	Rural Development Administration, KAIST, DSSLR
			Agricultural databank for food crops	Seoul National University, SPSA, DSSLR
4	Impact of digital transformation in the perspectives of household income, local government and culture	Investigate advantages and shortcomings in the development of small, medium and large scale digital transformation	Multi-years research on the impact of digital transformation on the livelihood, behavior and culture	KDI School of Public Policy and Management, SB, FEM
			Research on knowledge exchange and peer-to-peer learning among stakeholders in agriculture and aquaculture	Seoul National University, SB, FEM
			Multi-years research on ruralization within the context of spatial planning and policy making	Rural Development Administration, KDI School of Public Policy and Management, SB, DSSLR, FEM

Source: Written by author.

Abbreviations: SB – School of Business; DSSLR – Department of Soil Science and Land Resources; SPSA – Study Program of Smart Agriculture; FEM – Faculty of Economics and Management; DPP – Department of Plant Protection (all of IPB)

4.6. CONCLUDING REMARKS

The potential of digital technologies such as IoT, AI, and mobile-based applications in the study can focus on improving farming practices through data-driven insights in optimizing resource use while reducing environmental impacts. These technologies can help farmers make more informed decisions, directly supporting the study's objective of boosting agricultural productivity.

The data reveals significant barriers, such as low digital literacy and varying levels of internet access, which affect farmers' ability to adopt digital tools. Addressing these barriers through targeted training and improved access to technology aligns with the study's goal of enhancing farmers' livelihoods by enabling them to leverage digital solutions for better market access, price information, and crop management.

The study identifies the digital divide, educational disparities, and infrastructural gaps as key structural challenges within the agricultural sector. The findings suggest that bridging these gaps through supportive policies, infrastructure investment, and inclusive digital literacy programs is essential to achieve the transformation objectives. This directly addresses the study's aim to identify and propose solutions to the structural obstacles hindering digital adoption.

Addressing these challenges requires a collaborative approach involving the government, private sector, and educational institutions. Investment in digital infrastructure, training programs to enhance farmers' digital skills, and supportive policies are essential to bridge

the existing digital divide. By embracing these strategies, Indonesia can fully harness the potential of digital transformation in agriculture, leading to a more competitive, sustainable, and resilient sector that supports the livelihoods of millions of farmers and contributes to the nation's food security and economic growth.

2 Philippines[2)]

1. Overview of Digital Transformation in the Philippine Agriculture

1.1. Definition

In the Philippines, a clear definition of digitalization is lacking both in the policy and technological context. In most instances, it is assumed that the reader already knows the meaning of digitalization and proceeds to describe what programs or initiatives are generated in digitalization. The National Agriculture and Fisheries Modernization and

2) This chapter is written based on the report written and submitted by Edgar Allan Po internal data (2024) titled "Digital Transformation in the Agricultural Sector of the Philippines".

Industrialization Plan 2021-2030 (NAFMIP) did manage to offer a definition: "Digitalization refers to enabling or improving processes by leveraging digital technologies and digitized data, while digital transformation is business transformation enabled by digitalization (Gupta, 2020). Another definition adapted from the World Digital Competitiveness Ranking (IMD, 2023) defines digitalization as the capacity and readiness to adopt and explore digital technologies as a critical driver for the economic transformation of various sectors (IMD, 2023). Agricultural digital transformation in the Philippines integrates digital technologies into farming practices and the entire value chain. These technologies, including ICT (Information and Communication Technologies) tools, data analytics, and precision farming techniques, enable informed decision-making with real-time or near-real-time information. This underscores the necessity and significance of these initiatives in the context of Philippine agricultural digital transformation.

Digital transformation, encompassing the integration of digital technology into all areas of agriculture, is fundamentally reshaping the agricultural landscape in the Philippines. This initiative aims to enhance productivity, optimize sustainability, improve market access, and foster inclusion within the sector. Digitalization becomes critical for modernization and resilience as the farming industry faces significant challenges such as rural poverty, limited access to resources, and climate change impacts.

1.2. Scope of Digital Transformation in the Philippine Agriculture

The digital transformation in agriculture encompasses the entire agricultural value chain, from production to consumption. Different digital tools and technologies are utilized as agricultural products are produced at the farm, and when they leave the farm, they pass through different nodes of the value chain en route to reaching consumers.

Digital transformation in the agricultural sector includes various innovative technologies and practices that revolutionize traditional farming methods. Among the key components are precision agriculture, the Internet of Things (IoT), data analytics, drones, artificial intelligence (AI), and mobile applications. Precision agriculture leverages data-driven approaches to optimize resource usage. By employing technologies such as GPS-guided equipment, farmers can apply fertilizers, water, and pesticides more efficiently, targeting specific areas that need attention. This practice reduces waste, lowers costs, and enhances crop yields (Cropin, Accessed date: 2024. 8. 1.; Trace X, Accessed date: 2024. 8. 1.). IoT technology is pivotal in modern agriculture because it connects farming equipment and sensors to collect real-time data. This connectivity allows farmers to remotely monitor soil moisture, weather conditions, and crop health, enabling timely decision-making and interventions 9. Data analytics aggregates information from various sources, providing insights into market trends, crop performance, and resource management. This technology helps farmers engage in proactive planning and enhances their ability to respond to market demands,

thereby fostering better profitability (Briones et al, 2023; Trace X, Accessed date: 2024. 8. 1.). Drones are increasingly utilized for crop monitoring, irrigation management, and pest control. They offer a bird's-eye view of fields, enabling farmers to detect issues early and take remedial actions without extensive labor. Mobile apps and online platforms provide farmers with timely information and advice, direct connection with consumers and markets through online platforms to improve market access, and digital financial services (such as mobile banking and digital payment systems) to enhance financial inclusion for farmers. These platforms offer features such as real-time weather updates, market prices, and agricultural advice, thus improving the interchangeability of the agricultural supply chain (PIDS, Accessed date: 2024. 8. 1.). Farmer and farm profile databases enable the government to have spatial-based planning and deployment of intervention capability. Satellite imagery can be used for land use monitoring, damage assessment during calamities, and fact-based crop insurance payout.

1.3. Strategic Importance of Digital Transformation

The strategic importance of digital transformation in the agricultural sector of the Philippines cannot be overstated. Here are key areas where its impact is most significant:

1.3.1. Enhancing Productivity

Digital tools allow farmers to make data-driven decisions in real-time, resulting in more efficient agricultural practices. Increased productivity benefits individual farmers and supports national food security, as agriculture contributes significantly to the economy (Trace X, Accessed date: 2024. 8. 1.; PIDS, Accessed date: 2024. 8. 1.).

1.3.2. Promoting Sustainability

Digital transformation supports environmentally sustainable practices through efficient resource management and reduced reliance on chemical inputs—precision farming techniques lower agriculture's environmental footprint, fostering cleaner production processes (Cropin, Accessed date: 2024. 8. 1.; Open Gov a, Accessed date: 2024. 8. 1.).

1.3.3. Improving Market Access

Digital platforms provide farmers with direct access to markets, facilitating fairer pricing and ensuring that produce reaches consumers without intermediaries, which can erode profits. These platforms help integrate smallholder farmers into the broader value chain, increasing their competitiveness in the market (Trace X, Accessed date: 2024. 8. 1.).

1.3.4. Bridging the Digital Divide

The agricultural sector can empower marginalized communities by promoting digital literacy and technology access. This inclusivity uplifts these farmers economically and contributes to sustainable development goals addressing poverty and inequality (PIDS, Accessed date: 2024. 8. 1.).

1.3.5. Resilience to Climate Change

Digital tools enhance farmers' capacity to adapt to changing climate conditions by providing insights into weather patterns and enabling them to adopt appropriate interventions. Such resilience is critical for sustaining agricultural productivity and ensuring food security in the face of environmental challenges (Trace X, Accessed date: 2024. 8. 1.; Open Gov a, Accessed date: 2024. 8. 1.).

The digital transformation of the agricultural sector in the Philippines is not merely a trend but an essential evolution necessary to address the industry's multifaceted challenges. As farmers gain access to advanced technologies and data-driven insights, they can optimize their operations, enhance production efficiency, and ensure sustainable practices. The strategic integration of digital tools not only promises economic growth for farmers but also lays a strong foundation for the future of agriculture in the country, ultimately contributing to a more resilient and food-secure nation. The continued focus on digitalization will thus play a pivotal role in shaping the trajectory of the agricultural sector in the Philippines for years to come.

2. National and Agricultural Digital Transformation Policies

The Philippines actively pursues digital transformation strategies to enhance socioeconomic development across various agricultural sectors. This review examines the national policies guiding this transformation, particularly assessing their alignment with the agricultural sector's needs.

2.1. National Policies on Digital Transformation

The Philippine government has developed a robust framework to support digital transformation through several key policies as below.

2.1.1. Philippine Development Plan (PDP) 2023-2028

This plan sets the long-term vision for the country's development, emphasizing the importance of digital technology in improving governance and service delivery. It aims to enhance digital transactions, improve online government services, and foster an inclusive and resilient digital economy (Tsang, 2024).

2.1.2. Utilization of international funding stream on digitalization

The Philippines availed Digital Transformation Development Policy Loan (DPL) from the World Bank worth US$600 million to support reforms aimed at increasing digitalization (Open Gov b, Accessed date: 2024. 8. 1.; Philippines: AIIB, Accessed date: 2024. 8. 1.). The Department of Agriculture is not part of the implementation. The enhancement of digital infrastructure, endorsed and supported by the Development Policy Loan (DPL), has the potential to advance the adoption and utilization of precision farming technologies significantly. These technologies include, but are not limited to, unmanned aerial vehicles (drones) and Global Positioning System (GPS) units. Farmers can achieve a high degree of optimization in various farming operations by integrating these sophisticated tools into agricultural practices. Specifically, drones can be employed for aerial surveillance of crops, enabling real-time monitoring of plant health, soil conditions, and pest infestations. GPS systems can facilitate precise navigation and operation of farming machinery, ensuring accurate planting, fertilization, and harvesting.

Consequently, deploying such precision farming methodologies can lead to substantial improvements in crop management, efficiency, and overall agricultural productivity, resulting in increased crop yields and enhanced economic outcomes for the agricultural sector.

2.1.3. e-Government Master Plan (EGMP) 2022

This plan lays out the building blocks and strategies for developing the country's e-government systems through the digital transformation of basic services that cut across the whole government (Department of Information and Communications Technology, 2019). The EGMP aims to establish a unified government information system through digitization. It focuses on making government services more efficient and accessible, promoting transparency and accountability (Tsang, 2024).

These policies illustrate a commitment to integrating digital technologies into governance and public service delivery. They address the broader needs of economic development while recognizing the critical role of digitalization in enhancing government efficiency.

2.2. Strategies for Digital Transformation in Agriculture

Specific strategies have been outlined to foster the digital transformation of the agricultural sector as specified below.

2.2.1. Developing a Digital Roadmap for Agriculture

The Philippine Agriculture roadmap should promote inclusive development in farming and fishing villages, aiming to double smallholder incomes within five years by enhancing productivity, profitability, competitiveness, sustainability, and resilience. The

formulation should involve smallholder farmers, fisherfolk, local government units, SUCs (State Universities and Colleges), civil society, and the private sector to ensure equitable economic growth. A value-chain approach is essential for fair earnings. The Department of Agriculture should lead, engaging the private sector for expertise and funding (Blogspot, Accessed date:2024. 8. 1.). There is no publicly available information indicating the actual publication of this strategy.

2.2.2. Rural Connectivity Investments

The Philippines invests heavily in its digital infrastructure to meet rising connectivity demands, especially in remote areas. Efforts include expanding broadband networks, mobile connectivity, and ICT infrastructure. A key initiative is the National Broadband Plan (NBP) by the Department of Information and Communications Technology (DICT) to bridge the digital divide and promote digital inclusion. Also, under the NBP is the Broadband ng Masa (BBM) project, which aims to provide internet access to Geographically Isolated and Disadvantaged Areas (GIDA) by installing free Wi-Fi in key locations like schools (Manila Bulletin, 2023. 11. 30.). Addressing the digital divide among farmers due to factors like age, education, assets, and rural connectivity can be achieved through community organizing, rental markets, extension services, and investments in connectivity. In rural Philippines, solutions include large farmer-owned enterprises, shared facilities, fee-for-service equipment, technician visits, and public-private-farmer partnerships (Briones et al., 2023).

2.2.3. ONE DA – A Holistic Approach to Agriculture and Fisheries Transformation

This approach originally comprises 12 essential strategies to 'Grow' Agriculture in 2021 and beyond. It has now expanded to 18 strategies. The vision is a food-secure Philippines where farmers and fishers thrive. It aims to empower them, unite their efforts, and draw in private investments to boost agriculture's efficiency and sustainability. The main goals are plentiful harvests and high incomes for everyone involved. One of the strategies is to embrace digital agriculture by accelerating the completion of the National Farmers and Fishers Registry System, expanding e-Kadiwa to connect farmers directly with consumers, and creating publicly managed electronic marketplaces. Adopt service-based models for transporting perishable goods, leverage satellite technology to enhance crop insurance and damage estimates, and utilize the Philippine Rice Information System (PriSM) for efficient rice production management and extend its benefits to other crops (Dar, 2021).

2.2.4. Smart Technologies for Sustainable Agriculture, Smart Initiatives, and Strategic Approach towards Agricultural Innovation

The Department of Science and Technology's strategy involves funding a variety of initiatives that use ICT tools and technologies to develop interventions for specific problems in agriculture (DOST-PCAARRD, Accessed date: 2024. 8. 1.).

2.2.5. Philippine Development Plan (PDP) 2023-2028 (agriculture section)

The administration's Philippine Development Plan (PDP) 2023-2028 aims to reduce poverty to a single digit and elevate the nation to an upper-middle-income economy via an 8-Point Socioeconomic Agenda. This agenda targets immediate and medium-term growth constraints, focusing on enhancing agriculture, forestry, and fisheries through improved production efficiency, market access, value chain resilience, and institutional strength. The government will optimize physical and digital infrastructure investments, leveraging tools such as the Agricultural and Biosystems Engineering Management Information System and the GEOAGRI Portal. Key initiatives include upgrading transport and logistics for perishable goods, implementing cold chain technology, establishing green ports, incorporating advanced information systems, and promoting mobile and web-based platforms for farmers and fisherfolk. The Department of Agriculture will further digitalization efforts with projects like the National Farmers and Fisherfolk Registry System and the Agribusiness Portal. The Philippine Crop Insurance Corporation will introduce index- and weather-based insurance schemes and enhance digital insurance programs to expedite transactions and payments (National Economic and Development Authority, 2023).

2.3. Policies and Strategies Aligned with Agricultural Needs

The national policies and strategies reveal a conscious effort to align with the specific needs of the agricultural sector as specified below.

2.3.1. Enhancing Productivity

Integrating digital technologies is crucial for improving agricultural productivity through precision farming and real-time (or near-real-time) monitoring. By investing in digital tools, the government supports farmers in making informed decisions, thereby increasing yields (Trace X, Accessed date: 2024. 8. 1.; Mabalay et al., 2022). Enhancing Philippine agriculture and agribusiness productivity involves addressing various challenges identified in the Philippine Development Plan (PDP). Strategies include diversifying farm and non-farm income, consolidating farms, adopting improved technology, and improving access to production requirements like land, water, and credit. Additionally, creating opportunities for primary producers to participate in value-adding activities, improving infrastructure, and protecting local agriculture against unfair competition are key policy measures to enhance productivity (Briones et al., 2023).

2.3.2. Addressing the Digital Divide

Current strategies recognize the challenges of unequal access to digital resources and aim to enhance connectivity for underserved regions. This alignment is essential for ensuring that all farmers can

participate in the digital economy (Tsang, 2024; Open Gov c, Accessed date: 2024. 8. 1.). However, the challenges small-scale farmers face in adopting agricultural automation and digital technologies include low levels of digital literacy, especially in rural areas, inadequate infrastructure like limited connectivity, lack of electricity access, and financial limitations. Asset endowments are correlated with the early adoption of ICT, indicating that farmers with more resources tend to adopt technology sooner. Additionally, smallholder farmers generally have low ICT literacy, with better-educated and younger farmers showing higher levels of ICT literacy (Briones et al., 2023).

2.3.3. Promoting Financial Inclusion

The DPL and other strategic frameworks emphasize expanding financial services through digital platforms. This focus is particularly relevant for small farmers, who often lack access to credit and banking services that enable technology adoption and growth (Tsang, 2024; Open Gov c, Accessed date: 2024. 8. 1.). The utilization of a crowd-funding platform has been used as a solution to the lack of capital for agricultural ventures by various funders. Existing regulations from the Securities and Exchange Commission under Memorandum Circular (MC) No. 14 (Series of 2019): Rules and Regulations Governing Crowd-funding govern the dynamics of this inclusion mechanism. Existing private sector initiatives came up with a comprehensive profile of farmers and developed a credit scoring service to mitigate risk. In addition, partnership with PhilGuarantee and PCIC to further mitigate risk (Briones et al., 2023).

2.3.4. Supporting Market Access

Policies aiming to increase the use of digital platforms for transactions directly address the market access challenges faced by smallholder farmers. Farmers can command better prices for their produce by facilitating connections to markets, thus enhancing their economic viability (Tsang, 2024; Trace X, Accessed date: 2024. 8. 1.). The Philippine government's policies and strategies regarding establishing digital markets like e-Kadiwa are geared towards the particular needs of farmers to access the market.

2.4. Identification of Gaps and Challenges

Despite the positive alignment between national policies and the agricultural sector's needs, several gaps and challenges persist:

2.4.1. Digital Literacy and Skills Gap

Many farmers (due to age, education, assets, and rural connectivity, among others) lack the skills to utilize digital technologies effectively. Initiatives to enhance digital literacy are still in their infancy, limiting the benefits of technological investments (Tsang, 2024). Some notable observations from telcos (telecommunication companies) state, "Digitalization is widening the gap in agriculture because farmers are aging and not so open to new technologies". There are many applications designed for agriculture, but adoption, subsequent utilization, and monetization are challenges based on anecdotal evidence from the Agricultural Training Institute of the Department of Agriculture (Project Rebound, Accessed date: 2024. 8. 1.).

2.4.2. High Upfront Costs and Affordability Issues

Adopting advanced technologies can be prohibitive for small farmers. Targeted financial support and subsidies are needed to alleviate these costs and make digital tools more accessible (Project Rebound, Accessed date: 2024. 8. 1.). Utilizing freely available remote sensing data is a possible alternative to mitigate the cost. However, processing remotely sensed data at the individual farmer level will be challenging. Another option is for a system where existing extension services with the data can be a contact point for vegetation indices (computed from remotely sensed data), for example, can be transformed into actionable recommendations, and then the recommendation is passed on to farmers. Available processed

remotely sensed data can be available between $2 to $4 a hectare (EOS Data Analytics, Accessed date: 2024. 8. 1.).

2.4.3. Interchangeability and Integration Challenges

Digital tools' varying compatibility can hinder their practical use in agriculture. A more cohesive approach to integrating different technologies is needed to ensure farmers can seamlessly adopt new systems (Tsang, 2024; Trace X, Accessed date: 2024. 8. 1.).

There has been recommendation to ensure that a single data set and advisory underpins the various decision support systems used by government in light of observations of lack of agreement about land and climate characteristics, base maps, parcel maps, and other relevant information. The government must initiate a harmonization process, first by convening regional technical working groups (TWGs), with representatives of DA, DENR, DOST, and SUCs. In addition, a single portal linked to all the online sites and apps for digital agriculture developed by the government must be established. The portal should catalog and describe each linked advisory tool to guide potential users to the most relevant for their needs. Lastly, there is a need to integrate digital solutions to standardize farm management in the DA's clustering and consolidation program based on the formation and capacity building of large cooperatives. DA must now consider digital agriculture as a technological solution to centralizing and standardizing production and management practices to optimize production within these clusters. Furthermore, to ensure economic viability and sustainability, clusters may need to cover thousands of

hectares (compared with the current 100ha guideline), all under a single cooperative. This will entail consolidating numerous small cooperatives and associations into larger groups, with an aggressive campaign of recruiting currently unorganized farmers and fisherfolk. Expanding fewer cooperatives to cover a more significant share of the farm population enables the absorption of high overhead costs from hiring professional and technical staff needed to run sophisticated management operations (Briones et al., 2023).

The national policies and strategies for digital transformation in the Philippines demonstrate a proactive approach to enhancing various sectors, particularly agriculture. While the frameworks show a strong alignment with the specific needs of the agricultural sector—such as improving productivity, ensuring financial inclusion, and bridging the digital divide—significant existing challenges must be addressed. Fostering digital literacy, reducing technology costs, and promoting interchangeability will be critical in ensuring the agricultural sector's successful realization of digital transformation goals. The collaborative efforts of government, the private sector, and communities will be essential for building a robust digital ecosystem that supports sustainable agricultural development in the Philippines.

3. Technological Applications in the Philippine Agriculture

The agricultural landscape in the Philippines is increasingly embracing digital technologies, reflecting a global trend that seeks to enhance productivity, sustainability, and efficiency within the sector. Given that agriculture constitutes a vital component of the Philippine economy—employing approximately 20% of the workforce and contributing to about 9.5% of the GDP—modernization through digital means is not just desirable but an essential move. This report provides an overview of the digital technologies currently implemented in the agricultural sector of the Philippines, examining both hardware and software solutions that are transforming traditional practices.

3.1. Hardware Digital Solutions

In recent years, various hardware innovations have emerged in the Philippine agriculture to improve farming efficiency and productivity.

3.1.1. Drones

Drones have gained significant traction as a revolutionary tool in agricultural management. They are employed for multiple applications, including crop monitoring, land mapping, and precision spraying. By providing aerial insights, drones enable farmers to assess crop health, monitor growth patterns, and identify pest outbreaks

more efficiently than traditional methods. For instance, the Albay Provincial Agricultural Office has implemented a Digital Clustered Rice Farming project utilizing drone technology over 500 hectares, modernizing rice farming practices and allowing farmers to make data-driven decisions about crop management (PIDS, Accessed date: 2024. 8. 1.).

