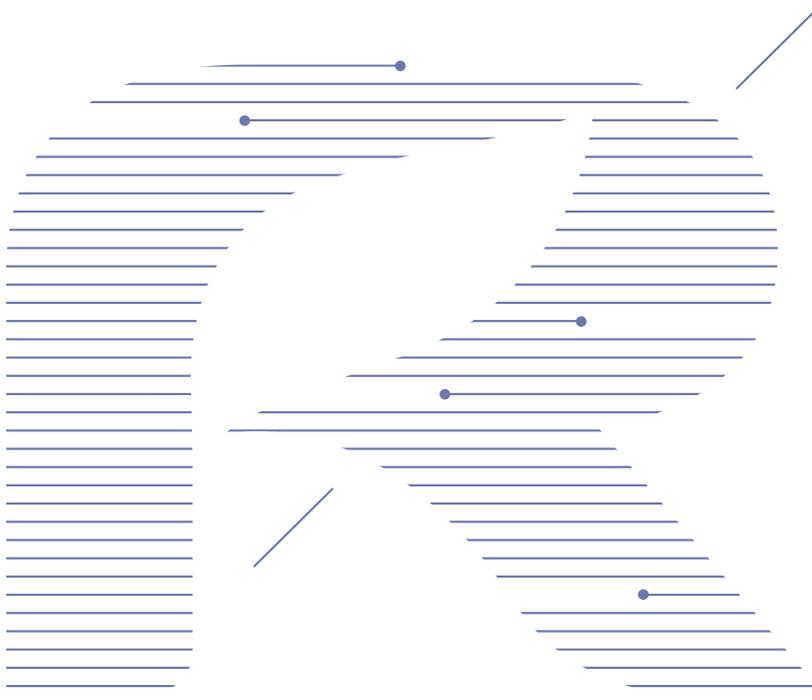**KREI**

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Current Status and Policies of Smart Agriculture Overseas and Policy Implications: Myanmar, Vietnam, and Indonesia

Yin Lei Win Swe · Phan Nguyen Thai · Heri Akhmadi

한국농촌경제연구원

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25-33-01	K-푸드 플러스(K-Food+) 수출 확대 방안 (2/2차년도)	한국농촌경제연구원
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		국립부경대학교
25-33-03	해외 스마트농업 현황 및 정책과 시사점: 미얀마, 베트남, 인도네시아	Monywa University of Economics
		Hue University
		Muhammadiyah University of Yogyakarta

2. 참여연구진

구분		연구책임자	공동연구원	연구보조원
저자		정대희, 남경수, 곽혜선, 유사라, 석준호, 유정호, Yin Lei Win Swe, Phan Nguyen Thai, Heri Akhmadi		
주관 연구기관	한국농촌경제연구원	정대희 부연구위원 (총괄책임자)	남경수 부연구위원 곽혜선 전문연구원 유사라 연구원	-
협력 연구기관	전북대학교	석준호 부교수		
	국립부경대학교	유정호 교수		
	Monywa University of Economics(미얀마)	Yin Lei Win Swe		
	Hue University(베트남)	Phan Nguyen Thai		
	Muhammadiyah University of Yogyakarta (인도네시아)	Heri Akhmadi		

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Yin Lei Win Swe · Phan Nguyen Thai · Heri Akhmadi

한국농촌경제연구원

연구 담당

Yin Lei Win Swe ┃ Monywa University of Economics 조교수 ┃ 미얀마 스마트농업 현황 및 정책 분석
Phan Nguyen Thai ┃ Hue University 조교수 ┃ 베트남 스마트농업 현황 및 정책 분석
Heri Akhmadi ┃ Muhammadiyah University of Yogyakarta 조교수 ┃
　　　　　　인도네시아 스마트농업 현황 및 정책 분석

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1 Smart Agriculture in Myanmar: Current Status, Policies, and Implications

1. Introduction

The agricultural sector plays a critical role in ensuring food security, employment, and export earnings in Myanmar. In 2023, it accounted for approximately 13.8% of the national GDP, 16.2% of total exports, and 45.2% of total employment (CSO, 2024). Despite its importance, agricultural productivity remains low, largely because of persistent structural and institutional challenges. These include limited data and information systems, low investment in research and development (R&D), weak quality control mechanisms, outdated farming techniques, inadequate rural infrastructure and irrigation systems, and the increasing impact of climate change (Flanders Investment & Trade, 2020).

The agricultural sector is dominated by small-scale farmers who often lack sufficient access to formal, education, agricultural knowledge,

information networks, and modern technologies to manage unpredictable farming risks effectively. Globally, agriculture is undergoing the "fourth agricultural revolution", characterized by the integration of information and communication technologies (ICT) within farming systems. These advancements enable digitally mediated and automated agricultural practices. For instance, robots are increasingly used for harvesting and weeding, while drones are engaged for fertilizer spraying and monitoring crop growth.

Smart agriculture, which integrates the Internet of Things (IoT) and artificial intelligence (AI), could offers promising opportunities for Myanmar. These technologies enable continuous monitoring of climate conditions, soil properties, and moisture levels. IoT-based systems can connect devices such as robots, drones, and ground sensors through the internet, facilitating automated farm management and enhancing production efficiency. However, in developing countries such as Myanmar, adoption remains limited and uneven. Existing IoT applications in Myanmar are confined to specific agricultural functions such as crop monitoring, irrigation optimization, improvement in livestock management, and productivity enhancement (Dutta, 2023). The expansion of digital agriculture is also highly dependent on supportive infrastructure such as electricity and communication networks. Consequently, limited rural infrastructure and the high cost of IoT devices remain barriers to the widespread adoption of these technologies in Myanmar's agricultural sector (Dutta, 2023).

The country is also highly vulnerable to climate change due to its tropical location. The population and infrastructure along coasts of the Bay of Bengal and Andaman Sea are exposed to cyclones during the

monsoon season on a recurrent basis (Barbon et al., 2022). Cyclone, floods, and landslides have severely damaged crop and livestock production, contributing to food insecurity in Myanmar (WFP, 2017; FAO, 2021).

In response to these risks and the need to improve productivity, several studies in Myanmar have proposed technology-based solutions. These include IoT-based smart weather monitoring and notification systems (Thway et al., 2025), GSM-based automatic greenhouse control systems (Thwe et al., 2019), automated greenhouse systems (Hlaing & Soe, 2019), smart irrigation systems (Htet et al., 2021), and IoT-based plant disease detection and hydroponic systems (Win, 2018; Thazin et al., 2019). Such innovations demonstrate the emerging role of smart agriculture in mitigating climate-related risks and improving farming efficiency.

In addition to smart farming technologies, digital extension services are emerging as complementary tools in delivering information to farmers. For example, Goeb et al.(2025) examined an SMS-based extension system in Myanmar, which showed potential to maintain information flows during crises, although success depends on digital literacy and network reliability.

Building on these technological approaches, digital technologies in agriculture specifically, mobile applications, computing capacity, and internet connectivity are becoming increasingly important worldwide. The above studies indicate a growing interest in digital and automated solutions in Myanmar, while also highlighting the need for supportive infrastructure and affordable access, which remain significant barriers to large-scale adoption of smart farming solutions.

A key enabler of digital agriculture is robust telecommunications infrastructure. Myanmar's telecommunications sector underwent major reforms starting in 2013, reducing SIM card prices from $350 in 2012 to around $8 and introducing four major operators (MPT, ATOM, Ooredoo, and MyTel). The country now has extensive telecom infrastructure, including 26,778 towers, 68,832 km of fiber, submarine cables, and cross-border links, with mobile density at 109.35%, internet penetration at 100.61%, and population coverage at approximately 98%. The Ministry of Transport and Communication implemented the Universal Service Fund (USF) and Universal Service Strategy (2019–2023) to expand rural connectivity, broadband access, and digital literacy. In addition, the Digital Economy Development Committee (DEDC), formed in 2017, drives digital transformation through tax incentives, MSME digital adoption, and infrastructure improvements. Despite these achievements, rural connectivity, policy coordination, and institutional capacity remain challenging, hindering full digital integration and smart farming adoption (ASEAN, 2024).