The policy environment backs smart farming technologies. The Department of Agriculture (DA) is leading this push. For example, DA's Memorandum Order No. 16 from 2021 advocated using agricultural drones to modernize Philippine agriculture. This initiative continues under the current administration with MO No. 13 from 2023, which supports using drones for various tasks like fertilizer application, seed sowing, spraying, and topographic surveys. The policy also promotes Laser Land Levelling (LLL) as part of precision farming to aid in clustering and consolidation. Large agribusiness companies have also embraced smart farming, as they are better equipped to handle the hefty investment costs. Del Monte Philippines is a large agricultural corporation involved in pineapple production. Since 2018, it used its fleet of drones to map out over 20,000 hectares. They recently got a third-party drone equipment provider to spray pesticides and herbicides on its plantations. Other private firms integrating drones in their operations include Syngenta Philippines and Denso Philippines (Briones et al., 2023).

3.1.2. Sensors

Another critical advancement includes various sensors, including soil moisture sensors, weather stations, and nutrient analyzers. These

devices are vital in precision agriculture, as they facilitate monitoring environmental conditions essential for optimal crop growth. For instance, low-cost sensors connected to cloud-based systems help farmers accurately gauge soil moisture levels, enabling them to use water resources more efficiently and reduce waste (Syntactics, Accessed date: 2024. 8. 1.). Scientists at the Philippine Nuclear Research Institute are working on precision farming techniques for rice and corn using radioisotopes and stable isotope tracers like nitrogen-15. These methods help determine the right amount and timing for fertilizer application throughout the crops' growth stages. They also use soil moisture neutron probes to fine-tune irrigation schedules and carbon-13 and oxygen-18 isotopes to assess different irrigation techniques. Their results show that these better practices can boost fertilizer efficiency by up to 70% and improve water use efficiency by about 25% while reducing losses. These findings will help update outdated fertilizer and water use guidelines in farming (PNRI, 2024). We can consider under the category of sensors Global Navigation Satellite Systems receivers (GNSSr), which enable farmers to digitize on the field the location of their farm and thereby create a geo-referenced polygon data where other aspect of farm operations can be joined or linked. This makes farm operations partly or fully digital. In addition to creating polygons, farmers can generate point data to represent the location of infrastructures within the farm and even individual trees in an orchard, for example.

3.1.3. Internet of Things (IoT) Devices

IoT devices have further propelled the digitization of agriculture by connecting various equipment to the internet, allowing for real-time data collection and analytics. Smart irrigation systems, for example, automatically adjust water application based on soil moisture levels, significantly enhancing water use efficiency and crop yield. Additionally, devices that monitor livestock health offer farmers insights into animal behavior, enabling better management practices and improved livestock outcomes. There is not much commercial implementation of IoT except under research setup like the one funded by the Department of Science and Technology titled "Gul.ai: AI- and IoT-Assisted Small-scale Plant-growing System". The Gul.AI system is showing a lot of promise. By deploying plant box components capable of collecting data through onboard sensors, data is collected, and parameters not easily seen before - such as water pH level, relative humidity, temperature, luminance, and live imaging of the monitored area - are recorded (Open Gov d, Accessed date: 2024. 8. 1.). Most automatic weather stations used by government agencies or private farm entities can usually throw their data online and into mobile phones or computer apps.

3.2. Software Digital Solutions

In addition to hardware, software innovations are crucial in enhancing agricultural productivity in the Philippines.

3.2.1. Farm Management Software (FMS)

Farm Management Software plays a pivotal role in modernizing agricultural practices. These platforms assist farmers in managing their operations by integrating inventory management, financial tracking, and resource optimization. Tools such as the Farmers' Toolbox and various mobile applications provide farmers with valuable data and decision support, making agricultural management more efficient. An app developed by the Philippine Rice Research Institute named AgriDOCApp is free and can be downloaded to Android phones from the Google Play Store. It features simple record keeping of farm activities and expenses, which is then categorized into primary farming operations; it can do Geo-Visualization, where users can view their farms through satellite images provided by Google Maps; and Easy Task Scheduling, where tasks and reminders of their activities can be viewed. Additional features include information and knowledge links to help users make informed decisions on caring for their rice crops (PhilRice, Accessed date: 2024. 8. 1.).

3.2.2. Mobile Applications

Mobile applications link farmers and necessary information, facilitating access to agro-advisory services and market trends. Apps can offer real-time weather updates, pest management recommendations, and tips on best farming practices. For example, the Mango Pest Buster app helps farmers identify infestations and obtain tailored recommendations, ultimately reducing pesticide costs and improving yield (PIDS, Accessed date: 2024. 8. 1.).

3.2.3. Data Analytics Tools

Data analytics tools are transforming the decision-making process in agriculture. Farmers can make informed decisions regarding crop rotation, resource allocation, and pest management by analyzing collected data. These tools enable predictive analytics to forecast yields and market trends, allowing farmers to plan more effectively and increase their financial returns.

3.2.4. Blockchain Technology

Emerging technologies like blockchain are also making inroads into the agricultural sector, particularly for supply chain management. Blockchain enhances transparency and traceability, enabling farmers to track their products from farm to market. This technology can help build consumer trust by verifying the origin and quality of agricultural products, thus providing farmers access to broader markets (Bhadra et al., 2024).

3.3. Benefits of Adopting Digital Technologies

Applying these digital technologies offers significant benefits for the agricultural sector in the Philippines. A few advantages of digital adoption are enhanced productivity, improved market access, and sustainable farming practices. Precision agriculture techniques allow farmers to optimize inputs, such as water and fertilizers, which increases yields and minimizes environmental impacts (Open Gov e, Accessed date: 2024. 8. 1.).

Moreover, integrating digital tools fosters an inclusive agricultural ecosystem by providing smallholder farmers with previously inaccessible resources and connections. As the Philippine government pushes for agriculture modernization under the "OneDA Reform Agenda," the potential for digital technologies to address food security and agricultural sustainability issues becomes increasingly relevant (ITA, Accessed date: 2024. 8. 1.).

The agricultural sector in the Philippines is on the edge of a significant transformation driven by digital technologies. Both hardware and software solutions are pivotal in redefining agricultural practices, enhancing productivity, and promoting sustainable practices. As these technologies evolve and become more integrated into everyday farming operations, the potential for a more resilient and efficient agricultural landscape in the Philippines becomes apparent. To harness these benefits fully, ongoing investment in digital infrastructure, training programs, and awareness campaigns will be essential in ensuring that all farmers—especially those from vulnerable communities—can participate and benefit from this digital transformation.

4. Readiness and Adoption Challenges for Digital Transformation

The Philippine agricultural sector is poised for a digital revolution, where integrating modern technologies can enhance productivity, market access, and overall sustainability. However, the sector's readiness for digital transformation depends on several factors, notably the availability of essential infrastructure in rural areas and the farmers' readiness and willingness to adopt these digital technologies.

4.1. Infrastructure Availability in Rural Areas

The lack of reliable internet connectivity is a primary barrier prohibiting digital transformation in the rural agricultural sector. Various reports indicate that rural areas in the Philippines often struggle with poor broadband access, exacerbated by the country's geographical layout comprising over 7,100 islands. The costs of laying down internet infrastructure in these isolated regions create significant challenges (Richest Philippines, Accessed date: 2024. 8. 1.). This disparity limits communication and restricts access to crucial online resources and services supporting farming practices.

Moreover, the availability of hardware essential for implementing digital technologies remains inadequate. While some big farmers have access to crucial equipment, high-tech tools such as precision

agricultural devices, drones, and other smart farming technologies are often beyond their reach due to high costs and limited availability in rural markets (PIDS, Accessed date: 2024. 8. 1.). This lack of necessary tools poses a significant hurdle for farmers seeking to adopt digital practices effectively.

4.2. Farmers' Readiness to Adopt Digital Technologies

The willingness and readiness of farmers to adopt digital technologies is another focal point in assessing the sector's preparedness for digital transformation. While many farmers acknowledge the potential benefits of digital technologies, such as enhanced productivity and reduced costs through precision agriculture, there is a notable gap in actual adoption. Most rural farmers often lack the necessary digital literacy to use advanced tools effectively, which stifles their potential participation in the digital economy (PIDS, Accessed date: 2024. 8. 1.).

Awareness campaigns and training programs are essential to promote digital literacy among farmers. For instance, initiatives like Globe's support for the Department of Agriculture's Agricultural Training Institute have been established to provide training and connectivity support in remote areas (Globe, 2024. 8. 1.). These programs aim to empower farmers with the skills and knowledge required to leverage digital technologies effectively.

Additionally, age, education, and economic status significantly influence farmers' readiness to embrace digital agriculture. Older

farmers, in particular, may exhibit reluctance due to unfamiliarity with technology (PIDS, Accessed date: 2024. 8. 1.). In contrast, younger, non-traditional farmers display a higher propensity to adopt technological innovations, suggesting a demographic divide in the readiness for digital transformation.

Farmers are budding and willing to embrace digital transformation in agriculture despite the infrastructural challenges and varying readiness levels. Many farmers perceive the advantages of technology in enhancing crop management, accessing real-time market data, and optimizing resource use (Open Gov e, Accessed date: 2024. 8. 1.). Successful local initiatives, such as the Digital Clustered Rice Farming project in Albay, which employs satellite systems to modernize practices, inspire other farmers to follow suit (PIDS, Accessed date: 2024. 8. 1.).

However, for widespread adoption to occur, continuous government support and collaboration with private sectors to provide necessary resources and infrastructure must occur. Establishing centralized platforms for sharing information and offering digital services to farmers can facilitate a smoother transition to digital methods (PIDS, Accessed date: 2024. 8. 1.). Moreover, addressing the core issue of digital literacy through comprehensive training programs will be critical in fostering an environment conducive to change.

The Philippine agricultural sector's readiness for digital transformation is multifaceted, hinging on the availability of adequate infrastructure, as well as the readiness and willingness of farmers to adopt new technologies. While significant challenges persist,

including limited internet connectivity and hardware availability, an increasing awareness of the benefits of digital technology among farmers offers a pathway toward modernization. A concerted effort from government bodies and private sector players is essential to address these infrastructure gaps and foster a culture that embraces technology. By investing in both infrastructure and education, the Philippine agricultural sector can position itself to leverage digital tools for sustainable growth and enhanced productivity.

4.3. World Competitiveness Ranking – Philippines

One metric is not agriculture-centric but provides a perspective on the level of digitalization undertaken by Philippine society. This metric is the ranking provided by the International Institute for Management Development (IMD) World Competitiveness Center. The ranking is based on three weighted factors: knowledge, technology, and future readiness. Each factor has its corresponding sub-factor.

The Philippines' showing in the 2023 IMD World Digital Competitiveness Ranking is a bit of a mixed bag, showcasing both strides forward and areas needing work. This year, the country slipped to 59th out of 64 nations, down from 56th last year (Manila Bulletin, 2023. 11. 30.). This drop points to several areas where improvements are needed to boost digital competitiveness. On the factor of knowledge, which looks at talent, training, and scientific focus, the Philippines bumped to 62nd from 63rd. This shows some progress in

building skills and education for a digital economy. The country is still behind many others, highlighting the need for better investment in education and training to create a more digitally astute workforce. There is a positive trend from the technology factor, which looks at technological framework, regulations, and capital. The Philippines jumped from 54th to 49th. This boost highlights efforts to upgrade tech infrastructure and regulations vital for innovation and digital growth. Initiatives like the National Broadband Plan and regulatory reforms have helped drive this progress. Lastly, on readiness for the future, which measures the extent to which technology is adopted by the government, businesses, and society, the Philippines dropped to 58th from 57th. The decline in this area suggests that while the infrastructure and regulatory environment are improving, there is still a gap in the adoption and integration of digital technologies across various sectors. This gap could be due to several factors, including limited digital literacy, resistance to change, and insufficient incentives for businesses to adopt new technologies. Interestingly, these possible explanations were pointed out in the prior section of this report. The drop in rankings highlights some ongoing issues. Infrastructure is significant, especially in rural areas lacking internet access. Another critical area is education and skills development—we need a digitally literate workforce to make the most of new technologies. Plus, the country should ramp up efforts to adopt digital tools across all sectors, like agriculture, healthcare, and government services. The rankings do not occur in a vacuum, as equivalent efforts from other countries can cancel the Philippine government's

commendable steps in pushing digital transformation with initiatives to boost connectivity, improve digital skills, and foster innovation. Keeping up the investment and addressing these gaps can help the Philippines climb back up regarding digital competitiveness ranking-wise. It does not diminish that these efforts are being initiated and implemented.

The agricultural sector in the Philippines is poised for a transformation by integrating digital technologies to enhance productivity and sustainability. However, several significant challenges and gaps hinder the achievement of strategic goals in agricultural digital transformation. These challenges necessitate robust international cooperation to ensure that vulnerable farmers are not left behind and the full potential of digital agriculture is realized.

4.4. Challenges for Digital Transformation in Agriculture

4.4.1. Low Levels of Farm Mechanization

One of the most pressing challenges in the Philippine agricultural sector is the low level of mechanization. Many farmers continue relying on traditional farming practices, significantly limiting productivity and efficiency. The lack of access to modern machinery not only affects output but also perpetuates the cycle of poverty existing among smallholder farmers. Embracing mechanized farming can lead to better yields and reduce labor costs, but the initial investment poses a barrier for many (Trace X, Accessed date: 2024. 8. 1.).

4.4.2. Lack of Access to Technology

Limited access to technology also significantly hampers agricultural digital transformation in the Philippines. Many smallholder farmers lack the digital tools and platforms to facilitate improved farming practices. This lack of accessibility is especially pronounced in rural areas, where resources are scarce. Consequently, many farmers miss the opportunities to enhance their productivity and income due to their inability to adopt modern agricultural technologies (Trace X, Accessed date: 2024. 8. 1.; Digitalisation Boosts Philippine Agriculture, Accessed date: 2024. 8. 1.).

4.4.3. Digital Literacy Among Farmers

Digital literacy remains a critical barrier to the adoption of agricultural technologies. While some farmers may have access to digital tools, many lack the skills and knowledge to use them effectively. The inability to interpret data or utilize applications for farm management inhibits growth and adaptation in an increasingly digital agriculture landscape. Surveys indicate that despite high access to information and communication technology (ICT), actual usage among farmers for agricultural purposes is significantly lower, highlighting the need for targeted training initiatives (Trace X, Accessed date: 2024. 8. 1.; Manila Bulletin, 2022. 12. 5.).

4.4.4. Infrastructure Limitations

Infrastructure limitations are a significant impediment to agricultural digital transformation. Many rural areas suffer from inadequate internet connectivity, restricting farmers' access to vital information in real-time (Trace X, Accessed date: 2024. 8. 1.). Moreover, the absence of reliable electricity sources further complicates the challenge, as many digital tools and applications require stable power supplies to function effectively. Improving infrastructure is crucial to ensure farmers can fully leverage digital technologies for better outcomes (Trace X, Accessed date: 2024. 8. 1.).

4.4.5. The Risk of Exacerbating the Digital Divide

The pursuit of digital transformation risks exacerbating the existing digital divide among farmers. Vulnerable populations, particularly those in remote areas, may be further marginalized as digital solutions become more prevalent. While some farmers may benefit from advanced technologies, others could be left behind due to various barriers, including costs, lack of access, and insufficient support systems. This growing disparity could adversely affect the broader agricultural economy and food security (IRRI 2024 Accessed date: 2024. 8. 1.).

3 Vietnam[3)]

1. Overview of Digital Transformation in Vietnam Agriculture

1.1. The Definition and Importance of Agricultural Digital Transformation of Vietnam

Governments of many countries have realized the importance of digital transformation in increasing operational efficiency and ensuring national security and have quickly entered a new race in the digital transformation of various fields.

In Vietnam, the concept of digital transformation is understood as

3) The chapter is written based on the report submitted by Chu Diem Hang (2024) to KREI's commissioned research for the Digital Agriculture Transformation in Vietnam.

the process of changing from a traditional organizational operation model into a digital organizational operation model using digital technologies such as big data, internet of things (IoT), cloud computing, etc., to change the methods of management, leadership, work processes, organizational culture, etc. Digital transformation involves collecting and exploiting data obtained from the digitalization process, applying technologies to analyze and transform this data to create new values. For state management agencies, digital transformation uses data and digital technology to change the user experience with state-provided services, change business processes, and change the model and operation methods of state management agencies. Digital transformation contributes to increasing labor productivity, changing the perceptions of leaders, and those with the capability to decide the direction and success of the organization's digital transformation.

New technology strengths are helping industries and start-ups gain advantages in traditional production fields. This trend creates significant changes in the value chain of agricultural, industrial sectors, etc., as well as the global supply chain. In the current context, it requires traditional production industries and management models to undergo strong changes by applying modern and advanced technology to continue to exist and develop.

Digital transformation can be seen as starting from digital technology breakthroughs, but more importantly, digital transformation is about accepting a new thing, a revolution in thinking, perception, institutional policy, rather than just a technological revolution.

1.2. Overview of Digital Transformation in Agriculture and Rural Development of Vietnam

Agriculture and rural areas have experienced numerous revolutions, from the introduction of systematic crop rotation and other farming advancements centuries ago to the "Green Revolution" a few decades back, which brought systematic farming methods and the widespread use of synthetic fertilizers and pesticides. Agriculture is undergoing the Fourth Revolution thanks to the exponential increase in the application of information and communication technology in agriculture.

According to the Vietnam Digital Agriculture Association, digital agriculture is understood as the use of digital technology to integrate agricultural production from farming areas to consumers. These technologies can provide the agricultural sector with tools and information to make more informed decisions, improve productivity, and support efficient management.

Vietnam is an agricultural country with rural areas accounting for 63% of the population, 66% of households, and 68% of workers; agriculture accounted for 11.96% of GDP in 2023. The small-scale production model, inefficiency, and lack of value chain linkages have been the longstanding issues of our agriculture sector, hoping that digital transformation will thoroughly address these issues.

Agricultural digital transformation must be the new driving force to change Vietnam's agriculture from "agricultural production thinking" to "agricultural economic thinking," towards an integrated "multi-value" agriculture, creating an ecological agriculture, sustainable rural

development, and modern and knowledgeable farmers mastering science and technology.

Agricultural digital transformation must create a connection between the state - enterprises - scientists - cooperatives and farmers to link, integrate, enhance agricultural product value, and reduce risks in agricultural production. Agricultural digital transformation is the key opportunity to achieve the goal of farmers producing high-quality agricultural products at the lowest cost but selling at the highest price.

Agricultural and rural digital transformation is implemented based on the following pillars:

- Digital government: Applying digital technology to optimize management, enabling timely policy development for agricultural development such as market forecasting, warning, planning management, ensuring national food security.
- Digital agricultural economy: Applying digital technology to manage production, manage the agricultural product supply chain; increase the quality and value of agricultural products; increase competitiveness in domestic and international markets.
- Digital rural farmers: Applying digital technology to build modern rural areas and civilized farmers; ensuring a prosperous and happy rural life. Digital transformation in agriculture is not only about applying technology to create additional surplus value for the economy but also to help millions of farmer households access and update new knowledge, opening up new thinking and doing, ready to change to keep pace with development trends. This is the great value that digital transformation brings.

To implement agricultural and rural digital transformation, the main contents to be implemented include:

- Data digitization: Digitizing management data and each stage in the agricultural product value chain such as input materials, breeding, cultivation, collection, transportation, distribution, consumption into digital form (in such fields as cultivation, livestock, aquaculture, forestry, salt production, veterinary, disaster prevention, etc.), ensuring agricultural sector digital data is always complete, accurate, and timely.
- Process digitization: Digitizing management processes, cultivation, and harvesting processes will be digitized and managed in a digital environment.
- Process automation: Automating some repetitive, dangerous processes for humans when exposed for long periods, wasting resources with devices, tools, and solutions for automatic operation.
- Interconnection: Different processes with different operations are able to interconnect, synchronize to exchange information and data in the digital space.
- Intelligentization: It can make automated decision notifications, handle intelligently to self-learn and adjust processes suitable for many input parameters, allowing for automatic optimization of processes.
- Digital agricultural space: It can produce, manage, operate, create value and new agricultural services in the digital space.

The digital technologies used for agricultural and rural digital transformation are the main technologies of the Fourth Industrial Revolution: cloud computing, big data, artificial intelligence, blockchain, virtual reality, etc.

Agricultural and rural digital transformation is not only an effective solution to overcome the difficulties and limitations of the sector but also an urgent requirement of the common development trend worldwide.

2. National and Sectoral (Agricultural) Digital Transformation Policies

2.1. The Digital Policy of Vietnam

The XIII National Congress of the Party's Resolution has mentioned one of the country's development orientations for the 2021-2030 period is to promote national digital transformation, develop a digital economy on the basis of science and technology, innovation.

- Resolution No.53/NQ-CP dated July 17, 2019, of the Government on solutions to encourage businesses to invest in agriculture effectively, safely, and sustainably.
- Resolution No.52-NQ/TW dated September 27, 2019, of the Politburo on some guidelines and policies to proactively participate in the Fourth Industrial Revolution.

- Resolution No.50/NQ-CP dated April 17, 2020, of the Government implementing Resolution No. 52-NQ/TW dated September 27, 2019, of the Politburo on some guidelines and policies to proactively participate in the Fourth Industrial Revolution.
- Resolution No.76/NQ-CP dated July 15, 2021, of the Government promulgating the Overall State Administrative Reform Program for the 2021-2023 period.
- Decision No.749/QD-TTg dated June 3, 2020, of the Prime Minister approving the National Digital Transformation Program to 2025 with a vision to 2030.
- Decision No.942/QD-TTg dated June 16, 2021, of the Prime Minister approving the E-Government Development Strategy towards Digital Government for the 2021-2025 period, with a vision to 2030.
- Decision No.150/QD-TTg dated January 28, 2022, of the Prime Minister approving the Sustainable Agricultural and Rural Development Strategy for the 2021-2030 period, with a vision to 2050.
- Decision No.411/QD-TTg dated March 31, 2022, of the Prime Minister approving the National Digital Economy and Digital Society Development Strategy to 2025 with a vision to 2030.
- Decision No.255/QD-TTg dated February 25, 2021, of the Prime Minister approving the Agricultural Restructuring Plan for the 2021-2025 period.
- Decision No.146/QD-TTg dated January 28, 2022, of the Prime Minister approving the National Digital Transformation Awareness Improvement, Skills Development, and Human Resource Development Plan to 2025, with a vision to 2023.