2. Market size and growth potential

2.1. The harvested area, total production and yield of major crops

Rice, pulses, maize, and oilseeds dominate Myanmar's crop sector, with rice holding the largest share. It occupies about 43.6 percent of the

country's total cropped area, making it the single most important crop in terms of both household consumption and its role as a major source of export revenue. Rice is also the primary staple food: per capita annual consumption is estimated at 170 kilograms in rural areas and 145 kilograms in urban areas (USDA, 2024). According to the Myanmar Living Conditions Survey (MLCS) 2017, around 60 percent of farming households cultivate paddy (CSO, UNDP & World Bank, 2020).

Paddy cultivation is highly seasonal. About 79 percent of the total paddy area is sown during the monsoon season, while the rest is grown in the post-monsoon (summer) season (Boughton et al., 2024). The Bago, Yangon, and Ayeyarwady regions constitute the core of rice production in Myanmar, accounting for 45 percent of paddy output in the monsoon and as much as 69 percent in the summer (Minten et al., 2023).

〈Figure 1-1〉 shows the harvested area, total production, and yield of rice from 2000 to 2023. The harvested area was about 6.3 million ha in 2000, increased steadily to 8 million ha between 2006 and 2010, and then declined to 6.5 million ha in 2023.

〈Figure 1-1〉 The harvested area, total production and yield of rice
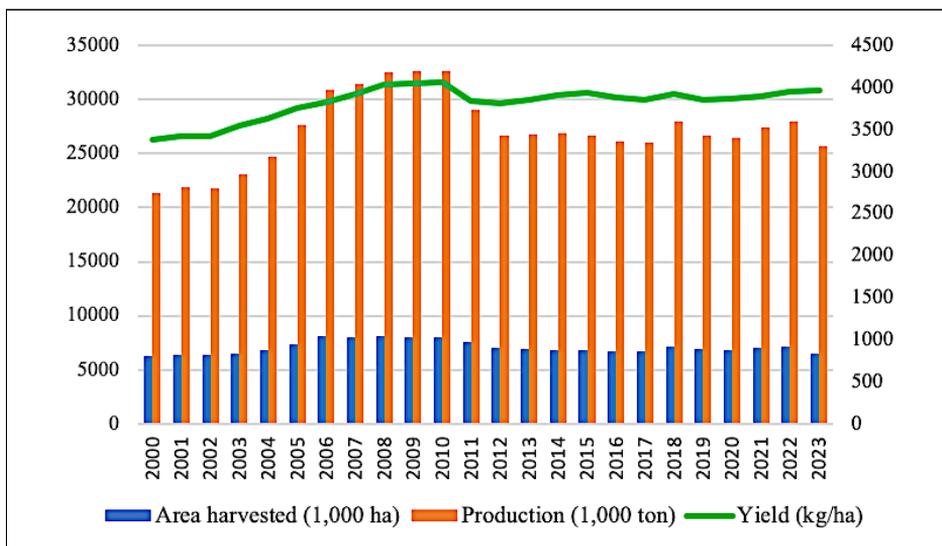
Source: FAOSTAT(https://www.fao.org/faostat/en/#data), retrieved: 2025. 9. 15.

Dried leguminous crops represent the second most important category of crops in Myanmar, both in terms of harvested area and contribution to domestic consumption and exports. Data from the Myanmar Living Conditions Survey (MLCS) 2017 show that about 32 percent of farming households are engaged in pulse cultivation (CSO, UNDP & World Bank, 2020).

Pulse production is highly seasonal and location-specific. Roughly 70 percent of pulses are grown in the delta region during the winter months, while the remainder is cultivated in the central dry zone and Shan State during monsoon(USDA, 2018). Among the wide range of pulses produced, four crops are particularly significant: black gram, green gram, chickpea, and pigeon pea. Of these, black gram, green gram, and pigeon pea together account for 70-75 percent of the country's total bean output and are essential for Myanmar's export-oriented pulse sector(USDA, 2018).