2.2. Agricultural Digital Transformation Policy of Vietnam

The agricultural digital transformation policies are as follows:

- Directive No.6524/CT-BNN-KHCN dated 07/08/2017 of the Ministry of Agriculture and Rural Development on strengthening the capacity to approach the 4th Industrial Revolution.
- Decision No.3628/QĐ-BNN-KHCN dated 07/09/2017 of the Minister of Agriculture and Rural Development issuing the implementation plan for Directive No. 6524/CT-BNN-KHCN on strengthening the capacity to approach the 4th Industrial Revolution.
- Resolution No.499-NQ/BCSĐ dated 11/04/2018 of the Party Committee of the Ministry of Agriculture and Rural Development on promoting the application of high technology in agriculture to serve the restructuring of the sector towards increasing added value and sustainable development.
- Decision No.1563/QĐ-BNN-KHCN dated 04/05/2018 of the Minister of Agriculture and Rural Development issuing the implementation plan for the Resolution of the Party Committee on promoting the application of high technology in agriculture to serve the restructuring of the sector towards increasing added value and sustainable development.
- Resolution No.839-NQ/BCSĐ dated 19/07/2019 of the Party Committee of the Ministry of Agriculture and Rural Development on continuing to innovate science and technology activities in the Agriculture and Rural Development sector in the context of international economic

integration and the approach to the 4th Industrial Revolution.

- Action Plan No.1057-KH/BCSĐ dated 27/05/2020 of the Party Committee of the Ministry of Agriculture and Rural Development on the implementation plan for Resolution No. 52-NQ/TW dated 27/09/2019 of the Politburo on some guidelines and policies to proactively participate in the 4th Industrial Revolution in the field of Agriculture and Rural Development.
- Decision No.3112/QĐ-BNN-KHCN dated 12/08/2019 of the Minister of Agriculture and Rural Development issuing the implementation plan for Resolution No. 839-NQ/BSCĐ on continuing to innovate science and technology activities in the Agriculture and Rural Development sector in the context of international economic integration and the approach to the 4th Industrial Revolution.
- Decision No.4632/QĐ-BNN-KHCN dated 16/11/2020 of the Minister of Agriculture and Rural Development approving the Information Technology Application Plan, development of Digital Government, and ensuring network information security of the Ministry of Agriculture and Rural Development for the period 2021-2025.
- Decree No.98/2018/NĐ-CP dated 05/07/2018 of the Government on policies to encourage the development of cooperation and linkage in the production and consumption of agricultural products.
- Decision No.124/QĐ-TTg dated 02/02/2012 of the Prime Minister approving the Master Plan for the development of the agricultural production sector to 2020 and the vision to 2030.
- Decision No.899/QĐ-TTg dated 10/06/2013 of the Prime Minister approving the Agricultural Sector Restructuring Scheme towards

increasing added value and sustainable development.

- Conclusion No.54-KL/TW dated 07/08/2019 of the Politburo on continuing to implement the Central Resolution 7 of the 10th tenure on agriculture, farmers, and rural areas.
- Decision No.357/QĐ-TTg dated 10/03/2020 of the Prime Minister issuing the implementation plan for Conclusion No. 54-KL/TW dated 07/08/2019 of the Politburo on continuing to implement the Central Resolution 7 of the 10th tenure on agriculture, farmers, and rural areas.
- Decision No.505/QĐ-TTg dated 22/04/2022 of the Prime Minister on National Digital Transformation Day.
- Decision No.964/QĐ-TTg dated 10/08/2022 of the Prime Minister approving the National Cybersecurity Strategy, proactively responding to challenges from cyberspace by 2025, with a vision to 2030.
- Decision No.2151/QĐ-BNN-VP dated 15/06/2022 of the Minister of Agriculture and Rural Development approving the Digital Transformation Plan of the Agriculture and Rural Development sector for the period 2022-2025.
- Decision No.4891/QĐ-BNN-TCCB dated 14/12/2021 of the Minister of Agriculture and Rural Development on Digital Transformation Day in Agriculture.

2.3. Current status of E-Government Development Towards Digital Government at the Ministry of Agriculture and Rural Development (MARD)

To promote the application of information technology and develop e-government to meet the requirements of sustainable agricultural economic development and international integration, the Politburo and the Government have issued important resolutions and decisions with high orientation, specifically:

- Decision No. 150/QD-TTg dated January 28, 2022, of the Prime Minister approving the strategy for sustainable agricultural and rural development for the period 2021 - 2030, with a vision to 2050, has specified the main goals, orientations, and tasks to be implemented.
- Decision No. 749/QD-TTg dated June 3, 2020, of the Prime Minister approving the National Digital Transformation Program until 2025, with an orientation to 2030. Digital transformation in the agricultural sector will develop high-tech agriculture, smart agriculture, and precision agriculture, increasing the proportion of digital technology agriculture in the economy.

To synchronously implement e-government and digital government, the Ministry of Agriculture and Rural Development issued the E-Government Architecture 2.0 of the Ministry on December 31, 2021, which is a master plan for the application of IT in the Ministry. An update to version 3.0 is expected in 2024. This includes components and their relationships, integrating IT applications with the business

areas of the Ministry, creating a unified, synchronized e-government development model.

In addition, MARD has also developed and improved the legal environment to ensure and facilitate the implementation of IT applications in MARD. Specifically, MARD has issued regulations on the management, exploitation, and application of IT, such as regulations on the management and use of digital signatures and specialized digital certificates of MARD; regulations on the management and use of the Ministry's IT system; regulations on providing information for the websites/portals of units within MARD; regulations on online meetings, and regulations on the use of the MARD's electronic office software.

The Ministry of Agriculture and Rural Development (MARD) has identified digital transformation in agriculture as a move from complete dependence on natural conditions and consumer markets to production based on data and forecasts of natural conditions, demand, trends, and market preferences. Therefore, MARD has been closely coordinating with other ministries and sectors to promote digital transformation in agriculture, creating value development for agricultural products, saving costs, and improving the health of farmers.

MARD has also been involved in all processes of management and supervision of origins; forming a digital agriculture ecosystem to encourage people and businesses to participate in digital transformation and apply digital technology in the production and provision of agricultural services. Particularly, digital transformation will accelerate the application of new technologies to address the congestion of

agricultural products during peak harvest times, helping farmers maintain product prices and avoid price suppression by traders.

3. Technological Applications in Vietnam Agriculture

3.1. Governmental Technology Application

3.1.1. Ministry of Agriculture and Rural Development (MARD)

On September 27, 2011, the Ministry issued Directive No. 2793/CT-BNN-TH on promoting the application of information technology in the management and operation of the Ministry for the period 2011-2015, which includes a section on the development of the IT workforce, policies, and special incentives for IT personnel in the Ministry. With this attention, IT specialists in the Ministry's units have been invested in, selected, and participated in specialized IT training courses.

〈Table 3-1〉 Basic Criteria of IT Personel in MARD

No.	Criteria	Departments of MARD	Institutes of MARD	Schools of MARD	Average
1	Rate of IT personels/total personels	1.71%	1.00%	4.00%	2.25%
2	The average rate of dedicated staff with a college degree or higher in IT	93.02%	55.17%	100%	82.73%
3	The average rate of staff proficient in using computers for work	99.57%	84.00%	87.00%	90.23%
4	The average expenditure on IT training per person (VND)	108.623	375	54.373	52.579

Source: Author (Chu Diem Hang).

Regarding state management units under the Ministry, some units have dedicated IT staff, and some have specialized IT departments, sections, or rooms, forming a network that facilitates advising, directing, and implementing IT applications and development for individual units and the Ministry as a whole.

However, many units still have IT responsibilities handled by concurrent staff, limiting the time and expertise available for IT application. Some units even lack dedicated IT personnel.

Regarding IT personnel training, the Ministry annually organizes several IT training courses to enhance the professional competence of IT specialists and improve IT application skills for civil servants and public employees, funded by the training budget. Additionally, some training classes are conducted with financial support from other projects and programs such as the DANIDA Project, the Macro Administrative Reform Project, Project 95, the Infrastructure Upgrade Project, etc.

The funding for training is not substantial and is mainly integrated into IT projects, making broad implementation challenging. The Ministry's IT staff training plans and strategies are not clearly defined and are still passive. Currently, most of the Ministry's civil servants are primarily trained in office IT. IT specialists have attended short-term IT training courses with the support of several related projects. The number of experienced experts in agricultural digital transformation is very limited. To meet the requirements of the comprehensive digital transformation mission in the agricultural sector, attracting and training IT staff and experts should be a top priority during implementation of digital transformation.

3.1.2. Provincial Departments of Agriculture and Rural Development (DARD)

According to a recent survey by the Ministry of Agriculture and Rural Development conducted at the DARDs of provinces/cities, 100% of agricultural and rural management staff at the DARDs have basic IT training; the percentage of civil servants trained in information security and safety averages from 80-100%; 100% of the DARDs have dedicated IT and digital transformation staff, and some DARDs have established separate digital transformation units in agriculture and rural development. Awareness of the role and benefits of IT applications in work among the staff at the DARDs has significantly improved. Many important tasks related to digital transformation at the local level have been completed, contributing to enhanced IT application activities and improving the efficiency of work at the DARDs.

The specialized IT and digital transformation workforce at the provincial DARDs is still limited; the digital skills and proficiency of many dedicated IT staff are not high, and the capacity training for IT staff at the local level has not matched or met the set requirements. Therefore, most localities desire support for programs and budgets to train and improve the quality of human resources for digital transformation, especially training to enhance the awareness and capabilities of key officials at the Departments of Agriculture and Rural Development.

3.2. IT Infrastructure and Technology Platforms

During the 2016-2020 period, the Ministry of Agriculture and Rural Development implemented the IT application project "Building an IT system for state management and executive operations of the Ministry of Agriculture and Rural Development" (Decision No.4382/QD-BNN-KHCN dated October 30, 2017), continuing with several components:

(i) Upgrading and expanding the shared Electronic Office software system to serve management, operations, and inter-connection for sending and receiving documents with the Ministry's units, provincial DARDs, and the Government's Office;

(ii) Ensuring information security and safety for specialized databases of the Ministry of Agriculture and Rural Development.

(iii) Enhancing technical infrastructure capacity to implement e-Government, meeting the state management requirements of MARD and the sector of agriculture.

The network infrastructure of the Ministry of Agriculture and Rural Development is ensured, with most units at the Ministry's headquarters using a shared network infrastructure. At premises with many departments and units of the Ministry, including the headquarters at 10 Nguyen Cong Hoan street, at 16 Thuy Khue street, and other locations in Hanoi, independent LAN infrastructures have been developed.

The Ministry has also connected a wide area network (WAN) between its offices at 2 Ngoc Ha and 10 Nguyen Cong Hoan. For other units based in Hanoi, the Ministry has not yet implemented WAN

connections. The average internet bandwidth per civil servant is relatively good, averaging 493.27Kbps. Wireless network devices (wifi) are installed to diversify access forms and information exploitation by users.

The Ministry has provided 100% of its civil servants with computers, with 60% having licensed software such as Windows and Microsoft Office installed; 100% of the Ministry's units have LANs and internet connections, creating a seamless electronic working environment leading to a marked increase in work productivity and efficiency.

General assessment: Overall, the IT infrastructure of the Ministry generally meets the requirements for internal information exchange, information search, and internet-based information exploitation for the professional work of each unit within the Ministry. However, the IT infrastructure is not uniform, being invested from various sources and implemented at different times with different technologies, leading to some issues such as:

- Significant difficulties in inter-connecting the LANs of units to ensure uniformity in forming a unified LAN and deploying shared IT applications within the Ministry.
- The Ministry's existing servers were invested before 2018, and their configurations are outdated, not meeting the requirements for applications to be developed during the 2021-2025 period.

3.3. Digital Technology Applications in the Management and Operations of the Ministry of Agriculture and Rural Development (MARD)

3.3.1. For the Ministry's One-Gate Information System

In compliance with Government Decree No. 61/2018/ND-CP dated April 23, 2018, on the implementation of the one-gate mechanism in handling administrative procedures and the Government Office Circular No. 01/2018/TT-VPCP dated November 23, 2018, guiding the implementation of some provisions of Decree No. 61/2018/ND-CP, since January 2020, the Ministry's Office has coordinated with the Vietnam Posts and Telecommunications Group (VNPT) to develop the Ministry's One-Gate Information System to receive administrative procedure documents submitted directly at the one-stop shop and via postal services.

The Ministry's One- Gate Information System meets the functional requirements of Decree 61/2018/ND-CP regarding the implementation of the one-stop-shop mechanism in handling administrative procedures, connecting the National Public Service Portal with the Ministry's Public Service Portal, provincial-level Public Service Portals, and national and specialized databases. Additionally, the system provides SMS information retrieval and monitoring of administrative procedure resolution progress, allowing units to coordinate the resolution of administrative procedures online seamlessly and consistently.

The Ministry's One Gate Information System has been deployed to

14 units under the Ministry, updating and applying 206 administrative procedure processes within the Ministry's jurisdiction.

3.3.2. Ministry's Administrative Reporting Information System

Recently, through the Ministry of Agriculture and Rural Development's reporting acitivities, a diverse information source has been formed to serve analysis, evaluation, and forecasting in the agricultural sector, supporting the Ministry's leadership, the Government, and the Prime Minister's directives.

However, the periodic reporting regime of the entities as regulated in the Prime Minister's Decision No. 293/QD-TTg dated February 24, 2020, on issuing the aggregated indicator set for periodic reports and statistical reports on socio-economic conditions to serve the Government's directives, has been implemented, but the reporting has not been regular. The information and data reported are incomplete, untimely, and inaccurate, with a high percentage of units still using paper reports, employing various reporting methods, resulting in time-consuming report compilation and low effectiveness in information and data utilization.

3.3.3. The Ministry's Electronic Document Storage System

The Ministry's shared Electronic Office System has been operating a new version since June 1, 2019, with a massive volume of electronic documents currently stored in the system's database. According to Circular No. 02/2019/TT-BNV and Decree No. 30/2020/ND-CP, the

Ministry lacks a proper electronic storage system capable of storing, retrieving, preserving, and preventing incidents for electronic documents.

Currently, the Ministry is implementing the project "Building e-Government, aiming towards a Digital Government of the Ministry of Agriculture and Rural Development for the period 2021-2025" with the main objectives of:

(i) Building an electronic One-Stop-Shop system to meet the requirements of administrative procedure simplification;

(ii) Developing a reporting information system to implement the periodic reporting regime;

(iii) Establishing an electronic document storage system for the Ministry;

(iv) Upgrading the Ministry's IT infrastructure;

(v) Enhancing the Ministry's official email system;

(vi) Establishing the Ministry's cyber security monitoring system (SOC).

3.3.4. The data and information systems by specialized fields of MARD

In the field of crop production, the Crop Production Department manages and exploits several information systems and databases, including:

- The Plant Variety Protection Database: The Crop Production Department has been supported by the JICA organization to develop software for updating the Plant Variety Protection Database. However, the software is now outdated and has many technical limitations, making it difficult to share and connect with other systems, hindering the

execution of specialized tasks.

- The databases for variety trials, variety testing, plant variety circulation, and self-declaration; Rice land conversion; Testing laboratories, certification organizations in crop production: Data is manually updated on computers via Word and Excel files and updated on the Crop Production Department's electronic portal.
- The database system for monitoring and evaluating the implementation of crop production plans aimed at enhancing the effectiveness and efficiency of state management: The software is outdated and has technical limitations affecting data updates.
- For administrative procedures, the Department has developed and put into use software providing one administrative procedure in plant variety import, registered on the national one-stop-shop portal, which is currently operating very well and effectively; the Department has five administrative procedures on the Ministry's online public service portal.

In addition, with support from the International Rice Research Institute (IRRI), the Department is using the RiceMoRe software system to monitor and report rice production, managing, exploiting, and utilizing data for production directive and forecasting tasks for rice. The data is updated through a network of local officials from the commune level. Data is linked with geographic information systems and other information layers, facilitating production planning, disaster response, and pest management.

In 2021, the Plant Protection Department developed a database software with the objective of supporting online reporting and

statistics, facilitating the exchange of information and reports between subordinate units and departments within the Plant Protection Department according to a unified process. This reduces costs related to storage, duplication, and processing time, enhancing the operational efficiency of the leaders and specialists, making reporting and statistics more convenient.

In the field of plant protection, the Plant Protection Department is currently implementing several management and operational applications as follows:

The Plant Protection and Quarantine Department's database software, which manages, processes, and statistically analyzes internal activities data from specialized departments to related businesses and units in 63 provinces nationwide. This software is being trained for implementation.

The database management software for harmful organisms (HOs) on crops across 63 provinces nationwide is managed by the Plant Protection Department. It facilitates accurate and comprehensive statistics on the forecast and occurrence of HOs, enabling proactive management and control of HOs on crops nationwide and advising the Ministry on directives during potential widespread outbreaks.

The Fertilizer Management specialized software, managed by the Fertilizer Management Department, oversees the national fertilizer database.

The Plant Protection Pesticide Registration database software, managed by the Plant Protection Pesticide Department, maintains the national pesticide database.

The Plant Protection Pesticide application (Apps) on smartphones (iOS, Android) supports farmers in finding information on pesticides and necessary control measures from the database, helping users select and use pesticides to control HOs according to the "4-rights" principle.

The Plant Protection Department, in collaboration with Viettel and An Giang, is developing a crop pest identification application. The application was piloted in An Giang in January 2022. However, it still requires development of the pest identification function due to the need for a large image database, costly image collection, AI development, and operation.

The online public service software provides 45 administrative procedures (AP) in the field of plant protection and quarantine, including 31 APs under the jurisdiction of the Department: National Single Window Portal (04 procedures); Level 3, 4 online public services (07 procedures); and using the Ministry's electronic single-window information system.

In the field of Animal production and Animal health, digital technology is also adopted as follows. In the livestock sector, the Department of Animal production has collaborated with VNPT Group to develop software as a tool for collecting, updating, and reporting, thereby creating a feed database and a livestock facility database within the agricultural and rural sector's foundational database system. To date, the livestock database software has been basically put into trial operation with its main functions and interface. The feed database subsystem includes 269 feed mills nationwide and provides 600 accounts for data updates to the mills, local veterinary officers,

and large livestock enterprise farms.

In the veterinary sector, the Department of Animal Health currently manages five specialized databases serving management, research, production, and professional activities in the following fields: prevention and control of terrestrial and aquatic animal diseases:

The online information system for terrestrial animal disease prevention, abbreviated as VAHIS (Vietnam Animal Health Information System), was developed with financial support from the United States Agency for International Development (USAID) and technical assistance from the Food and Agriculture Organization of the United Nations (FAO). VAHIS allows for online animal disease reporting, replacing paper-based reporting systems to provide complete and timely reports, offering data for scientific analysis, meeting the requirements for management, prevention, and control of animal diseases in line with the World Organisation for Animal Health (OIE) and regional demands. VAHIS enables localities to report animal diseases online, reducing the labor-intensive and time-consuming process of paper reporting, making data aggregation and analysis easier and more responsive to urgent disease prevention needs.

However, VAHIS is currently only used for reporting some major diseases (including avian influenza, foot-and-mouth disease, African swine fever, and lumpy skin disease). Many other dangerous animal diseases are not fully and promptly reported, leading to insufficient data for timely and effective disease prevention and control measures. As a result, many diseases still occur on a large scale, causing significant economic losses and health risks. Additionally,

infrastructure limitations (servers, internet connections, computers at veterinary agencies), personnel, and computer skills hinder data handling, and VAHIS still faces technical issues. Thus, the system needs further upgrades, adding functions for: (i) proactive animal disease surveillance; (ii) animal disease-free zones and facilities; (iii) registration and statistics of household pet ownership and rabies management.

The online aquatic disease reporting system (creating a disease database) includes features for data processing, charting, and online epidemiological mapping, integrated into the Department of Animal Health's electronic portal. However, due to technical shortcomings, the system needs adjustments to meet local needs and is not yet fully implemented nationwide. The aquatic disease reporting system requires upgrades and additional components such as diagnosis, disease testing results, aquaculture data, and environmental monitoring in farming areas to be fully effective.

The National Single Window information portal system serves registration and issuance of export and import quarantine certificates for animals and animal products. Currently, 80-99% of registration and certification procedures are processed through this system. However, it lacks functions for supporting, aggregating, and analyzing animal quarantine data for export and import, necessary for management.

The online information system for veterinary sanitation inspection, animal slaughtering control, and food safety management has only recently been used for administrative procedures like

issuing/reissuing veterinary sanitation certificates for facilities listed under mandatory of veterinary sanitation, food safety inspection on the online public service portal. It does not support aggregation or analysis of slaughterhouse statistics, which are still manually processed in excel files from local reports. A database management software for animal slaughterhouses is needed for effective reporting and decision-making by the Department of Animal Health and the Ministry of Agriculture and Rural Development. Upgrades and additional features are required.

The administrative procedure processing system on the National Single Window portal handles applications for "Veterinary drug import licenses and raw materials for veterinary drugs" and "State inspection of imported veterinary drug quality" for organizations and businesses. This system primarily meets administrative needs like licensing and quality inspection of imported veterinary drug shipments, processing about 60% of applications annually.

The various databases are difficult to aggregate and report due to several challenges: i) Lack of functionality for compiling, extracting, and classifying veterinary drugs by type, disease, supplier, and time to evaluate trends and set limits, especially for controlled substances; ii) Poor integration and digital record retrieval capabilities for raw materials and imported veterinary drugs, requiring extensive manual processing in Excel files before analysis, limiting continuous data storage value; iii) Inability to meet OIE reporting and management requirements.

Now, it is the field of Forest production and Forest protection. The

Forest Resource Information System (http://maps.vnforest.gov.vn/vn) includes information on 1.12 million forest owners, of which 1.118 million are individuals and 2,000 are organizations, all digitized and updated.