〈Figure 1-2〉 shows the harvested area, total production, and yield of beans and pulses from 2000 to 2023. The harvested area increased steadily from 1.8 million ha in 2000 to 3.3 million ha in 2016, before declining to 2.8 million ha in 2023.

〈Figure 1-2〉 The harvested area, total production and yield of dried leguminous crops
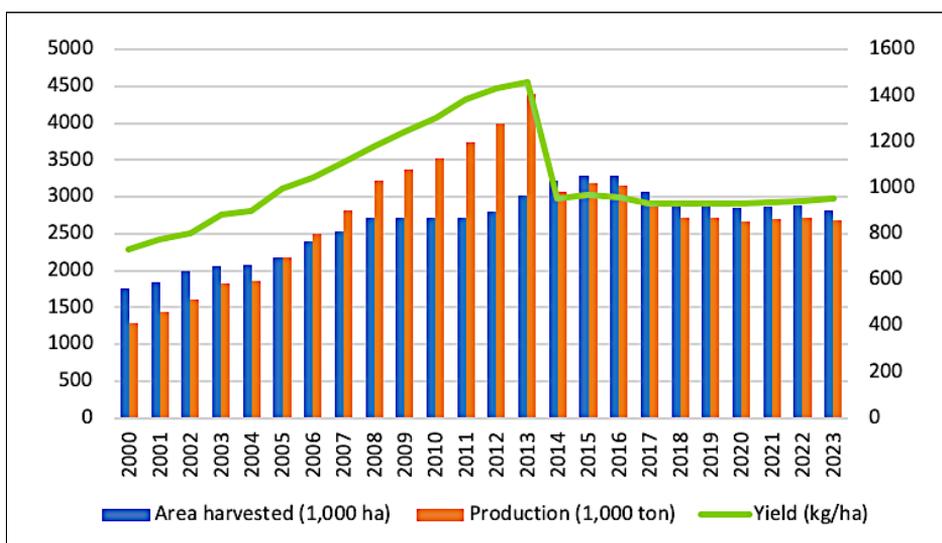
Source: FAOSTAT(https://www.fao.org/faostat/en/#data), retrieved: 2025. 9. 15.

Maize is Myanmar's second most important cereal crop after rice and plays a vital role in the country's agricultural export sector. According to the Myanmar Living Conditions Survey (MLCS) 2017, about 83 percent of maize production is concentrated in Shan State, while smaller shares are produced in the central dry zone and delta region (CSO, UNDP & World Bank, 2020). 〈Figure 1-3〉 shows the harvested area, total production, and yield of maize from 2000 to 2023. The harvested area steadily increased from 0.3 million ha in 2000 to 0.6 million ha in 2023.

〈Figure 1-3〉 The harvested area, total production and yield of maize
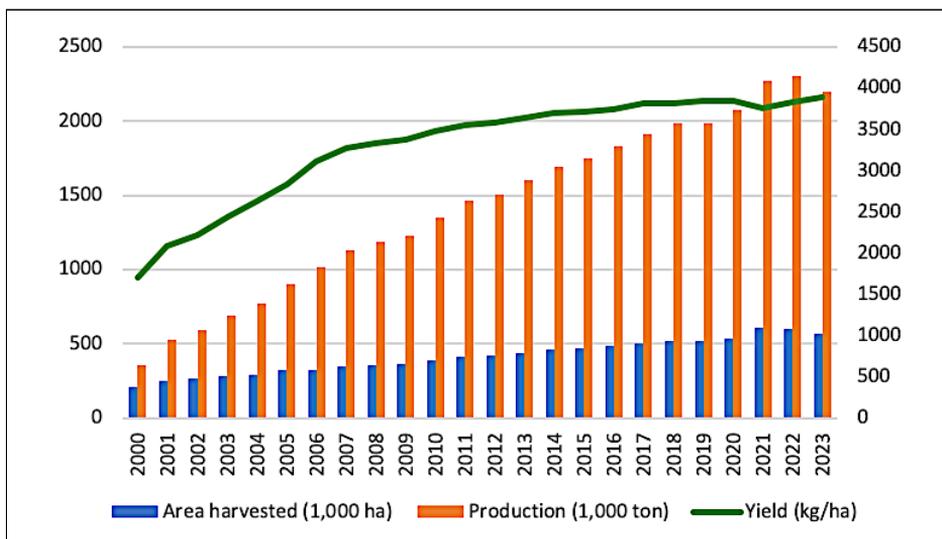
Source: FAOSTAT(https://www.fao.org/faostat/en/#data), retrieved: 2025. 9. 15.