In addition, there are several databases on wildlife breeding facilities, forest environmental service payments, forest planting season maps, etc., serving to access and exploit information for citizens and for directing and managing tasks, developing plans, and formulating policies in the forestry sector.

Regarding forest fire prevention and control forecasting: Since early 2007, a MODIS remote sensing image reception station has been installed and operated in Hanoi to detect early forest fire hotspots across Vietnam. The detected fire point information has been transmitted to localities nationwide via email and the Forest Protection Department's website.

Although the MODIS remote sensing image reception station has greatly supported forest fire prevention and control, early detection of forest loss and fires still faces many issues, such as the long time required for warning detection and transmitting fire point information to forest fire management levels (approximately 1 - 4 hours).

In terms of public services, 2 out of 20 administrative procedures are conducted online at levels 3 and 4, including issuing CITES permits for the export, re-export of specimens of endangered, precious, and rare forest animals and plants, and for the import of specimens of endangered wildlife and plants.

In the field of Fisheries development, the Department of Fisheries

and the Department of Fisheries Extension is the units responsible for management in this field from central to local levels, several tools, software, information systems, and databases have been developed for management purposes as follows:

- The Aquaculture Database System, part of the national fisheries database (accessible at http://ntts.tongcucthuysan.gov.vn), has been implemented to manage data for facilities certified to produce, rear, and breed aquatic species, aquatic feed production facilities, and environmental treatment products in aquaculture. The system is implemented by the Ministry of Agriculture and Rural Development and managed and utilized by the Directorate of Fisheries, accessible in provinces and cities nationwide.
- The National Fisheries Database (Vnfishbase): operational since 2019, meets the requirements for fisheries exploitation management, particularly the data management of fishing vessels, registration management, and licensing for fishing vessels with a maximum length of 15 meters or more. This database system meets the basic requirements for fisheries exploitation management, especially the management of fishing vessel data, which is updated, utilized, and managed uniformly from central to local levels. The system was implemented in 2020 to conduct electronic verification and certification of the origin of aquatic products as per regulations, serving the traceability of aquatic products and the sector's directive management. It is implemented by the Ministry of Agriculture and Rural Development and managed and utilized by the Directorate of Fisheries in 28 coastal provinces and cities (Fisheries Sub-Departments,

Port Management Boards, processing enterprises, vessel owners), and other relevant units.

- The Fisheries Processing and Market Database: helps manage information on processing and export by product and export market as per the provisions of Circular No. 24/2018/TT-BNNPTNT dated November 15, 2018, by the Ministry of Agriculture and Rural Development regarding the update, exploitation, and management of the national fisheries database.
- The Database on Administrative Violations in Fisheries Exploitation (accessible at http://vphc.tongcucthuysan.gov.vn) and implemented in coastal provinces and cities.

In the field of Irrigation and Disaster management, the following technology is adopted:

- The Water Resources Sector Database System: consists of four modules including basic data for the water resources sector, management and operation of water resource works, dam and reservoir safety, and rural clean water.

Many large and medium-sized irrigation projects across the country have been equipped with SCADA systems to support monitoring and operational management of the works. Software for calculating crop water requirements, river basin water balance, and software for drought and salinity intrusion forecasting have also been successfully applied in many irrigation projects nationwide. Advanced automatic water-saving irrigation technology combined with fertilization for crops has been applied to over 500,000 hectares of crops across the country.

In recent years, with the support of various resources, the Department of Dyke Management and Natural Disaster Prevention has built several databases, such as the dyke database, riverbank and coastal erosion database, natural disaster damage and recovery database, and the Vietnam Natural Disaster Monitoring System.

However, the current data is still incomplete (lacking data from 63 provinces/cities, no data down to district and commune levels), lacks comprehensive information fields, lacks various types of data (spatial data, non-spatial data), is not synchronized, and lacks a unified data architecture to form shared data for the agriculture and rural development sector, the natural disaster prevention field, and other related fields. Therefore, it does not yet meet the timely requirements for the direction and decision support of the leaders of the National Steering Committee for Natural Disaster Prevention and Control and the Ministry of Agriculture and Rural Development.

For the field of agro product quality management, the Department of Quality, Processing, and Market Development has mobilized support resources from Ireland to implement the construction of the Database and Information Management System for Seafood Quality and Food Safety. This is the first priority module to be built to carry out the tasks assigned by the Ministry according to Decision No. 5275/QĐ-BNN-VP, "Implementation of the Food Safety Assurance and Traceability System for Agricultural, Forestry, and Fishery Products."

In the field of cooperation economy, the digital transformation is also applied. Aiming for comprehensive digital transformation across all management fields, the Cooperative Economic Department has

gradually organized and operated several databases, including:

- The Agricultural Cooperative Data Management System on an online platform, accessible at the address: http://quanlyhtxnongnghiep.gov.vn, which updates periodic reports on agricultural cooperatives from district, provincial, and central levels on a monthly, quarterly, and yearly basis. Software applications used in the production and business activities of agricultural cooperatives include: production management and traceability software for 250 cooperatives; Traceability labels used by 50 cooperatives; 173 agricultural cooperatives using WACA accounting software; 246 agricultural cooperatives using electronic diaries (FaceFarm).
- Trading platform at the address: sanocop.vn: Over 600 agricultural cooperatives have participated, facilitating the export of goods worth over 300 billion VND to markets in Japan, the UK, France, the Netherlands, South Korea, Thailand, and China, with products such as durian, sweet potatoes, pomelo, mango, and rambutan.
- Traceability portal at egap.vn: This is the management and monitoring information portal for the traceability of Vietnamese agricultural markets, with administrative rights divided into three levels: Level 1 (Department), Level 2 (province and district), and Level 3 (cooperative).

In collaboration with Sorimachi Company, they developed a data management system for origin codes for raw material regions and cooperative accounting software. The Department has introduced and guided the Agricultural and Rural Development Sub-Departments of 13 provinces involved in the raw material region project to

introduce these systems to cooperatives in those regions for implementation and use.

For the establishment of a database supporting the management of the cooperative economy and rural development sector, the Department has built the "Database management software for monitoring and evaluation capacity of the cooperative economy and rural development sector.: This software consolidates data down to the district level when used.

General assessment: In recent years, with the spirit of promoting the application of information technology to build e-government, the Ministry of Agriculture and Rural Development has directed its units to mobilize various resources to build several information systems, software, and databases for management, direction, and administration purposes. Many applications have been highly effective, facilitating timely direction and administration and supporting people and businesses in the sector. However, some limitations still exist, as follows:

- These applications primarily serve specific tasks within the affiliated units. Most of the software remains fragmented and independent, leading to dispersed data that lacks comprehensiveness and does not ensure data sharing, connectivity, interoperability, and aggregation across the entire sector. Consequently, this causes difficulties in statistics and reporting, which hampers management, direction, administration, and policy-making processes.
- The databases and application software lack a common architecture, being mainly developed spontaneously based on immediate needs;

they are not shared or interconnected between different levels and functional units. Data updates are not timely or done in real-time. Some databases, built with non-refundable grants based on the donors' ideas and perspectives, are "hard-coded," making them difficult to connect and share.

- The management, exploitation, and use of databases are mainly done manually through Excel files. With a large amount of data, information retrieval, management, and reporting are challenging; coordination between specialized departments and units is thus inefficient and time-consuming.
- The content serving production and business activities for people and businesses on these platforms is very limited. Participation in exploiting, providing, and updating data from grassroots levels, people, and businesses in the agricultural sector is almost nonexistent.
- Applications serving the digital economy in agriculture and rural development, and digital farmers, are nearly neglected.
- E-government applications have been implemented in all units, but many units are still at a low level (level 2).

3.4. Application of Information Technology by Enterprises, Agricultural Cooperatives, and Farmers

In recent times, the application of information technology (IT) to support and expand the consumption market for agricultural products

has become an essential business trend, particularly for agricultural cooperatives. However, there are still many issues that need to be addressed.

Most enterprises, cooperatives, and entities have not shown much interest in or taken proactive steps toward adopting digital technology and platforms to serve digital transformation. The development of the digital economy in the province is still spontaneous, small-scale, and low-value.

Small-scale, fragmented farming practices still exist with a significant proportion; livestock productivity among households is uneven, and the stages in the production-purchasing-slaughtering-processing and consumption process are not tightly linked, resulting in suboptimal production efficiency.

Brand building efforts are still limited. All provinces and cities across the country have identified key agricultural products; however, most of the produced products are not processed and are mainly sold in small-scale, free-market forms, leading to low profits for livestock producers. In an open market economy, competition with similar products on the market or with imported goods is very weak. Therefore, it is necessary to promote the production of high-quality products that meet consumer tastes to stabilize and develop the livestock industry in the province.

The livestock production chain is still fragmented, with no centralized slaughterhouses, only small, scattered slaughterhouses, making it difficult to manage disease and food safety and hygiene. Centralized, safe food slaughter management is not thoroughly implemented, resulting

in low product prices that do not encourage livestock development or digital transformation in livestock production.

There is no unified process for connecting, sharing, and integrating data with national databases and information systems from the central to local levels. Therefore, provinces and cities face difficulties in coordinating with ministries (databases, information systems); some old investment software is inconsistent in architecture and technology, leading to difficulties in interoperability, integration, and information exchange.

Infrastructure for developing and applying digital technologies is not synchronized, with fragmented infrastructure, field planning, livestock barns, and ponds unsuitable for digital transformation applications.

The mindset of officials and farmers has not kept pace with the development and application of digital technologies. There is a reluctance to change and a preference for familiar methods.

Applying digital transformation requires significant capital investment from agricultural enterprises, cooperatives, and farms, most of which are still lacking.

Policies for implementing high-tech programs and models and applying digital transformation are still inadequate. For example, in building normal models, 100% support is provided for particularly difficult communes and 70% for mountainous communes, but only 40% support is provided for high-tech models.

The information technology infrastructure serving the industry's digital transformation is not synchronized; IT hardware systems are

low in configuration, and information security and safety systems are lacking.

Funding for IT application investment in the industry is still challenging, not meeting the requirements for digital transformation.

In agricultural production and business activities, attention has been paid to applying IT in the stages of agricultural production and business, specifically as follows:

In crop production: Some enterprises, cooperatives, and farmers have applied automatic irrigation systems, drip irrigation, and automatic temperature control in greenhouses and net houses. Additionally, using LED lighting technology in cultivation has helped save labor costs, water resources, and increase crop productivity.

In livestock production and veterinary medicine: Some livestock farms and enterprises have applied sensor systems to regulate the microclimate in barns, automatic feeding systems, and automatic drinking water systems; managing and monitoring livestock, sales, and animal origins on computers. Centralized slaughterhouses have applied modern industrial slaughter technology; managing and monitoring slaughtering and sales on computers.

In aquaculture: In fisheries exploitation, journey monitoring systems and Vnfishbase software have been applied to manage fishing vessels and support fishermen during marine exploitation; some ship owners have applied fish school detection devices. In aquaculture, production facilities, and enterprises have applied aquaculture in tents, automatic aeration systems, and environmental management technology in aquaculture ponds.

3.5. The Development of E-Commerce in Agriculture and Rural Development

On February 9, 2022, the Prime Minister issued Decision No. 194/QD-TTg approving the Project on Innovating Business Methods for Agricultural Product Consumption for the period 2021 - 2025 with an orientation to 2030. Accordingly, the Trade Promotion Department has promoted trade promotion measures, strengthened the connection of agricultural product consumption for localities, and supported traders in boosting agricultural product consumption through e-commerce channels, achieving some results as follows:

- Many Vietnamese agricultural products such as Thanh Ha lychee, Luc Ngan lychee, Vinh Chau purple onion (Soc Trang), Japanese sweet potato from Vinh Long province, Tam Hoa Bac Ha plum, and Bac Kan fragrant green pumpkin are now being offered in prime positions on reputable e-commerce platforms, demonstrating that e-commerce platforms are playing a certain role in promoting agricultural product consumption.
- On May 19, 2021, Thanh Ha lychee was officially launched on the homepage with a priority position on Viettel Post's Vỏ Sò e-commerce platform - a Vietnamese e-commerce platform through the "Online Vietnamese Store". Previously, on May 14, Thanh Ha lychee was launched in the "Hai Duong Provincial Store under the National Trade Promotion Program" on the Lazada platform.
- On May 28, 2021, the Voso e-commerce platform launched the Bac Giang specialty lychee with the goal of consuming 100 tons of

lychee per day. Additionally, Vỏ Sò supported, guided, trained, and accompanied farmers in Bac Giang to create stores and actively list products on the platform. Besides listing on the Vỏ Sò platform, Bac Giang also activated the existing e-commerce platform "vaithieu.vn". Additionally, Bac Giang cooperated with businesses in the province to open stores on the Alibaba e-commerce platform.

- On May 28, the People's Committee of Son La province cooperated with the Trade Promotion Department (Ministry of Industry and Trade) to organize the program "Handing Over Son La Mango Products According to the Consumption Agreement for Processing, Consumption, Export, and E-commerce Units in 2021". After signing the cooperation agreement, Son La's hậu plum and Yen Chau round mango products were officially listed on the Shopee e-commerce platform from May 28. All products listed on the e-commerce platform were supported by the Trade Promotion Department for traceability, labeling, and ensuring transparent product information.
- In June 2022, the Ministry of Industry and Trade announced the "Cross-border E-commerce" model on the e-commerce platform developed and operated by Vietnam through the cooperation program between the Department of E-commerce and Digital Economy (Ministry of Industry and Trade) with the Vỏ Sò e-commerce platform and Viettel Post. On June 22, 2021, over 3 tons of GlobalGAP standard Bac Giang lychee were exported and cleared smoothly at Frankfurt Airport (Federal Republic of Germany)

through the Vỏ Sò e-commerce platform, marking the first time Vietnamese agricultural products were exported to the European market under this model.

This is the result of the gradual development of cross-border e-commerce applications for Vietnamese export enterprises. However, selling agricultural products through e-commerce platforms also faces several supply chain challenges.

Currently, fruits from the garden to consumers' hands must go through many intermediaries, and to maintain freshness like when freshly harvested requires strict preservation processes. When buying online through e-commerce platforms, buyers need inspections from authorities, commitments from units in the supply chain, and from the cooperatives and farmers themselves.

Moreover, one of the biggest challenges is the limited awareness of farmers and businesses regarding e-commerce business methods. To get products to consumers, businesses need to be well-trained and educated on how to promote online, build product and business images, customer care methods, post-sales services, commitment forms, and product quality management.

Currently, consuming agricultural products through e-commerce platforms has achieved some results, but compared to the total demand for agricultural product consumption, this channel is just beginning and accounts for a very small proportion. Therefore, for the consumption of agricultural products through e-commerce platforms to advance further and develop sustainably, businesses and local authorities need to continue to pay attention and improve access to

e-commerce platforms. The most important factor is to create quality, reputable products with transparent and accurate information when delivered to consumers, building trust for buyers when using this sales channel.

Regarding agricultural product consumption, the sale of products on e-commerce platforms has just begun, with some agricultural products having product codes on platforms such as Postmart.vn, Voso.vn, and Sendo.vn.

Regarding agricultural product traceability, since 2016, traceability of agricultural products by QR code labels has been implemented; to date, about 100 products have been labeled for traceability.

Traceability is carried out through contracts with service providers via traceability systems: traceverified.com, agricheck.net, icheck.com.vn, trace.icheck.vn, smartcheck.vn… The number of establishments with traceable products is still small, mainly enterprises and cooperatives, only implementing when necessary, such as entering supermarkets, exporting, or participating in support programs (such as OCOP). Traceability mainly reaches processing establishments; traceability to linked production households and planting areas is still limited.

According to the General Statistics Office, by mid-2020, the application of mechanized production and scientific and technological applications in production has diversified at all stages of the production process, with a significant increase in the number of units compared to the previous period. On average, 100 households engaged in agriculture, forestry, and fisheries use 0.74 vehicles for

production, 3.89 times more than in 2016; 1.93 generators, 5.36 times more; 28.87 motorized pesticide sprayers, 2.23 times more; 0.44 combined harvesters, 1.61 times more; 2.84 other harvesters, 1.32 times more; and 4.02 motorized

3.6. Digital Technology Application in Agriculture Management in some Specific Provinces

Most localities are currently only at the stage of computerizing activities and management processes, and are in the process of building e-Government through the implementation of management applications (electronic office, email, etc.). Few state management agencies in agriculture and rural development operate based on digital technology.

Some localities have effectively applied digital technology in agricultural management, such as Quang Nam (with integration into the provincial government system) and Dong Thap (applying solutions for monitoring pests and controlling humidity and water levels for rice in a 4.0 farming model), specifically:

a) In Hai Duong province (in the Red River Delta region): The key agricultural product is lychee, which has been subject to traceability using QR codes on the products. However, surveys and actual checks reveal the following:

- QR code tagging is currently only carried out by purchasing businesses to increase profits and participate in e-commerce platforms or exports.

- Electronic diaries are not directly implemented in lychee-growing areas but are done via memory or manual notes, which are then transferred to the Plant Protection Department for system entry.
- Data-based farming practices such as fertilizer control, pesticide use, and monitoring soil and air moisture are not yet implemented; these tasks are still based on traditional farming experience.
- In livestock farming, technology application is also at a basic level, with no control over scale or monitoring factors affecting product quality. Thus, quality control by household is not yet feasible, and purchasing units could easily transfer QR codes from one growing area to another as they wish.

b) In Dong Nai province (belonging to South Central Coast region): The locality has many large-scale livestock farms and family farm models. The survey results indicate:

- The application of technology in agricultural management is minimal, primarily following the internal e-Government development roadmap (document management, email, asset and financial management...), with no connection to systems or farm activities.
- The application of digital technology in livestock farming is uneven, with some units only using basic automation for processes like lighting and temperature control.
- In crop cultivation, farmers have only applied technology to modernize irrigation practices.
- Some egg-laying poultry businesses in Dong Nai have successfully applied modern technology, using digital data for production, automating processes from breed control, temperature, lighting,

feed, disease monitoring to harvesting, packaging, and labeling. This is a model that could be replicated in other regions nationwide.

c) In Tra Vinh province and Dong Thap province (belonging to Mekong Delta region): The main products are rice and mangoes. The survey results on digital transformation for these commodities are as follows:

- In terms of digital transformation, only Dong Thap provice (out of 13 Mekong Delta provinces) has applied digital technology in agricultural management. The locality has used the experimental solutions of Rynan Technologies to manage multiple processes in a 4.0 farming model.
- For mangoes, technology application is limited to modernizing irrigation compared to traditional methods. Some orchards have implemented traceability but only provide information about the farm or growing area, and electronic diaries are not yet thoroughly used.
- For rice, Dong Thap province has tested a comprehensive solution from Rynan Technologies for water control, pest monitoring, and integration with a central system managed by the Department of Agriculture and Rural Development. Farmers control and provide information and records via mobile devices. The model is relatively well-implemented but remains limited in scope due to equipment availability.

d) In other provinces and cities in agricultural regions, the application of digital technology is still sporadic and simple, with most farming practices remaining traditional, resulting in no breakthroughs in productivity and quality.

4. Readiness and Adoption Challenges for Digital Transformation

4.1. Current Status of Digital Farmers

The Fourth Industrial Revolution has been and is impacting all fields of life, including agriculture and farmers. In fact, accessing and mastering digital technology will be a key to helping farmers improve production efficiency based on applying scientific and technical achievements to the entire production and consumption process.

Accordingly, hundreds of thousands of farmers across the country have effectively applied digital technology to agricultural production. With the support of functional agencies and the boldness and decisiveness of the "4.0 farmers," the initial implementation of digital transformation has been applied in the agricultural sector in fields such as cultivation, livestock, aquaculture, and forestry, bringing about very positive results.

Numerous programs and software for garden management and precision agriculture have been applied to optimize resource use (water, fertilizers, etc.) to gradually transition from traditional agriculture to modern agriculture, creating many opportunities to increase labor productivity, reduce dependence on environmental and weather conditions, and better control diseases.

According to a survey by the Crop Life Asia Association, nearly 50% of Vietnamese farmers growing rice, fruit trees, and vegetables

surveyed expressed their desire to apply digitalization in agriculture. Compared to the three ASEAN countries in the same survey, Vietnam had the highest rate.

This shows that Vietnamese farmers are more interested in digitalization than anywhere else in the region. To successfully digitize agriculture, it is essential to accompany farmers and support them in applying digital technology to production. Farmers in the agricultural digital transformation not only play a key role but are also the group that needs the most attention.

In terms of advantages, with government support policies, most Vietnamese farmers today regularly use mobile phones. Therefore, applying digital transformation in agriculture makes farmers the easiest and most direct target to introduce new scientific and technical field technologies and promote output product consumption channels into the agricultural production process.

Additionally, farmers have begun to master and increasingly promote their role in developing digital agriculture. Farmers are increasingly absorbing more scientific and technical advancements brought by various levels, sectors, and means. In reality, in recent years, along with societal development, smart agricultural production models have become familiar to farmers. From "unmanned livestock farms," "soil-free vegetable gardens," "automated farms," to "e-commerce platforms," these are the initial successes of farmers in the 4.0 era when applying technology to the production process.

However, farmers still face many difficulties in mastering digital technology. These include traditional production and consumption

habits, limited access to technology for most farmers, and financial difficulties in supporting and helping farmers.

Objectively, one of the biggest challenges of digital transformation in agriculture is the level of labor force in agriculture, which consists mainly of farmers who have not been formally trained; they find it difficult to absorb scientific and technical advancements. Additionally, the connection between the government, production processing enterprises, and farmers is still limited, with many products lacking a clear national development strategy.

To solve this problem, the role of associations is very important. It is necessary to strengthen propaganda and support farmers in enhancing their knowledge of digital transformation, changing their traditional production mindset to a transparent, responsible agriculture; guiding farmers to directly participate in building large agricultural databases such as crops, livestock, aquaculture, and land; providing information on the environment, weather, and soil quality for farmers to decide on suitable production and business directions.

Promote information and communication work to inspire creativity and upward aspirations in farmers; diversify forms of training and fostering, supporting farmers in accessing digital technology, especially equipping farmers with skills to exploit and use the Internet and skills to participate in e-commerce platforms. Each farmer also needs to be more proactive in exploring and applying technology to the entire production and consumption process; mastering and fully exploiting the strengths and advantages of digital technology related to specific production fields.

Participating in the digital society, building smart agriculture, and a digital market are the requirements for every farmer today. To make this process truly effective, more cooperation and support from various levels, sectors, and localities are needed so that Vietnamese farmers can truly become “4.0 farmers” and “smart farmers,” in line with the current global trend.

4.2. Recommendation

The above issues highlight the challenges in the digital transformation of agriculture:

- Regarding Mechanisms and Policies: Legal regulations (on information provision, system processing and operation from central to local levels, etc.) need to ensure consistency and synchronization. There are no standards or regulations for digital technology, and overlapping areas and dispersed data will require substantial time and effort to synchronize all databases and common information systems of the Ministry.
- Regarding Awareness: The comprehensive and extensive awareness of digital transformation among the units under the Ministry of Agriculture and Rural Development (MARD) and provincial Departments of Agriculture and Rural Development is still low. Technology applications have not yet been organically integrated into programs, projects, and specialized tasks. Management and governance approaches are not yet synchronized and consistent. Data sharing and connectivity are weak, with many units not yet

changing their views on sharing and connecting databases to form a common industry platform. Digital transformation is a new field, and most agricultural sector officials involved lack IT expertise; many still have a vague understanding of what digital transformation is and what goals need to be achieved for it to be considered successful.

Most organizations, individuals, and the public are still accustomed to operating in a physical environment. Additionally, technical infrastructure is not yet guaranteed, such as software that has been in use for years but still has many errors that have not been resolved, leading to lengthy processing times. Information sharing is not widespread, resulting in a high volume of information to be submitted. Procedures and paperwork are numerous, and with limited memory capacity, submitting documents online is challenging. Administrative procedures are still implemented in parallel both online and on paper, requiring double the time to handle tasks due to the lack of regulations on using digital versions instead of paper.

- Regarding IT Applications: Current IT systems only meet individual business requirements. While there is an Electronic Government Architecture 2.0 for MARD, the implementation of tasks according to this architecture is slow, and there is no formation of common foundational databases or standardization of business databases for data sharing and decision support. The use of IT in specialized business requirements remains sporadic and not widespread, with limited use of data in management. There is no specific software for monitoring and managing the development of legal documents

or for policy development and institutional improvement within the Ministry.

The current situation involves too many outdated software and databases, with many not being synchronized. There has been no comprehensive reform of business process execution towards the application of digital technology. Software platforms are independently built and isolated, limiting the ability to link and connect data portals between different software. Without connectivity, data entry may need to be done multiple times across different software.

- Regarding Resources: There is a lack of specialized IT personnel, especially those with expertise in new 4.0 technologies, at the Ministry's agencies and provincial Departments of Agriculture and Rural Development. There is also a lack of resources for upgrading and maintaining information systems and updating databases. Investment funding is not adequately prioritized. When investments are made, they are too dispersed and fragmented, without clear focus on priority areas. IT equipment is lacking and not synchronized, leading to ineffective digitalization of documents, updating of documents, and electronic record-keeping.
- Regarding Information Security: According to survey results from provinces and cities, most units believe that information security is not given adequate attention.

Digital transformation is a comprehensive issue that requires substantial resources; therefore, international cooperation is one of the solutions the Vietnamese government is pursuing to accomplish

digital transformation, particularly in the fields of agriculture and rural development. Consequently, some of the key actions needed in international cooperation include:

a) Government agencies in agriculture and rural development should collaborate with businesses that provide digital platforms and services to offer public services through the public postal network and the businesses' applications. This will help support farmers in accessing digital government services and e-government services. Priority should be given to cooperation in promoting and training skills related to the use and exploitation of electronic trading platforms, electronic payments for buying and selling agricultural products, and recognizing and preventing online fraud.

b) Strengthen cooperation with domestic and international businesses, organizations, associations, and IT experts to access advanced and modern technological solutions and digital transformation solutions that can be applied and implemented in agricultural management, production, and business.

c) Collaborate with foreign organizations and companies to attract resources, knowledge, transfer technology, and digital agriculture models suitable for Vietnam's conditions.

d) Enhance international cooperation to implement digital transformation in agriculture and rural development to mobilize and utilize resources, promote, and expand markets for Vietnamese agricultural products.

4 Lao PDR[4)]

1. Overview of Digital Transformation in Lao PDR Agriculture

1.1. The Definition and Scope of Agricultural Digital Transformation of Lao PDR

Agriculture remains the primary source of income for the majority of the Lao PDR population. The country is characterized by smallholder farmers, and agriculture and forest product remain critical to food security. This sector's employment, which is 70% of the population, makes a significant contribution to reducing rural

4) The chapter is written based on the report submitted by Manoluck Bounsihalath internal data (2024) to KREI's commissioned research for the Digital Agriculture Transformation in Lao PDR.

poverty. The sector is dominated by low-productivity rice production, which is characterized by inefficient use of purchased inputs such as improved seeds and fertilizers. Farm families sell a small percentage of their rice to the market, with the majority of it consumed by family members.

The agriculture sector grew by only about 3% between 2021 and 2019, with crop and livestock (4%) and fishery (5%) sectors accounting for the majority of the growth.[5] Rice, mung beans, soya beans, peanuts, tobacco, cassava, coffee, and tea are among the most common agricultural products. Insufficient access to farm inputs, low adoption of agricultural technologies, poor product standard compliance, and high transportation and logistics costs to access markets all hampered growth.

Agriculture's role in households has decreased due to increased connectivity between rural districts, urban populations, and neighboring countries. In 2018, the Asian Development Bank[6] reported that households with a higher proportion of agricultural income are poorer, especially if they grow wet season or irrigated rice. Many rural households in Laos earn only 25% increase, but lagging behind 24% inflation[7] (World bank, 2024), with the remainder coming from non-farm sources such as casual labor, paid employment,

5) Asia Development Bank(ADB) (2021), Developing Agriculture and Tourism for Inclusive in Lao PDR.

6) Asia Development Bank(ADB) (2018), Agriculture, Natural Resource and Rural Development Assessment, Strategy and Road Map for Lao PDR.2018.

7) World Bank(https://www.worldbank.org/en/country/lao/brief/monitoring-the-impact-of-covid-19-in-lao-pdr), Accessed date: 2024. 8. 5.

government salaries, and extended family remittances. In 2023, average inflation was recorded at 31.2%, rising to above 20% in early 2024. This high inflation rate has been driven by the depreciation of the Lao kip, high external debt, and global price increases for imported goods. High inflation has significantly affected agricultural product prices. Also, the prices for staple foods like rice, sugar, oil, and chicken doubled due to a combination of delayed growing seasons, labor shortages, and increased input costs, Food inflation averaged 39.5%[8] (Development Asia, Accessed date: 2024. 8. 5.).

The definition of agricultural digital transformation for Lao PDR is the integration of various digital technologies across the agricultural sector to enhance productivity, efficiency, and resilience. The scope includes a range of tools such as mobile payment applications, e-platforms for information sharing, precision agriculture tools, and supply chain management systems that support farmers and agribusinesses. This transformation also involves improving digital infrastructure, like mobile broadband access, and developing supportive regulatory frameworks. These initiatives aim to enhance connectivity, digital literacy, and collaboration among stakeholders, fostering an innovation ecosystem to modernize Lao PDR's agricultural value chains and meet market demands.

8) Development Asia(https://development.asia/insight/securing-lao-pdrs-food-and-nutrition-future), Securing Lao PDR's Food and Nutrition Future, Accessed date: 2024. 8. 5.

1.2. The Importance of Agricultural Digital Transformation in Lao PDR

The government's National Agenda prioritizes increasing commercial production to reduce imports and boost exports in economic corridors. The recent 9th National Socio-Economic Development (2021-2025) aims for an average annual economic growth of 4-5%, with agriculture accounting for 15.3% of GDP by 2025, based on an average growth rate of 2.5%. Agriculture, livestock, aquaculture, agro-forestry, and NTFP conservation are among the most important agricultural sub-sector. The most recent National Agenda, approved in August 2021 at an extraordinary session of the National Assembly's ninth legislature, calls for increased commercial production to reduce imports and boost exports along economic corridors. To accomplish this, the government has directed the Ministry of Agriculture and Forestry (MAF) to work with other organizations to promote agricultural production and animal husbandry throughout the country, as well as to promote digital transformation in a variety of sectors, including agriculture. Application of digital technologies in the agriculture sector aims to further the development of agricultural value chains that follow the strategic direction of clean, safe, and sustainable agriculture on the basis of industrialization and modernization in connection with rural development.

Urbanization increases the demand for food in the country, and smallholders play an important role in ensuring food security. During the COVID-19 lockdown, there is concern that the restrictions on the

import and export of foods and goods will lead to food insecurity in the country if they take longer than anticipated. Food prices have risen since the COVID-19 outbreak, owing to restrictions on food imports and the market's high rate of inflation. The government capitalizes on the situation by encouraging domestic food production. The government places a high priority on assisting smallholder farmers and agribusinesses in implementing good agriculture practices, organic agriculture, climate resilience, and technologies to increase rice production and diversify crops, vegetables, livestock, and aquaculture production to ensure adequate domestic market supply.

The government's infrastructure and regional integration policies have led to increased cross-border trade and international cooperation in agricultural and livestock production. The government has pledged to increase Chinese investment in agriculture and forestry, leveraging the Laos-China Railway's potential to boost exports.

Several documents reported similar challenges that limit potential in agriculture development, among them two biggest challenges are a low productivity and a lack of modernization farming practice. The main causes of low productivity of agriculture and a lack of modernization in farming practice could be summarized as follows [9]:

- Smallholder farmers still have limited knowledge for new techniques of production and capacity of farmer cooperation / organization / groups are weak.
- Farmers still use traditional equipment and methods of cultivation

9) Ministry of Agriculture and Forestry(MAF) (2021), Draft Agriculture Development Strategy to 2025 and Vision 2030 (Revised).

like manual ploughing, one crop pattern and old system of irrigation.

- Insufficient irrigation facilities which limited farmers to produce one crop only in a year.
- Problems of soil quality because of overuse of pesticides, especially in the upland area.
- Problems of pests and animal diseases (e.g. Fall Army Worm, Grasshopper, African swine fever, lumpy skin disease in cattle).
- Inadequate credit facilities in the rural area led to difficulty to access to finance for the smallholder farmers.
- Poor access to quality and resilience seeds
- High cost of transportation forces the farmers to sell their product in higher prices.
- Reduction of cultivation land due to the demand for land in agriculture has to complete with the national priority in other sectors and overuse of pesticide.
- Limited diversifying agricultural commodities.
- Lack of capacity to meet the rising demand for a greater variety, higher quality, and higher quantity of agricultural products, as well as higher safety and hygiene standards.
- Lack of capacity to cope with climate change and threats from natural disasters.
- Limited use of technology in the agriculture sector, especially no technology uptake in the post-harvest process.
- Access to finance and market information by farmers/producer groups.
- Declining trend in labor availability in the agricultural sector.

Agriculture and forestry investment comes from three sources: the Public Investment Program (PIP), Overseas Development Assistance (ODA), domestic Lao private sector investment, and foreign private investment (FDI). The revised The National Agriculture Development Strategy (ADS) in 2021 stated that MAF receives ODA from a variety of sources, including international financial institutions, international organizations (Asia-Pacific and African), Europe and America, and international non-governmental organizations. The promotion of private investment, both domestic and foreign (FDI), in crops, animal husbandry, and industrial plantations for commercial purposes is significant, with a total of 800 companies up to 2020 and an investment value of $4.4 billion, of which 1.8 billion is from the registered fund, and 547,00 hectares under contract farming and land concession. In this context, it is important to consider the role of these actors in driving the demand for the adoption and use of digital technology in the agriculture sector.

2. National and Sectoral (Agricultural) Digital Transformation Policies

2.1. The Digital Policy of Lao PDR

Lao PDR has made significant progress in developing a number of digital policies and regulations. The lead ministry in charge of digital

development is the Ministry of Technology and Communications (MTC). The E-Government Center under the MTC is in charge of the electronic government system. The center is in charge of centralizing the government's IT services, managing and developing administration and service software, and there is still limited capacity for expanding the hosting platforms. Other ministries are currently investing in their own data centers, which are not yet connected. A number of key laws and regulations governing digital technology development management have been listed on government online platforms for public access, including the Lao Official Gazette website and the Lao Law application.[10)]

Since 2012, the government has issued several laws and decrees related to ICT, including Law on High Technology, 2012 (No.07/2021), Law on Telecommunication (amendment) 2021 (No.05/2021), Law on Electronic Signature, 2018 (No. 59/2018), Law on Electronic Data Protection, 2017 (No. 25/2017), Law on Radio Frequency, 2017 (No. 17/2017), Law on ICT, 2016 (No. 02/2016), Law on Cyber Crime, 2015 (No. 61/2015), Decree on Online Information Management, 2014 (No. 327/2014), Law on Post, 2013 (No. 45/2013), Decree on Satellite Communication, 2019 (No.471/2019), Decree on Telecommunication Transmission System, 2020 (No.01/2020), Decree on Internet Data Center, 2016 (No. 412/2016), Decree on Internet Information Management, 2014 (No.327/2014), Decree on Frequency Waves, 2014 (No.60/2014), Decree on Internet Management and Use, Internet Code, 2012 (No.164/2012). In 2021, the government also passed a

10) https://laoofficialgazette.gov.la/

Decree on Electronic Commerce, opening the stage for future electronic commerce expansion. Although those legal frameworks are existed, building trust for citizen in areas such as e-commerce, data privacy, cyber security, security for mobile payment apps is required time and investment.[11)]

Digital transformation is a critical government policy to lead the country into the industrial 4.0 era. The long-term National Information and Communication Technology (ICT) Strategy (2016-2025) and Vision to 2030 were developed, aiming at creating a universal one-data center and driving innovation across sectors. The digital transformation of the county is moving towards 1) a digital government by transforming communication and collaboration within government organizations through the use of electronic systems such as e-office, G-chat, and teleconferencing systems; 2) a digital economy by promoting digital forms, spending in electronic financial systems such as Mobile Money or the bank's digital payment applications like BCEL OnePay payment application and e-commerce (e.g. plaosme.com); 3) a digital livelihood and user-friendly society by transforming society into a digital form of public access to services such as the LaoKYC application for accessing government services and information on COVID-19 vaccinations and disease management, Lao Digital ID, taxi service (e.g LOCA), food delivery applications (e.g. FoodPanda and Gotedy).[12)]

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11) Center for Strategic and International Studies Briefs (2022. 2. 16.), "Digitalizing Laos: Improving Covenant Transparency, the Business Environment and Human Capital".

12) Ministry of Technology and Communication (2015), The National Information and Communication Technology (ICT) Strategy (2016–2025) and Vision to 2030.

2.2. The Agricultural Digital Policy of Lao PDR

The Ministry of Agriculture and Forestry (MAF) has recognized the importance of digital technology applications in addressing a number of challenges in the agriculture and forestry sectors, which outlines in its Information and Communication Technology (ICT) Strategy to 2025. Following the strategic direction of the National Information and Communication Technology (ICT) Strategy and Vision to 2030, the ICT Strategy for 2025 of the Ministry of Agriculture and Forestry (MAF) was developed to accelerate agricultural modernization. The strategy has defined four areas of entry points for ICT intervention, according to the mandate of the ministry, including an ICT program to monitor the implementation of the ADS, support to improve the situation of food production, commercial agriculture, and forestry management. However, implementation remains reliant on technical and financial support from development partners.

〈Table 4-1〉 ICT for Agriculture and Forestry Entry Point and Indicative Programs Requirement

ICT for Agriculture and Forestry Entry Points	Indicative ICT program services requirement to address challenges in agriculture and forestry sector	Some detail support activities, application and advisory
Agriculture and Forestry Sector Development Plan	– A result-based monitoring and evaluation system for ADS implementation. – Collaboration platforms for sub-sectorial policy dialogues. – Rural development and poverty reduction MIS	– Information integrated system for governances and sharing platforms – Decision support system. – Cross sectorial data sharing and integration.

(continued)

ICT for Agriculture and Forestry Entry Points	Indicative ICT program services requirement to address challenges in agriculture and forestry sector	Some detail support activities, application and advisory
Food Production	– ICT infrastructure improvement program. – Disaster risk reduction and management system. – Climate change adaption knowledge management system. – Land resources information management system – Developing a centralized database to store and analyze agricultural data. – Smart Farming Technologies	– Expanding broadband and mobile internet coverage in rural areas. – Setting up digital hubs or community centers equipped with internet access and digital tools. – Implementing digital tools for real-time data collection on crop yields, soil health, and pest infestations. – Establishing farmer field schools with a focus on digital technologies. – Introducing precision agriculture tools such as soil sensors, weather stations, and GPS-guided equipment. – Conducting pilot projects with drones for crop monitoring and pest control. – Demonstrating the use of IoT devices for automated irrigation and fertilization.
Commercial Agriculture	– Capacity development program on ICT. – Agriculture production and marketing information integration. – Rural advisory service. – One Agriculture information Mobile app. – e-commerce platforms – Financial Services and Digital Payments.	– Organizing workshops and training sessions on digital literacy and the use of agricultural apps. – Creating online courses and resources on digital farming techniques. – Training local authorities and extension workers on data management and analysis techniques. – Developing user-friendly agricultural apps for smartphones that provide information on weather, crop management, and market prices. – Train local communities on how to use e-commerce platforms to expand market access for their products.

(continued)

ICT for Agriculture and Forestry Entry Points	Indicative ICT program services requirement to address challenges in agriculture and forestry sector	Some detail support activities, application and advisory
Commercial Agriculture		– Partnering with Fintech companies to develop digital payment solutions tailored for farmers. – Providing training on mobile banking and digital financial management. – Integrating SMS and USSD services for farmers without smartphones to access essential information. – Facilitating access to microloans and insurance products through digital platforms.
Forestry	– Forest cover GIS – Forest protection database. – Forest production MIS – Carbon emission/sequestration simulation/monitoring system. – Smart Forestry Technologies	– Forest Monitoring Apps: Develop mobile applications for forest monitoring, which include features for reporting illegal logging, forest fires, and pest outbreaks. – Create online platforms for sharing information on sustainable forestry practices, market prices for forest products, and conservation strategies. – Use satellite imagery and Geographic Information Systems (GIS) for real-time monitoring of forest cover, deforestation, and reforestation efforts. – Establish databases to store and manage forestry data, making it accessible for analysis and decision-making. – Drones: Utilize drones for aerial surveillance and mapping of forest areas to monitor health and detect illegal activities. – IoT Sensors: Implement IoT sensors in forests for real-time monitoring of environmental conditions such as temperature, humidity, and soil moisture.

(continued)

ICT for Agriculture and Forestry Entry Points	Indicative ICT program services requirement to address challenges in agriculture and forestry sector	Some detail support activities, application and advisory
Policy and Regulatory Framework	– Developing supportive policies and regulatory frameworks to encourage the adoption of digital technologies in agriculture and to protect data privacy and security.	– Drafting and implementing policies that support the adoption of digital technologies in agriculture. – Establishing regulations to ensure data privacy and security for farmers. – Creating incentives for private sector investment in agricultural digitalization.
Public–Private Partnerships	– Encouraging collaboration between the government, private sector, non-governmental organizations, and international agencies to drive the digital transformation of the agricultural sector.	– Collaborating with tech companies to develop tailored digital solutions for agriculture. – Engaging with non-governmental organizations to provide training and resources. – Partnering with international agencies for funding and technical support.
Research and Innovation	– Promoting research and innovation in agricultural technologies and practices to ensure the continuous improvement and adaptation of digital solutions to local needs.	– Funding research projects on the application of digital technologies in local agricultural contexts. – Encouraging innovation through competitions and grants for tech start-ups in agriculture. – Collaborating with universities and research institutions on developing new agricultural technologies. – These activities collectively aim to transform the agricultural sector in Laos by leveraging digital technologies to improve productivity, market access, and overall sustainability.

Source: MAF (2016), ICT Strategy for the Lao PDR Ministry of Agriculture and Forestry 2025.

Putting digital transformation into implementation in different sectors requires new knowledge, skills, and resources. The digital transformation is complex. The use of ICT in the public sector is still

limited in the country due to the fact that the organization still has limited financial resources and skills in ICT human resources. The Lao Social Indicator Survey II (LSIS-II) survey in 2017 confirmed that socioeconomic disadvantage and a lower education level appeared to be factors that contributed to a lower likelihood of young people using ICT skills. According to the survey, people with a university education represent about 26% of those who have ICT skills, while those who did not attend primary school had none.[13] In addition, the transformation of digital requires participation from all actors. It is, therefore, important for everyone to understand the scope, strategic direction, and interventions in order to engage them in the transformation process and activities.

3. Technological Applications in Lao PDR Agriculture

3.1. The Digital Technology of Lao PDR

In terms of accessing ICT and internet application, the government, in partnership with private sectors has made significant progress in connecting its citizens to the internet. According to Ministry of Technology and Communication statistics, Laos had 92,900km of fiber

13) United Nations Children's Fund & Government of Lao PDR (2020), Lao Social Indicator Survey II 2017.

optic cables in 2020, which covered all districts and provinces in the country. Mobile phone base stations are located in 96% of the country's villages. High-speed internet via 3G and 4G mobile phones reached 82% and 55% of all villages, respectively. High-speed internet access in rural or remote areas is not yet widespread. The number of villages without telephones totaled 400 in the country, accounting for 5% of the villages without an internet signal. GSM wireless telephone numbers totaled 1.3 million, with 47,000 wireless landlines covering 96% of the country's coverage area. Individuals' use of cellular devices has increased, particularly smartphones, which are very popular through the 3G and 4G networks to access social media and applications, accounting for 95% of actual phone numbers (4,636,690 numbers). The total number of cellular subscribers has increased since 2016, as shown in 〈Table 4-2〉. The majority of internet users use mobile devices to access the internet across the country. Vientiane Capital has a lot of broadband internet connections. Figure 2 illustrates the distribution of mobile phone numbers by province.[14]

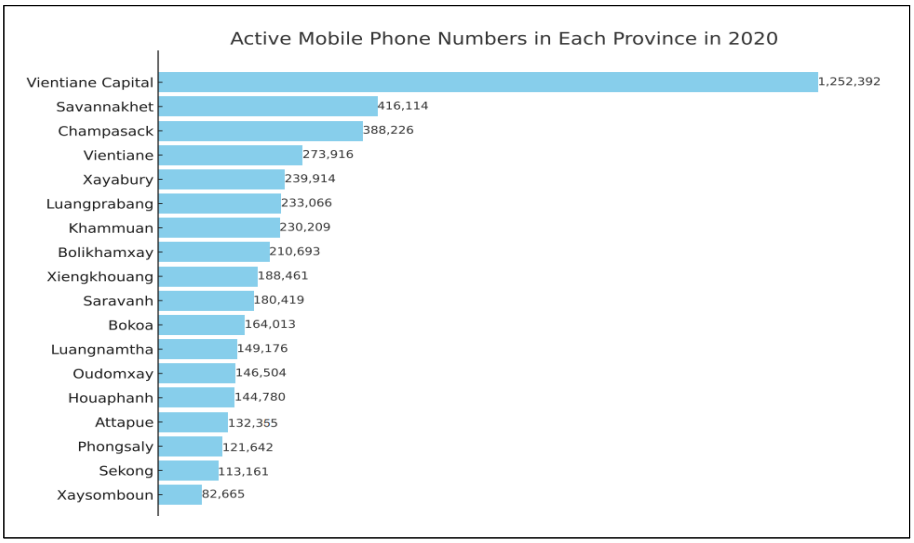
〈Table 4-2〉 Total Mobile Phone Number in Laos in 2020

Years	Active mobile telephone number	GSM number (number)	Pre-paid/Refill number
2016	3,958,510	200,696	3,757,814
2017	3,711,813	195,864	3,515,949
2018	3,662,336	207,424	3,454,912
2019	4,636,926	204,976	4,431,950
2020	4,636,690	265,449	4,371,241

Source: Ministry of Technology and Communication (2020), Annual Technology and Communication Statistics Book.

14) Ministry of Technology and Communication (2020): 2020 Annual Technology and Communication Statistics Book.

〈Figure 4-1〉 Active Mobile Phone Number in Each Province



Source: Ministry of Technology and Communication (2020), Annual Technology and Communication Statistics Book.

The Ministry of Communication and Technology holds the primary role in regulating the country's telecom market. There are five telecom operators serving the Lao population. The government owns a financial stake in the telecom operators 〈see table 4-3〉, and the decision is still subject to agreement by all shareholders. The main issue with this situation is that the regulatory regime appears to create an environment in which providers have few incentives to invest in new infrastructure or improve service quality; sufficient returns on investment cannot be guaranteed with such strict pricing controls, and there is the possibility of political interference.[15)]

15) BuddeComm Worldwide Network (2022), Laos launches 5G services in the hope of fueling telecom sector growth.

〈Table 4-3〉 Telecom Operators in Laos

Name of Telecom Operators	Type of Services	Share of Investment
ETL Company Limited	PSTN	49% Lao Government 51% JIAFU (China)
	2.5G (GSM900/1800, GPRS)	
	3G (GSM2.1 GHz)	
	ISP (XDL, HIL, VPN, FTTX)	
Lao Telecom Company (LTC)	PSTN	51% Lao Government 49% Shennington (Thailand)
	2.5G (GSM900/1800, GPRS)	
	3G/4G (GSM)	
	ISP (XDL, IP Star)	
Star Telecome (UNITEL)	PSTN	51% Lao Government 49% VietTel (Vietnam)
	2.5G (GSM900/1800, GPRS)	
	3G (GSM)	
	ISP (XDL, FTTX)	
T.plus	2.5G (GSM900/1800, Edge)	100% Lao Telecom Company (LTC)
	Wimax, 3G, FTTX	
Best Telecom	Fiber, FTTx, Wifi and Quad Play	100 Lao Government
	DPLC, IPLC, Dark Fiber	
	IPTV, VOIP, IDC, BISS and SI	
	Mobile Broadband (BB-WiFi, BB Mobile 3G/4G)	

Source: Ministry of Technology and Communication (2020), Annual Technology and Communication Statistics Book.

The assessment of the World Bank (2018) reported that the cost of technology for both hardware and software in Laos is quite high, leading to the high cost of their services.[16] The report indicated that the IT infrastructure and internet services are not reliable and expensive due to the fact that the vast majority of materials are imported with high cost.

The number of service providers has grown, allowing to drive the

16) World Bank (2018), Digital Connectivity in Lao PDR – Lagging Behind Peers: A short assessment with policy recommendations to catch up.

success of using more digital technology in society. According to MTC's Annual Technology and Communication Statistics Book for 2020, nationwide companies registered to provide internet connection service to the public increased from 15 in 2018 to 32 in 2020, where ICT service providers/companies also increased annually, as shown in 〈Table 4-4〉.

〈Table 4-4〉 A numbers of ICT service providers in Laos in 2020

ICT Service Providers	Unit	2016	2017	2018	2019	2020
Internet cafe shop	Shop	454	691	772	509	512
Business that supplies data in an electronic format.	Company	26	9	12	8	8
ICT Consulting Companies	Company	10	23	15	39	40
ICT Training companies	Company	3	8	14	20	20
Software development and service companies	Company	30	48	51	79	81
Import ICT equipment companies	Company	170	24	42	39	40
IT equipment distribution service companies	Company/ shop	–	709	789	1,466	1,473
ICT installation and repair service companies	Company	391	118	602	443	445
Total ICT Service Providers	Company/ shop	1,084	1,630	2,297	2,603	2,619

Source: Translated from the MTC (2020), Annual Technology and Communication Statistics Book 2020.

3.2. The Digital Technology of Lao PDR Agricultural Sector

Using the digital devise in the agriculture sector is increasing. Various forms of digital technology tools are using in the agri-food system which can categorize them as follow. These tools have been used and enable farmers and other value chains stakeholders to

increase ability to access inputs and credit, while also receiving knowledge and advisory services to support better resource management and improving efficiency of business services. However, most of digital tools are still simple and services are being used at scale. Below are selected examples and experience of existing digital technology used in agriculture sector by different government, development projects, banking institutes, inputs suppliers, traders, agri-food processers, transporters, farmers and public in general.

- **E-extension:** The common types of e-extension used in Laos include e-learning both online and offline and e-farming technical advisory services, which use the power of online networks, computer communications, and digital interactive multi-media to facilitate dissemination of information and knowledge.
- **Laos Climate Service for Agriculture (LaCSA) application:** This mobile application was created as part of the Agro-climatic Monitoring and Information Systems (SAMIS) project, which was funded by the Food and Agriculture Organization (FAO), in collaboration with the Ministry of Natural Resources and Environment (MONRE) and MAF. LaCSA is a mobile climate service application that provides Lao farmers with agro-meteorological information in a compact format. Bulletins are the standard output channels, and they are published online and delivered to subscribers. Farmers received weather forecasts, pest and disease reports for their respective areas, as well as flood and drought warnings. Farmers could access agro-meteorological data on a weekly, monthly, and

district-by-district basis. This application aids in the early detection and response to climate change and pest disease events, which may have an impact on farmer production, food security, and livelihood. The application is currently being used throughout the country. According to a recent FAO assessment, LaCSA has already reached over 110.000 farmers in the country through projects run by UN agencies and others. It was distributed via farmer groups, loudspeakers, and school posters. This excludes the weekly television broadcast, Facebook, and radio. Around 78% of farmers in the project's target villages have been listening to weather reports in LaCSA via loudspeakers. LaCSA influenced approximately 85% of the farmers who participated in the study to change their farming practices. This means that farmers used more innovative fertilizers or pest control methods, changed the crop varieties they planted, or that they tailored the irrigation process. This demonstrates how LaCSA can be used to supplement information for an extension.

- **Mobile4D application (no longer active):** This application aids in the early detection and response to climate change and pest disease events, which may have an impact on farmer production, food security, and livelihood. The application is currently being used throughout the country. According to a recent FAO assessment, LaCSA has already reached over 110.000 farmers in the country through projects run by UN agencies and others. It was distributed via farmer groups, loudspeakers, and school posters. This excludes the weekly television broadcast, Facebook, and radio. Around 78% of farmers in the project's target villages have been listening to

weather reports in LaCSA via loudspeakers. LaCSA influenced approximately 85% of the farmers who participated in the study to change their farming practices.

- **Online-learning :** The common tool used remains developing a short video to provide knowledge and information and posting in YouTube, Video. Interviews with key information suggests that this type of media is easy to use for the awareness raising and learning but have to ensure the availability in both online and offline in local languages.
- **E-Platforms:** This refers to the communication platforms that are accessible through websites or networks that are operated by projects supported by donors in partnership with government agencies. Website or network communication, social media platforms (e.g. Facebook, YouTube, Video, Instagram, WhatsApp, Messenger, etc.) are widely used in Laos, particularly by young people.
- **LaoFAB (www.laofab.org):** This is an ongoing forum for sharing information about farmers and agribusiness in Laos. LaoFAB was launched from 2006 to 2014 by the Extension for Agriculture Project (LEAP), together with MAF. Upon the completion of LEAP, funded by the Swiss Agency for Development and Cooperation (SDC). The Lao Upland and Rural Advisory Service (LURAS) continued to support the operation of this forum from 2014-to 2025. The platform has about 5,000 members, and thousands of documents are available in its repository library. Members include government officials, representatives from donor agencies and

non-governmental organizations, project experts, academics, and businesspeople. This project's lesson teaches us that this type of forum is extremely effective at facilitating technical discussions about agribusiness and rural development issues. However, farmers are not yet benefiting directly from this forum because their ability to participate in the discussion is limited. Farms typically benefit from the project's adoption and use of materials when working with farmers and producer groups.

- **Land Resources Information Management System (LRIMS) web-based application (www.lrims-dalam.net):** This active platform has developed as part of the implementation of the ongoing SAMIS project. The LRIMS is a large-scale land resource information management system. The system has been used to generate climate maps that describe past and future climatic variables on a geographical scale. The map of climate-related variables includes information such as humidity, atmospheric pressure, wind speed, sunlight hours, and so on. The results will facilitate the creation of agro-ecological zoning and feed into the Land Resource Information Management System (LRIMS), which will be used to develop agricultural and adaptation policies. A mobile phone application is under development. This app just recently launched and has not yet reported on the impact and lessons learnt from users.
- **Laotradeportal (www.laotradeportal.gov.la):** The website assists traders in finding all information about importing goods into Laos and exporting goods from Laos, including the import/export process, regulations for specific products, relevant laws, and other

useful information. The Department of Import and Export of the Ministry of Industry and Commerce hosts the website on behalf of all government agencies involved in the import/export process. It is in charge of the Trade Facilitation Committee Secretariat (TFCS) focal point. This website assists the government, farmers, and private sectors in determining what each agency requires for specific business operations.

- **Social Media Platforms:** Social media and internet advertising are popular in Laos. Despite the government's push for electronic commerce, the private sector is underutilized due to insufficient telecommunications facilities, particularly in rural areas, and a low rate of credit card use in the country. According to Data Reported, Laos had 3.80 million active social media users in January 2022, accounting for 51.1% of the total population. The number of users increased by 200 thousand, or more than 5.6%, between 2021 and 2022. Facebook is the most popular and effective way for private-sector businesses and entrepreneurs to communicate with their customers. According to data published in Meta's advertising resources, Facebook had 3.50 million users in Laos in January 2022, with Facebook's ad reach accounting for 92.2% of the local internet user base. Instagram is less popular in Laos. Instagram had 613.6 thousand users, and its ad reach in Laos was equivalent to 8.3% of the total population at the beginning of 2022.[17] Facebook Messenger, LinkedIn, Twitter, and WhatsApp are other popular social media platforms among Lao citizens.

17) https://datareportal.com/reports/digital-2022-laos

- **Mobile payment applications:** Mobile payment applications are a digital financial service for agriculture. Most telecommunications companies (mainly LTC, ETL, Unitel) and banking institutions (like state-owned commercial banks, joint state commercial banks, private banks, subsidiary banks, and foreign commercial bank branches) are shifting their services to mobile applications, including e-commerce/trading. They have tried to connect to other banking and online purchasing services in order to strengthen their services.
- **BCEL OnePay:** This is a mobile phone app that allows users to pay anyone, anywhere, directly from their account by simply photographing a QR code. It is a service provide by Banque pour le Commerce Exterieur Lao Public (BCEL). The bank also has many other app provide service for public.
- **U-Money:** This is a mobile bank service which Star FinTech Sole Co., Ltd. has launched as a new financial service. Star FinTech Sole Co., Ltd is a sub-company of Star Telecom (Unitel) that enables customers to recharge for prepaid and postpaid subscriptions as well as send and receive money quickly and securely across the country via Unitel's mobile network at any time and from any location.
- **M-Service:** This is a mobile bank service to allow people to do payment for their mobile and internet service. This is a product of the LTC.
- **Supply chain tool:** Several logistics and delivery companies operating throughout Laos, particularly in Vientiane, are now offering

door-to-door service during the lockdown, delivering products ranging from clothes to food and drinks to private homes. During COVID-19, logistics businesses, particularly goods delivery services, grew rapidly and expanded their scope. This has directly benefited the local economy through the economic dynamism of companies like Food Panda, HAL Logistics, and Shopping-D. Food Panda and GoTedh, for example, are both food delivery and grocery delivery apps that serve as one-stop mobile-based delivery services in the country. The country's e-commerce situation remains very limited due to a low number of people using e-payments. As part of society's adaptation to the new normal, vendors of food, fruit, clothing, and household products are increasingly using Facebook live streaming as an online platform to sell their products. This type of supply chain proved to be extremely effective, and people in society changed their shopping habits as a result of the new normal situation. Transportation logistics companies (e.g. Lao Freight Forwarding Co.Ltd; Lao American Logistics, Kiengkai, Anousith, Houngaloune Logistics, etc.) have developed an effective tracking system and linked their payment services to mobile payment applications.

- **Precision agriculture tool:** GIS, GPS, remote sensing, sprinkler systems, mini-irrigation systems, and solar-powered irrigation pumps have adopted by farms, producers, and larger agriculture concessions, depending on the scale of their farming business model. However, there are very limited smart farms in Laos due to the fact that they require investment in digital tools, which the characteristic of Lao farmers remains at a small scale using simple technology.

3.3. Requirements for Development of the Digital Technology of Lao PDR Agricultural Sector

There is required for basic conditions in the use of digital technologies and, as a result, for the digital transformation of agriculture and food. The FAO identified the basic conditions that must be improved in order for the country to fully transform, including infrastructure and connectivity (mobile subscriptions, network coverage, internet access, and electricity supply), affordability, educational attainment (literacy, ICT education), and institutional support.[18] Looking back at these basic conditions, the study attempts to define a variety of potential factors driving successful and emerging digital agriculture technology, which can be divided into demand and supply sides.

The supply-side that influence digital agriculture technology in Laos are: 1) expanding mobile and internet connectivity infrastructure, where the number of mobile broadband connections has increased; 2) more adaptable and affordable digital tools which have been tests and prove effective results by different actors (public and private sectors); 3) advanced data analytics and information exchange which can use as data and information to inform decision making; 4) a growing need for conceptual understanding of agricultural solutions and respond to challenges in agriculture and value chain development; and 5) government and international support communities driving the digital

18) FAO (2019), Digital Technologies in Agriculture and Rural Areas.

transformation to improve agriculture production.

The demand-side factors influence digital agriculture technology adoptions, including 1) rising populations and the expansion of urbanization, which increase the domestic demand for variety of detail tools and food; 2) the export demand for food is also growing, with demand coming from Thailand, Vietnam, and China; 4) number of farmers need to use mobile phone is increasing; 6) agribusinesses and trader are seeking to ensure a more stable supply of produce from farmer.

However, there are some challenges to be addressed to enable digital agriculture technology adoption, including the acceptable cost of internet mobile data investment, insufficient connectivity in rural areas, internet instability outside of urban areas, low rate of ICT literacy, access to finance and credit to support more investment in ICT and DAT and readiness of the country for transforming.

In the agriculture sector, there is high potential to scale up the investment in e-platform and e-extension with a focus on e-learning both online and offline and e-farming technical advisory services. In the Lao context, agricultural extension services refer to information that is designed to support increased production capacities and livelihood alternatives among farmers and other rural residents. The information available can consist of farming techniques and trends, weather forecasts, pest or crop disease advice, and seed or other input management techniques. The experiences shared from development projects demonstrated that using information technology as an advisory tool for rural development and agriculture knowledge transfer is possible and effective. In the e-Extension services should include

more informatics applications that producers would be able to access via mobile applications such as: an information and knowledge advisory portal on agricultural technologies and techniques, marketing, metrological forecasting, and natural disaster management; E-Learning modules for agriculture and rural development should include forestry management and conservation; ensure to provide interactive space for farmers are able to exchange information with expert's group to seek guidance on emerging issues and risks.

Lessons learnt from projects suggest that some challenges to be addressed in order to prevent the frailer of the E-Platform and E-Extension. Among them are:

- Ensure that infrastructure to facilitate accessibility of farmer
- Government Support and Policies: Develop rural development policies. Provide subsidies and financial incentives. Ensure transparency and accountability in projects.
- Infrastructure Investment: Improve roads and transportation. Invest in irrigation systems. Build storage and processing facilities.
- Community Engagement: Form farmer cooperatives. Offer training and capacity building. Involve local communities in planning.
- Public-Private Partnerships: Foster collaborations between government, private sector, and NGOs. Leverage private investment for infrastructure projects.
- Technology and Innovation: Use digital tools for market information and crop management. Encourage adoption of agri-tech solutions.
- Monitoring and Evaluation: Establish metrics to measure project effectiveness. Create feedback mechanisms for farmers.

- Sustainable Practices: Ensure environmentally sustainable projects. Promote efficient resource management.

Well plan for the sustainability, maintenance of ICT technologies, technology transfer and ownership. Many projects use and introduce new technological approaches to farmers. Those technologies worked well and left farmers satisfied during the project's activation. After the projects are completed, those technologies still require some operating and maintenance costs, which farmers and governments are unable to bear due to budget constraints, causing the tool to gradually stop functioning, as in the case of the Mobile4D application. The key to success in ensuring sustainability is to clearly define the target user to guide the design of e-extension service materials; promote community awareness and understanding of the benefits of using digital technology; costs were incurred in the implementation of various activities in the use of technology, so it is critical to institutionalize the tools to ensure self-sustainability.

Utilization of farming cooperatives and informal farmers' groups: Producer groups are beginning to use social media platforms such as Facebook pages, SMS, WhatsApp and Messenger groups, radio, TV, and YouTube videos to share and access information while marketing their products. It is critical to strengthen cooperative groups and farmer networks in order to gain more bargaining power, exchange knowledge, and share experiences among group members, particularly when using new digital tools in the field. The Ministry of Agriculture and Forestry is attempting to revitalize agricultural cooperatives as a

mechanism to deploy agricultural extension services in particular communities through cooperatives located in the same area.

There are few initiatives working on marketing/prices information. One of the reasons could be a lack of reliance on data and information, as well as a mechanism for systematic sharing of pricing and marketing information. Access to official data appears to be a significant factor. However, limited access to market information will have an impact on the accuracy and effectiveness of agricultural resource management decisions.

Private sector (business, agribusiness, logistic and transport providers, traders, agro-processor), banking, donor and international communities have been participating and working with the government to enable digital transformation in all sectors. The MAF, for example, has created an environment in its development strategy that allows stakeholder groups to participate in DAT by developing its ADS and creating its own ICT Strategy. The government, in collaboration with donors and INGOs, as well as local NGO communities, the private sector, and producer groups, provides and delivers extension services through a variety of both traditional and e-extension tools to assist individuals and producer groups in improving their production for food security and commercialization. The Star Telecom Co. Ltd. has signed a Memorandum of Understanding (MOU) with MAF to collaborate on the digital transformation of irrigation management. Cooperation entails conducting joint research to create solution products and digital technology for platform system development in irrigation, agriculture,

livestock breeding, fisheries, and human resource development. In March 2022, the Lao Telecommunication Public Company (Lao Telecom) announced that it would invest more than US $27 million to improve and expand its telecommunications service network, specifically mobile broadband and fixed broadband, in order to improve service quality. Investment from the bank can unlock banking and financial transactions that farmers can use as they engage in transactions for agricultural trading linked to access to mobile wallets, online banking and later to credit-scoring and lending facilities.

The SWOT analysis of the digital technology transformation in Laos summarized below are based on the experience of digital technology transformation development situation, previous studies from World Bank (2018), United Nations Children's Fund & Government of Lao PDR(2020), and the Information and Communications Department of the MTC:

Strengths	Weakness
– Polity and society stability for foreign investment. – Economic growth rapidly will lead to increased income of citizen, increased profitability for firms, enabling more spending on research and development. – Internet connectivity and smartphone users are increasing rapidly. About 80% of the population is connected via social media. – Foundation of the ICT policy are existed, but still have room for improvement, particular on protecting consumers and cyber security.	– Low level of ICT literacy due to the fact that low numbers of young people practice carry out ICT activities. The implementation of DATs requires high levels of investment and to have a workforce capable of facilitating advanced skills training. – Technological costs are extremely expensive for both hardware and software because the vast majority of materials are imported. – Infrastructure and services are not reliable and expensive for rural areas, so it is difficult for smallholder farmers to justify their adoption and financing. – Limit understanding of digital transformation in different sector, for example the digital agriculture technology concept is not well defined for the various utilizers.

(continued)

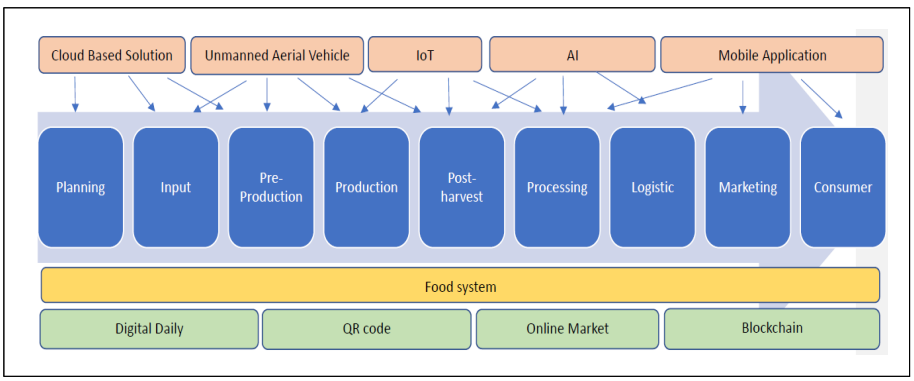
	– Building trust for citizen in areas such as e–commerce, data privacy, cybersecurity, security for mobile payment apps is required time and investment. – There are many DATs that are available in the region, particular technology for the smart farm tools, but they need to be tested through pilot projects and lessons learned drawn from them.
Opportunities	**Threats**
– The national digital economic policy has provided new opportunities for international investment in ICT. – Potential to partner with private sector About 60% (ILO, 2017) of population under the age of 25. Youth are active and innovative in using digital tools for marketing and start up. – There is potential partner with private sector to provide service and investment more in the digital connectivity facilities and service package which will be a key driver of economic and social development. – New advances in technology have been applied for start–up entrepreneurs. – Continue good partnership with international communities in providing technical and financial support to the government, MSMEs and producers groups. – Overtake on curves by new technology such as 5G	– Increasing of natural disaster such as more intense rainy season led to severe floods and droughts. – Lack of systematically ICT investment and construction plan. – Gap between Laos and ASEAN countries is likely to widen.

4. Readiness and Adoption Challenges for Digital Transformation

4.1. Readiness and Challenge Analysis Methodology

The study's findings are based on interviews with key stakeholders in the agri-food system, consultation with specialist groups, and a high-level meeting with the Ministry of Agriculture and Forestry to revise the value chain process, including planning, inputs, production, post-harvest processing, transportation/logistics, market access, and consumers <refer to Figure 4-2>.

<Figure 4-2> Digital Agriculture Technology in Agriculture Product's Value chain



Source: Author (Manoluck Bounsihalath).

The assessment evaluated the performance of six bottlenecks preventing successful and emerging agriculture transformation ecosystems from scaling up. The following criteria apply: (1) infrastructure service, (2) human capital, (3) density, (4) access to

finance, (5) regulatory framework, and (6) readiness. The dimensions chosen are based on literature on the characteristics of the entrepreneurship ecosystem[19] for scaling up start-ups and the characteristics of scaling up the digital agriculture technology ecosystem in Africa[20] and Vietnam[21], respectively. The readiness dimension was added to this assessment to capture the country's overall readiness based on stakeholder assessments, as well as the other five dimensions for farmer adoption and impact of digital agriculture transfer solutions in both urban and rural geographies. The assessment looks at the relationships between the six criteria, the size of the ecosystem, and its performance. The average score was used to analyze the ecosystem's current state. The scale was range from 1 to 5, with 1 being significant constraint, and up to 5 significant drivers of success. Scope of the six criteria and their sub-indicators have been defined as follows:

- **Infrastructure:** refers to telecommunications connectivity and may also include road transport and logistics.
- **Human capital and culture:** Human capital refers to the population's digital skills, labor force digital skills, user characteristics, and value chain actors' ability to adopt digitally. A culture is one that

19) Iseberg (2011), The Entrepreneurship Ecosystem Strategy as a New Paradigm for Economic Policy: Principle for Cultivating Entrepreneurship.

20) Kim et al. (2020), Scaling Up Disruptive Agricultural Technologies in Africa, World Bank Group.

21) World Bank Group, CIAT, CGIAR, FAO (no date): Digital Agriculture Profile of Vietnam, World Bank Group.

encourages experimentation and collaboration in innovation through entrepreneurship, research collaboration, economic freedom, and technological advancement. At the same time, it promotes risk tolerance and collaboration by encouraging businesses and farmers to incorporate digital tools into their business models, increasing demand for various types of digital technology in agriculture across value chains.

- **Density:** The frequency and intensity of engagement by various actors or services determine how frequently and intensely innovation occurs. The involvement of actors who form agglomerations of talented human capital in hubs and clusters increases the likelihood that successful innovations will emerge.
- **Access to finance:** The availability of low-interest financing (via micro loans, venture capitalists, and public capital markets) is critical to the success of start-ups and small businesses. Experienced investors can also help founders succeed by coaching and mentoring them along the way.
- **Enabling regulatory framework and incentives:** Governments play an important role in creating a stable, predictable, and encouraging regulatory environment for producers, entrepreneurs, and investors. Supportive policies include extension services, quotas, tax policies, patent protection, the formalization of alternative funding models, and investments in research and development.
- **Readiness:** A technology roadmap and level of readiness that can guide the public sector (government, CSOs), development partners, banking service providers, private sectors (agribusiness, traders,

agro-processing, transporters), farmers/producer groups, and individual workforce in transitioning to digitized workflows enabled by software and technology and leveraging key digital technologies.

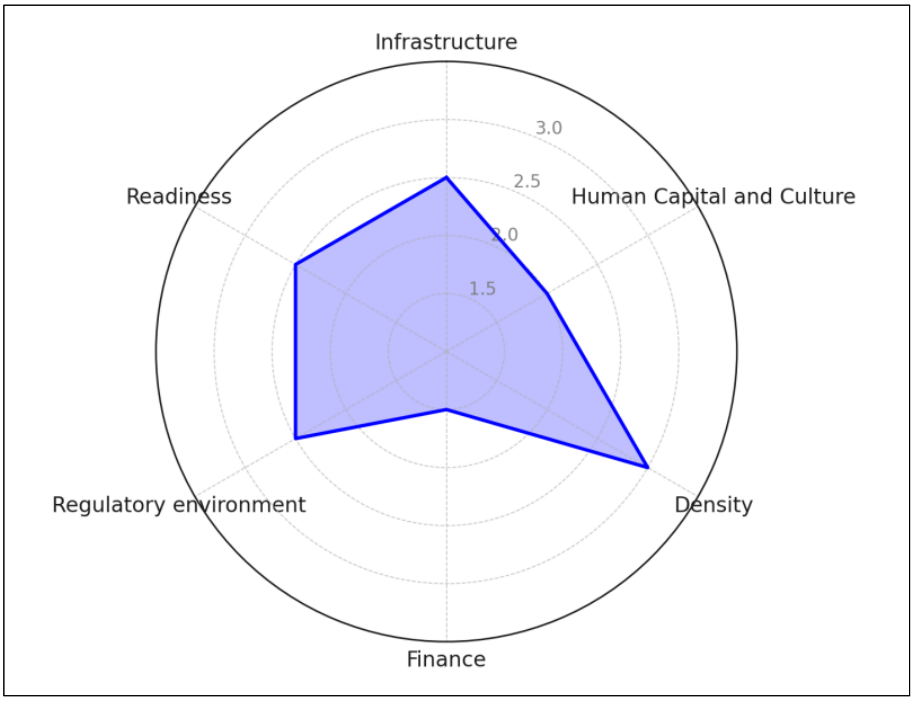
The purposive sampling method was used to select respondents and informants involved in agricultural value chains. Purposive groups were identified and selected using the following criteria:

- Diversity of user groups and service providers
- Farmers with prior experience using technology to support their farm business operations and market linkage.
- Agribusiness that has used digital technologies in their business operations.
- Competent internet service providers or IT solution providers offering a variety of service packages for various users.
- Agriculture, value chain development, and telecommunications management government agencies at the national and provincial levels.
- Development projects with activities and experience in integrating digital technology into their project activities or initiatives.
- Formal commercial banks that have service packages to support SME development and business start-up.

4.2. Readiness and Challenge Analysis

Figure 2 shows the average scores for the six dimensions used in this assessment. The composte score assesses the country's DAT ecosystem performance across six dimensions. The top three key success factors for achieving greater scale are ecosystem density (score 2), human capital availability (score 2), and infrastructure level (score 2.5). The regulatory environment, financial access, and readiness all have an impact on ecosystem performance.

〈Figure 4-3〉 Stakeholder's Perspective on Digital Agricultural Transformation



Source: Author (Manoluck Bounsihalath).

The stakeholders' assessment of the six criteria confirmed that the current performance of digital infrastructure services and the regulatory/enabling environment for DAT to scale up is moderate, while human resources, readiness, and access to finance are below average.

This section discusses the performance of six criteria based on the expert group meeting. The Expert Group Meeting was used to evaluate and confirm the findings of the literature studies and field survey scoring, ensuring that the study's conclusions are more reliable, accurate, and representative of a larger sample. The detailed analysis and scoring are discussed below.

- Infrastructure service score: 2.5

The infrastructure service received an average score. While the country is making good progress in expanding mobile and internet connectivity infrastructure, as well as the number of people using smartphones, rural access to stable internet and 4G services remains limited. Although internet service is now available to more than 80% of the country's population, access and quality in rural areas must be improved. The cost of hardware replacement is extremely expensive when compared to market revenue, as stated by Unitel, and it is truly difficult to upgrade internet services in rural areas with a small group of users, but at least 3G technology networks cover 95% of the country.

Telecommunication infrastructure is well established across the country. However, network coverage and signal stability can vary depending on geographic location. Farmers have enjoyed communicating,

sharing information, and learning from one another on a variety of topics via phone, SMS, WhatsApp, and Messenger. These types of communication are also used for communicating with input suppliers and buyers.

In this context, adequate and well-functioning telecommunication would enable scaling up of the innovative DAT however, indicate a willingness to adopt in the future, though not anytime soon. For this reason, smart farming practice in Laos is very limited. The country is in the transition of moving toward agricultural commercialization and modernization. It is required for the country to promote smart farms that adopt IoT and cloud-based solutions to improve the management of agri-food inputs, production, consumption, and distribution. The Agro-Farm Co., Ltd., for example, has a plan to invest in a smart farm. The company acknowledged that using IoT could assist in gaining detailed knowledge and valuable information about soil characteristics such as soil moisture, acidity level, the presence of specific nutrients, temperature, and a variety of other chemical characteristics that will aid in controlling irrigation and making water use more efficient.

- **Human capacity score: 2**

The infrastructure service received an average score. While the country is making good progress in expanding mobile and internet connectivity infrastructure, as well as the number of people using smartphones, rural access to stable internet and 4G services remains limited. Although internet service is now available to more than 80% of the country's population, access and quality in rural areas must be

improved. The cost of hardware replacement is extremely expensive when compared to market revenue, as stated by Unitel, and it is truly difficult to upgrade internet services in rural areas with a small group of users, but at least 3G technology networks cover 95% of the country.

Human capital is a main driver of digital agriculture technology development. The majority of since users of internet tools are adults, they have more access to women. For instance, at the start of 2022, women made up about 47.1% of Facebook's ad viewership in Laos, while men made up 52.9%.[22] Businesses of all stripes claim that the government has created an atmosphere that promotes innovation-related experimentation and teamwork. Two instances of engagement include research collaboration and entrepreneurship.

According to the Lao Social Indicator Survey II, socioeconomic disadvantage and a low level of education reduced the likelihood of young people using ICT capabilities. People with a university degree account for roughly 26% of those with ICT skills, whereas those who never attended elementary school have none. The IT Chamber of Commerce has confirmed that there are insufficient IT-skilled workers in the labor market to meet the country's demand. Because of the growing importance of digital technology, an increasing number of young people are enrolling in related courses.

As per the 2018 report by the Asian Development Bank[23], farmers face capacity constraints such as inadequate education, low literacy

22) https://datareportal.com/reports/digital-2022-laos

23) Asia Development Bank(ADB)(2018), Agriculture, Natural Resources and Rural Development Sector Assessment, Strategy, and Roadmap for the Lao PDR 2018.

and financial management skills, difficulty in accessing training to enhance their practices, and incapacity to conduct agribusinesses that comply with technical, sanitary, and phytosanitary (SPS) standards.

On the other hand, the occurrence of the COVID-19 outbreak indicates the important role of digital technology transformation and weaknesses in the e-learning system, It makes it necessary for all actors to have a solid plan and acquire ICT skills in order to enable them to use digital tools in their respective fields of work and take part in the digital transformation. In this situation, e-extension and especially e-learning has room to expand because it is comparatively less costly, has greater flexibility, is reachable by a larger user base, and fosters digital literacy in them. Social media has been noted to have grown in importance as a marketing tool for distributors, agribusiness, and farmers.

- Readiness score: 2.5

Laos has seen a steady increase in its digital transformation in recent years. Development sectors have embraced and supported the Lao digital economic plan, which seems to be a novel development for Laos. Advanced technology can be used to install and deploy business models, but there are still some challenges that need to be resolved, like literacy, advocacy, and people's ability to recognize both benefits and drawbacks. In certain ways, the digital infrastructure is also failing to keep up with the demands of the rapid advancement of digital technologies, which require quick responses and minimal latency. Another area where there is still work to be done to support the

development of digital technology is in the areas of human resource development and regulation enforcement. Concerns have been raised regarding the quality of IT education in order to meet market demand, and there has been discussion of relevant laws and regulations that may not be appropriate in certain situations.

For instance, the Agro-farm Company has made investments in greenhouses and hydroponics. Although the corporation was eager to invest in such technology in order to increase both the quality and quantity of their work, they understood that the expenses of such an investment were significant. However, technology developers find that they are ready to provide their users with technology goods that fulfill their needs. The Farmbook platform, which oversees agricultural production from farmer to customer, was introduced by JSL IT solution. The financial institution Maruhan Bank describes their financial service program for agri-tech companies, which is meant to assist start-ups and SMEs. National and local stakeholders have made an effort to integrate digital tools, like rainfall and climate monitoring, into their commercial operations.

A partnership between the National University of Laos and the Chulalongkorn University of Thailand was established with the aim of showing, testing, and advising the government on future scale-up in order to get the country ready to support smart farming in Laos. The Smart-Farming Model for Lao agriculture is depicted in 〈Figure 4-4〉. The organic farm served as an example of a smart farming approach, with the capacity to monitor and manage the farm remotely over the Internet. Growers can use their laptops, tablets, or smartphones to

manually turn resources on and off and to monitor them. A partnership between the National University of Laos and the Chulalongkorn University of Thailand was established with the aim of showing, testing, and advising the government on future scale-up in order to get the country ready to support smart farming in Laos. The Smart-Farming Model for Lao agriculture is depicted in 〈Figure 4-4〉. The organic farm served as an example of a smart farming approach, with the capacity to monitor and manage the farm remotely over the Internet. Growers can use their laptops, tablets, or smartphones to manually turn resources on and off and to monitor them.

- Regulation score: 2.5

Laos has produced a number of legislation supporting digital technology, however their actual implementation is lacking. There are rules that forbid cybercrime and promote digital payments as a kind of socioeconomic incentive. Social media has made the online market more prominent and widely used these days. Although it greatly increases market value, there is no legislation to back it in reality and link online retailers to the tax system. The COVID-19 pandemic is mostly due to the internet market in particular, and while the logistics sector is expected to grow quickly, there is now insufficient regulation to support its efforts to obtain an edge and manage the conflict.

The regulation has limited the performance of the DAT ecosystem.

It is still necessary to amend the laws and rules governing online company to take into account the present level of development. The results of the literature review also demonstrate that the government

has made great strides in establishing decrees and legislation pertaining to ICT. But putting those legal frameworks into practice is still difficult. Key informant interviews verified that rules and regulations pertaining to ICTs do not accurately represent the nation's contemporary developmental situation. For instance, many legal protections and rules governing digital procurement for online sellers and buyers are rendered ineffective as a result of e-commerce hurdles. Lao digital and ICT laws do not include any provisions or laws pertaining to online procurement; therefore, they must be adopted and introduced for legislative or regulatory change. While other agri-marketplaces, like Pinduoduo (www.pinduoduo.com), already have these kinds of fundamental customer policies that are supported and enforced by technology laws, existing regulations do not address these types of customer returns, payment security guards, and goods inspection requirements.

In addition, there is a lack of private sector participation in e-commerce regulation, In the absence of clear guidelines for data and information exchange between the several vendor and seller entities involved in the delivery, acceptance, and ownership of goods. On April 12, 2021, the Lao government released Decree on E-Commerce No. 296/GOV (henceforth referred to as "the Decree") in an effort to promote the expansion of this innovative method of conducting business. The Decree specifies the standards and process for e-commerce contracts, the regulatory framework for companies engaging in e-commerce operations, and how different government ministries would oversee e-commerce operations. June 14, 2021 was

the date the decree became operative. Nonetheless, specific regulations controlling the sharing of data and information in online information exchanges where participants' ownership is unclear still lack. The Lao government is in favor of creating an online marketplace for Lao agricultural goods in order to streamline the supply chain and reduce costs. Customers and producers will be able to access market and product information on this platform to fulfill necessary requirements, especially when exporting to China. Using an e-commerce strategy can help Lao agricultural products become more valuable by eliminating middlemen in the supply chain.

- Density score: 3

Development projects are underway in important areas where new technology solutions are in place and being implemented, such as logistics, digital payment, digital advisory, knowledge and information sharing, e-platform, and online meeting solution. Various sectors across the nation are making significant efforts to promote digital technology, particularly in the private sector. The CEO of JSL IT Solutions claims that we have developed numerous cutting-edge agricultural technologies that we can now incorporate into your business module as a result of our expertise with digital technology development. We have also received a number of intriguing requests from farming firms that are keen to test the solutions and observe the outcomes.

Ecosystem density, with an average score of 4.1 out of 5, is a key driver of success in achieving greater scale. This indicates that the

nation already has highly collaborative networks in place to facilitate the development of digital agriculture technology. The government collaborates with a wide range of stakeholders, including as INGOs, ICT service providers, SMEs, development partners/donors, input suppliers, and farmers, to support the digital technology revolution in agriculture. For instance, MAF and Unitel Telecom have joined together to create irrigation management through a public-private partnership. While networks of collaboration are available to assist in the development of DAT, projects still have difficulties in achieving synergy and connecting their current platforms.

- Financial score 1.5

Limited access to finance is one of the biggest challenges facing DAT innovators in Laos. Factors including household education, labor availability, and ethnicity affect farmer[24] capacity to obtain loans. Their decision to take out a bank loan is also influenced by other considerations, such as long-term loans, minimal collateral requirements, straightforward loan terms and conditions, and their capacity to manage and return the debt.

ADB (2018) states that there are three categories for the provision of rural financial services in the Lao PDR[25]: formal, semiformal, and informal. Commercial banks make up the formal sector. Project-based

24) National Agriculture and Forestry Research Institute (2020), Building and Evidence Base for Policy Formulation in the Agriculture and Rural Development Sector in Lao PDR.

25) ADB (2006), Rural finance in the Laos: Demand, Supply and Sustainability– Result of Household and Supplier Surveys.

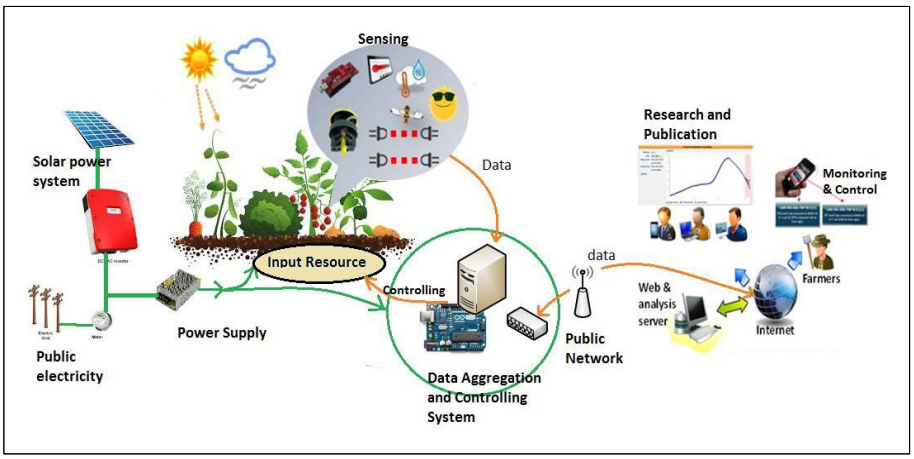
interventions are included in the semiformal sector. Loans made between friends and relatives, unofficial moneylending, and lending through the customary Lao houay are all considered to be part of the informal sector. With 41.0% of rural households having male financial managers and 37.2% having female financial managers, nearly 40% of all rural households had borrowed money.

Development agencies, like the EU, GIZ, IFAD, Luxembourg Development, ADB, and UNODC that have chosen to incorporate microfinance within their development projects are referred to as semiformal. The official commercial banks that lend to farming households include the farming Promotion Bank (APB), Nayobai Bank, and Lao Development Bank. When it comes to supporting farmers during natural catastrophes or disease outbreaks, the APB does not have a set policy. The Bank of Laos PDR may ask the APB for help when needed. Another source of lending that focuses on the commercial sector is microfinance institutions. A small number of farmers are able to borrow from microfinance firms because of the high interest rates. Microfinance organizations have a strategy of extending payment terms and cutting interest rates to support farmers in the case of a disaster.

Strong opinions are held by the expert group regarding the availability of funding for startups and entrepreneurs. Strict quarantine rules and regulations, along with inexperience in business and finance management, make approaching them more challenging. For farmer organizations, borrowing money for DAT investment is a challenging decision that comes with a heavy cost if they don't have a

well-defined business plan. There would be significant risks involved, as well as knowledge and experience gaps. The results of the interviews and literature analysis point to a number of problems facing small farmers and business owners who have no background in financial portfolio management and business planning. The great bulk of agricultural output is produced by these groups, but they don't get much funding to increase it. Another argument has been made that technology is better than taking out loans since money might not have a big impact on small household agricultural productivity.

〈Figure 4-4〉 Smart-Farming Model for Lao Agriculture



Source: National University of Lao (2017), Presentation of Department of Computer Engineering and IT, Faculty of Engineering, National University of Lao, ASEAN IVO Forum 2017.

4.3. Conclusion

The evaluation of the six criteria reveals that ecosystem density (score 3), human capital availability (score 2), and infrastructure level (score 2.5) are the main factors that contribute to the achievement of bigger scale. Access to financing, preparedness, and the routine environment all have an impact on the ecosystem's success. DAT-related laws and regulations are inconsistent and out of date, which makes implementation challenging.

Factors influence the growth of digital agriculture technology can be groups into demand and supply side driven. The supply-side factors that are driving the digital transformation to improve agriculture are: more mobile broadband connections; more flexible and reasonably priced digital tools that have been tried and tested; advanced data analytics and information exchange; an increasing need for conceptual understanding of agricultural solutions and responding to challenges in agriculture and value chain development; and government and international support communities. Demand-side reasons include urbanization and population growth, growing food export demand, the necessity for mobile phones among farmers, and the efforts of agribusinesses and dealers to guarantee a more consistent supply of produce from farmers.

A few obstacles that need to be addressed in order to facilitate the adoption of digital agriculture technology are the reasonable cost of investing in internet mobile data, inadequate connectivity in rural areas, unstable internet outside of urban areas, low ICT literacy rates,

credit and financing availability, and the nation's readiness for change. Because it may raise user happiness across the board for all online service platforms, people are most concerned about the quality of internet connections and services.

Various types of agricultural digital technology tools exist in the country, and there is an opportunity to use them. There are five categories into which Laos's digital tools fall: 1) Mobile payment applications; 2) e-platforms; 3) e-extensions; 4) supply chain tools; and 5) precision agriculture tools. These tools have undergone testing, and the findings indicate that they support farmers and other stakeholders in the value chain in improving their access to loans, inputs, information, and advisory services. Investing more money in the use of social media, e-platforms, and e-extensions in agriculture is a great opportunity. The experiences from development projects provided showed that it is both practical and efficient to use information technology as a consulting tool for agricultural knowledge transfer and rural development. E-commers in the current context of country refers to an-online market and trading between farers and agribusiness mostly the small and medical enterprises.

4.4. Recommandation

(Short-term plan) The e-extension should prioritize e-learning, both online and offline, as well as e-farming technical advisory services. More informatics applications, including a portal for

information and knowledge advising on agricultural technologies and practices, marketing, meteorological forecasting, and natural disaster management, should be included in the e-extension so that producers can access it on their mobile devices. Forested management and conservation should be included in e-learning courses for agriculture and rural development. It should also make sure that farmers have access to an interactive platform where they can consult with experts to get advice on new hazards and challenges.

(Long-term plan) Support for E-Commerce development. As more people turn to internet markets, the sale of agricultural goods and services has expanded gradually. These platforms are thought to be a vital conduit for communication between SMEs, crop merchants, farmer associations, and input suppliers during the COVID-19 pandemic. Due to the extensive usage of digital technology, customers now consider online trade and buying to be the new standard. These days, buyers and sellers utilize Facebook, WhatsApp, Messenger, Line, and WeChat not just for conversation, but also for greater trade and buying of farm produce, inputs, and parts. These days, scale-up solutions with an emphasis on logistics, tracking, GPS delivery monitoring, and packaging are becoming more popular.

(Short term plan) Promote the use of digital payments via mobile wallets (mobile banking) to provide a transformational pathway that can better connect remote populations to digital financial services. Customers can profit greatly from being able to swiftly and conveniently conduct transactions without physically visiting the bank by accessing their money in bank accounts. This cuts down on the

amount of time and money needed for travel, as well as the long lines and paperwork that come with Laos's current banking system. This solution may be able to remove some of the obstacles to agricultural trade in the communities of those living in remote places, particularly those in the uplands.

(Short-term plan) Create sustainable business models for digital service providers to aid in profitability, interoperability, and scale this is necessary to reach a critical mass that can be sustained, which will make it easier to apply food systems technology. The government should implement policies that assist new business owners and facilitate financing for small and medium-sized enterprises (SMEs) in order to facilitate the development of digital technology.

(Short-term strategy) Public-private partnership agreements should be used by the MAF to promote private sector involvement in DAT development. When it comes to fostering the development of digital technology, especially in the field of agriculture, the government is the main source of inspiration and support for the private sector. A functional mechanism needs to be created in order to promote and support DAT investment in the agricultural value chain.

(Long-term strategy) By facilitating funding applications, the MAF should enable ICT operators and service providers to allocate more funds toward the development and extension of ICT networks, especially in rural areas. One way to do this would be to encourage the growth of DAT credit, which offers flexible lending conditions such variable interest rates, small and large loans, and lengthy payback periods, while also reducing loan limits. encouraging farmers to raise

their output of commodities by providing them with access to more knowledge and information through a dependable internet connection and high-quality services at a fair price.

(Short-term strategy) MAF should work with pertinent ministries to update current legislation and policies pertaining to the creation and application of DAT. Compatibility with open competition, the market, and investment promotion trends in technology innovation should all be guaranteed by the modification. As a result, especially in large-scale agriculture, they will be able to use their digital technology to increase value and reduce the cost of agricultural output.

(short-term strategy) Technical officers and managers at all levels should be required by MAF to participate in programs for capacity building and digital literacy. This will guarantee that DAT's potential contributions to agricultural commodity production and food security, as well as how MAF has incorporated digital tools into its institutional processes, are fully known to its authorities and staff.

5 Cambodia[26)]

1. Overview of Digital Transformation in Cambodia Agriculture

The Royal Government of Cambodia considers agriculture as one of the main disciplines among other, which has contributed to the development of the national economy and reduce the poverty reduction. Because agriculture production has helps provide income-generating jobs for rural people who depend on the agriculture for their livelihoods. The agriculture is very potential sector in economic growth as well because its shared about more than

26) The chapter is written based on the final report written and submitted by Kong Thong (2024) titled "REPORT FOR PROJECT OF DIGITAL TRANSFORMATION IN THE AGRICULTURAL SECTOR OF THE CAMBODIA".

22% of economy of Cambodia in term of gross domestic product (GDP). Agriculture has also employment majority of the workforce about 36%.

Currently, the use of digital technology in Cambodia remains at a basic level, and public awareness of digital transformation is still in its early stages. Despite the rapid adoption of digital tools, the country lacks the necessary infrastructure and strategies to fully integrate digital transformation for promoting inclusive growth. For example, during the pandemic, only a small percentage of small and medium-sized enterprises (SMEs) utilized digital platforms for their operations, and about two-thirds of companies had no digital sales (World Bank, 2020). Moreover, the advantages of adopting digital transformation have not been evenly distributed across economic sectors, with disparities arising due to factors such as the condition of supporting infrastructure, the level of human capital and skills, and the availability of relevant regulations and laws (Velde et al., 2020).

The agriculture in Cambodia now a day not only produce for local consumption but also for full fill the demand of the world. The product that Cambodia had export to the world such as rice, casava, cashew nut, rubber, corn, pepper mango, banana, and other industry crops. Even though, Cambodia can export many agricultural products to the world but Cambodia agriculture still need to improve the quality, and safety of products to adapt to customer demand and the climate change that effect to the production yield by the insect, shortage of water, soil degradation, and biodiversity loss.

The agriculture technology in Cambodia had improved very fast

from applied traditional method to modern method and up to the smart agriculture or digitalization by using many techniques in recent year. The smart agriculture that was introduce to Cambodia agriculture recent year start to make farmer understand of benefit from this technology very fast because of saving labor, time, and water used; especially for the small scale farmer. Because of time and labor saving the farmers start to use drone for spray the pesticide to prevent their crop from the insect pest and spray the fertilizer mostly start to apply on the rice production. In case of applied smart farming, mostly the farmers applied on growing vegetable in the net-house but still limited. Anyhow, this smart agricultural technology is starting to growth from year to year.

Digital transformation in agriculture refers to the integration of digital technologies into all aspects of agricultural practices and operations. This includes the use of tools such as data analytics, artificial intelligence, the internet of Things (IoT), and precision farming techniques to enhance productivity, efficiency, and sustainability in agricultural processes.

2. National and Sectoral Agricultural Digital Transformation Policies

2.1. National Policies on Digital Transformation

The Royal Government of Cambodia has continued to develop the telecommunications and information and communication technology (ICT) sector by enacting various policies, laws, and regulations that align with international best practices and emphasize cooperation between the public and private sectors.

2.1.1. The Rectangular Strategy Phase III

The Rectangular Strategy Phase III, implemented from 2013 to 2018, emphasized the importance of further developing eGovernment and encouraged increased private sector investment in digital technology and infrastructure. Following this, in 2014, the Communication Technology Master Plan of Cambodia 2020 was launched with the objectives of promoting the growth of communication technology and information, enhancing human capital development, improving internet connectivity, strengthening digital security, and advancing public services through electronic means.

2.1.2 . The Rectangular Strategy Phase IV

Cambodia significantly reinforced its digital transformation journey in 2018 by introducing the specific strategy commonly known as Rectangular Strategy Phase IV for "Growth, Employment, Equity, and Efficiency: Building the Foundation Toward Realizing the Cambodia Vision 2050" (Royal Government of Cambodia, 2018).

From 2018 to 2023, the Cambodian government's Rectangular Strategy Phase IV focused on developing and implementing a long-term strategic plan for the digital economy, strengthening ICT infrastructure development, and promoting a legal framework to support digital growth and prevent risks.

In response to the challenges and opportunities presented by the 4th Industrial Revolution, Cambodia developed the Digital Economy and Society Policy Framework 2021-2035, which focuses on three core pillars: digital citizens, digital government, and digital business.

2.1.3. Cambodia Digital Government Policy 2022-2035

The Cambodia Digital Government Policy 2022-2035 is a strategic document that outlines the Royal Government's long-term vision and serves as a roadmap for achieving comprehensive digital government transformation. This policy organizes short-term, medium-term, and long-term priority actions in a coherent and comprehensive manner, aligning with the progress of digital technology, Cambodia's development trajectory, and best practices both nationally and

internationally.

The Cambodia Digital Government Policy 2022-2035 aims to establish a smart government by leveraging digital infrastructure and technology as a foundation for modernizing and reforming the governance system in a transparent and credible way. The goal is to foster an inclusive digital economy and society. The policy envisions "creating a digital government that enhances citizens' quality of life and builds their trust through improved public service delivery."

To realize this vision, the Cambodia Digital Government Policy 2022-2035 outlines 10 key strategies:

(1) Development and enhancement of digital connectivity infrastructure
(2) Creation and improvement of digital payment system infrastructure for public services
(3) Strengthening of digital security infrastructure
(4) Development of postal service infrastructure
(5) Organization of digital government governance
(6) Digital transformation of government operations and public services
(7) Development of digital human capital
(8) Promotion of digital research and innovation
(9) Facilitation of collaborations with digital technology companies
Encouragement of digital start-ups

These strategies encompass 83 priority actions, each involving various projects to achieve the policy's objectives **(The Ministry of Posts and Telecommunications (MPTC)**, 2022).

The Cambodia Digital Government Policy 2022-2035 aims to establish a smart government by leveraging digital infrastructure and technology as a foundation for modernizing and reforming the governance system in a transparent and credible way. The goal is to foster an inclusive digital economy and society. The policy envisions "creating a digital government that enhances citizens' quality of life and builds their trust through improved public service delivery."

2.1.4. Digital Technology (DigitalTech) Roadmap 2022-2030

The Digital Technology (DigitalTech) Roadmap is a strategic document that highlights the vision, goals, strategic products and services, and key technologies of Cambodia, in terms of national DigitalTech development. This roadmap aims to complement existing digital policy frameworks, roadmaps, and strategies, for the common goal of transforming Cambodia into an upper-middle-income country by 2030 and a high-income country by 2050.

2.1.5. Cambodia Digital Economy and Society Policy Framework 2021- 2035

The Cambodia Digital Economy and Society Policy Framework 2021-2035 sets policy measures to (a) develop digital infrastructure focusing on digital connectivity, financial technology infrastructure and digital payment systems, and logistics and last-mile delivery; and (b) build trust and confidence in digital systems focusing on responsive

and effective legal frameworks and strengthening digital security management. There are 82 policy measures to strengthen the three pillars, including (a) building digital citizens focusing on digital leadership, pools of talents, and digital citizens, (b) building digital government focusing on digital government and public services, keys to boosting digital performance, and data-driven governance in the public sector, and (c) enabling digital businesses focusing on enterprise transformation, entrepreneurial and start-up ecosystems, and the digital value chains (SNEC, 2021).

2.1.6. Cambodia ICT Master Plan 2020:

This master plan is part of a strategy for ASEAN integration to build Cambodia as a nation with intelligent people, society, and government by ICT through four strategic drives of Empowering People, Ensuring Connectivity, Enhancing Capabilities, and Enriching eServices. Enhancing digital literacy under the "Empowering People strategy" will create a special division responsible for national digital literacy projects inclusive of ICT training, cooperation with relevant stakeholders, and development of a national plan for digital literacy promotion.

The plan aims to build a National ICT infrastructure for building up a nationwide internet service base nationwide and bridging the digital divide, improving cybersecurity for online customers, improving the e-commerce environment, and enhancing e-banking and financial networks (KOICA, 2014).

2.1.7. Laws related to the digitalization

Law on Telecommunications

This law has 15 chapters and 114 articles approved by the National Assembly in 2015. The objectives of the law is to ensure safe, reliable, quality, and affordable telecommunication infrastructure to fulfill the needs of social and economic development, ensure governance and regulation of the telecommunication sector, and protection of internet users. Under the law, the Telecommunications Regulator of Cambodia (TRC) was established with the autonomous role to perform administration, regulation, and finance. TRC is independent of telecommunication operators and individuals involved in the telecommunication sector. The role of TRC is determined by a separate sub-degree. Under the Law on Telecommunications, The Ministry of Posts and Telecommunications (MPTC) has essential authority to formulate policies and develop strategic plans and legal frameworks to regulate telecommunication infrastructure, networks, and operations. MPTC is a signatory government representative in international cooperation in the telecommunication sector.

E-commerce law

This law was approved in November 2019. The key objectives are to define the accuracy and reliability of electronic practice, encourage safe e-commerce implementation, reduce obstacles in e-commerce, facilitate electronic data storage for public institutes, and build trust in digitalization. The approved law has chapters defining the legal processes and procedures of e-commerce implementation and the roles of relevant ministries in the facilitation of e-commerce

applications. It states that individuals and companies engaging in e-commerce must get a license from the Ministry of Commerce for an e-commerce license and approval from the Ministry of Posts and Telecommunications for online service certification. The law highlights criteria to protect consumers from purchasing products through online or ecommerce platforms, as well as fraud prevention and data protection. The roles and responsibilities of relevant ministries and consumers engaged in digital payment and transfer transactions are also highlighted in the law. Illustration of authorities of relevant ministries and stakeholders in processing complaints and punishment of perpetrators who committed fraud and misconduct of any activities in ecommerce is also stated there. However, the effectiveness of the law implementation including public awareness and understanding of its provisions as well as how the law provides benefits or drawbacks for ecommerce remain to be seen and require good cooperation between consumers, businesses, and regulatory institutions.

Consumer Protection Law

This law was approved in November 2019 with the objectives of protecting the benefits of consumers, promoting transparent business competition, and building trust among enterprises and consumers. The law defines clear authorities and the roles of relevant ministries in consumer protection who engage in online transactions and e-commerce platforms. It also defines and prevents fraud activities in business transactions, advertisement and fraud sales, outline procedures of complaints and investigation of fraud businesses, and other

business-related frauds. Similar to the E-commerce Law, the law's successful implementation and how it benefits consumers and relevant stakeholders engaged in online businesses, digital transactions, and ecommerce remains to be seen.

Cybercrime law

This law is in the drafting process inclusive of 6 chapters and 40 articles with the objectives to combat all the kinds of the offenses committed through the use of computer systems and prevention of all legitimate interests in using and developing technology.

Under the draft, a National Anti-Cybercrime Committee (NACC) is formed chaired by the Prime Minister with 12 members from relevant ministries to draft strategies, action plans, and programs to protect cyber and online information for the government (KOICA, 2014).

2.2. Strategies for Digital Transformation in Agriculture

2.2.1. Industrial Development Policy 2015-2025:

This policy was approved by the RGC in 2015 with the main objective to address structural challenges, invest in key industrial infrastructure for competitiveness and advantages of the industrial sector in Cambodia. There are three targets under the policy, including: (1) strengthening and transforming industrial structure in the national economy; (2) diversifying export products; and, (3) promoting SMEs.

The key strategy of this industrial development policy is to develop and modernize SMEs, innovate registered enterprises, improve technology development, and promote industrial linkages between domestic and foreign enterprises. The policy aims to encourage all small enterprises to register so that the government can have accurate information of business contexts to initiate enabling supporting policies, enable credit access, and provide businesses advice to increase business improvement opportunities (**the Royal Government of Cambodia (RGC)**).

2.2.2. Digitalization Strategic Plan for Ministry of Agriculture Forestry and Fisheries 2024-2028

Strategic Plan for Digitalization 2024-2028 in the agricultural sector to support the implementation of the Royal Government's policy, digital transformation that can accelerate operations in the agricultural sector, increase economic efficiency and improve the provision of public services through Increasing the use of digital technology (MAFF, 2024).

3. Technological Applications in Cambodia Agriculture[27)]

In term of digital transformation in agriculture just start to apply even in not full digital technology such as using automatic water sensor to control the use of water, drone to spray the pesticide and fertilizer, using precision tractor to leveling the landscape of field. The smart farming in Cambodia is still confused with climate-smart agriculture because the terminology was not yet identified to understand for whole. So, Cambodia's digital transformation is gathering progress but with different achievement in present situation and prospects across different groups in the economy.

3.1. Several Digital Innovations Have Been Introduced in Cambodia

A Cambodian group called Agri-Economiser created Smart Farm Assistance, a water conservation app that can help reduce water consumption by 20% to 50%. The app is internet-based and also uses a short message service (SMS), making it incredibly convenient for farmers. A farmer can use the app to connect to and control a device set up in their field. Sensors are also set up to check soil conditions and the weather and control water systems. The device will send information to the farmer about the condition of their field, weather

27) Borgen magazine (2022. 12. 5.), "The Digitalization of Agriculture in Cambodia".

and crops, and if the farmer sees that their crops need water and no rain is coming, they can press a button and water systems will work automatically. However, the system has only been in operation for a year, and currently, only a small number of farmers across the country are using it. Low-income farmers, in particular, face challenges in utilizing the system (TmeyTmey News, 2020. 12. 8).

Oxfam works with small-scale rice farmers in Preah Vihear province, in the central north of Cambodia, who are empowered with information about their supply chain and by electronic verification of the terms of their contract. A digital contract between primary producers organised in an agricultural cooperative, a Cambodian rice exporter and a manufacturer in The Netherlands were conducted to improve farmers' livelihoods and their supply chain conditions. An electronic user platform were introduced with an application providing full value chain transparency and traceability to the cooperative, exporter and importer, but also to end consumers. In this way, the consumer known that farmers have been paid correctly for their rice, which will contribute to sustainable livelihoods. Consumers are enabled to make an informed and conscious choice for rice that complies with social conditions and fair production standards. The smart contract were developed using blockchain technology in the organic rice value chain, by registering all chain actors with unique identification codes on blockchain.

3.2. Angkor Salad Project

In 2018, the Netherlands Space Office and the International Cocoa Organization (ICCO) began the Angkor Salad Project to use geodata to help at least 100,000 Cambodian vegetable farmers increase production and save money. The project has five information services farmers can access via SMS, voice and mobile app. Farmers can access irrigation advice to figure out how much water they need to use for their crops based on geospatial data and their crop cycle.

Fertilizer advice uses soil analyses and information on the vegetables to recommend what kind and how much fertilizer to use. Crop planting advice allows farmers to look up information on the vegetables they want to plant as well as when to plant them. Farmers can look up the price of their products, logistics cost and information on buyers using market information. Khmer GAP (Good Agricultural Practices) Compliance offers farmers customized information based on their crop, location and farming system.

3.3. SAAMBAT Project

In 2019, Cambodia's Ministry of Rural Development executed the Sustainable Assets for Agriculture Markets, Business and Trade (SAAMBAT) project to "sustainably increase rural connectivity, the productivity of youth and the rural economy." Its goals include providing digital literacy and connecting members of the agribusiness, partnering with the private sector

and providing grants to startups in the digital agricultural value chain.

In addition, the Ministry executed the Khmer Agricultural Suite (KAS), "an open digital platform for agricultural value chains," which multiple service partners and the Cambodian government's Techno Startup Center developed as part of the SAAMBAT Project. KAS uses satellites and other sources to collect and analyze data for members of the value chain. The project is intended to run until 2025 and intends to help 200,000 families.

4. Readiness and Adoption Challenges for Digital Transformation

Even the Royal Government of Cambodia had very good policy related to the digital transformation but some challenges also face such as:

Currently, digital information systems and data management within ministries, institutions, and sub-national administrations are often redundant, both within individual entities and across different ones. Despite the presence of a national data center managed by the responsible Ministry, these issues have not yet been resolved. Key challenges include insufficient infrastructure development, unclear ownership of existing systems, inadequate digital security measures, a lack of skilled human capital in digital technology, and the absence of regular operations and maintenance to support the development and

management of digital information systems and data. Additionally, internet penetration remains limited, particularly in rural areas where it is most needed by farmers. Limited capacity of human and financial resources are often an obstacle to investing in IT infrastructure such as foundation in term of network, severs, databases, cloud application.

Enhancing collaboration and networking among key actors in the ecosystem will ensure the building of a vibrant digital ecosystem in Cambodia. Effective collaboration and networking require a genuine interest in others, a willingness to learn, and a commitment to building relationships over the long term. Collaboration and networking are essential for success in many sectors, especially in the digital ecosystem.

There are still factors preventing the adoption of digital agriculture in Cambodia. According to a report from the Cambodian Centre for Policies Studies in 2020, farmers have limited digital literacy. In 2018, only 24% of rural farmers had access to smartphones.

In addition, rural areas can have slow internet connections and broadband internet services depend on fixed-line networks that are not easily available in rural areas, preventing wider internet penetration.

To continue support the growth of digital agriculture technology, some points should be consideration such as:

(1) Education and training on digital shall be consistently promoted to effectively respond to the fast changes of digital
(2) Reskilling and upskilling schemes shall be in place to ensure sustainable and inclusive development and guarantee that no one is left behind
(3) Investments on the digital transformation in agriculture sector

such as computer, robotic system, remote sensing, sensors, cloud base decision model, ⋯ are needed.

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