2.2. Types of irrigation systems in Myanmar

〈Table 1-1〉 presents the total irrigated area and percentage share by different types of providers. Between 2019 and 2024, Myanmar's total irrigated area grew moderately from 5.67 million acres to 6.04 million acres, reflecting a gradual strengthening of water management capacity. The composition of irrigation sources, however, reveals a persistent reliance on "other" systems, which consistently account for more than half of total irrigated land. Government canals and tanks together represent about a quarter of irrigated land, while private canals, tanks, and wells contribute smaller but stable shares. This distribution suggests that while large-scale public infrastructure remains important, a substantial proportion of irrigation depends on less formal or

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decentralized systems. From a smart farming perspective, this structure presents opportunities to introduce water-saving technologies across both government and private-managed irrigation schemes. Smart monitoring tools, efficient pumping systems, and data-driven allocation can help optimize the diverse irrigation base and reduce inefficiencies, particularly in the "other" category, where oversight remains limited.

〈Table 1-1〉 The Irrigated areas by different providers in Myanmar

Unit: 1,000 acres, %

Year	Total irrigated	Govt. Canals	Govt. Tanks	Private Canals	Private Tanks	Wells	Other
2019-2020	5,672	16.5	10.3	10.4	1.0	8.2	53.6
2020-2021	5,652	15.6	9.3	10.8	1.1	9.3	53.9
2021-2022	5,642	16.5	10.5	10.9	1.1	8.7	52.3
2022-2023	5,806	16.2	11.1	10.5	1.2	9.0	52.0
2023-2024	6,035	15.4	11.3	10.2	1.1	9.1	52.9

Source: CSO(2024).

2.2.1. Crops under irrigation

〈Table 1-2〉 shows the irrigated area by major crops between 2019-2020 and 2023-2024. The composition of irrigated crops in Myanmar highlights the dominance of paddy, which consistently accounts for the largest share, expanding from 4.6 million acres in 2019-2020 to nearly 5 million acres in 2023-2024. Pulses and oilseeds maintain relatively smaller but steady contributions, though pulses show a slight decline in the most recent years, while oilseeds fluctuate with modest increases. Sugarcane remains a minor irrigated crop, occupying less than 40,000 acres annually. Meanwhile, the category of other crops demonstrates

consistent growth, rising from 1.42 million acres in 2019-2020 to 1.65 million acres in 2023-2024, reflecting a gradual diversification of irrigated agriculture. This trend indicates that while rice continues to dominate irrigation usage, smart farming initiatives such as precision irrigation and crop monitoring could diversify and improve water-use efficiency in pulses, oilseeds, and other emerging irrigated crops.

〈Table 1-2〉 The Irrigated area by major crops

Unit: 1,000 acres

Year	Total irrigated	Paddy	Pulses	Oilseeds (Groundnut, Sesame)	Sugarcane	Other crops	Other
2019-2020	6,780	4,596	326	416	27	1,415	53.6
2020-2021	6,711	4,510	366	348	34	1,453	53.9
2021-2022	6,766	4,592	355	378	29	1,412	52.3
2022-2023	7,098	4,799	340	419	36	1,504	52.0
2023-2024	7,432	4,978	339	445	25	1,645	52.9

Source: CSO(2024).

2.3. Share of GDP at current prices by the agriculture sector

〈Table 1-3〉 shows the share of GDP contributed by the agriculture sector from 2019-2020 through 2023-2024. Agriculture's contribution to Myanmar's GDP at current prices exhibits noticeable fluctuations over the period from 2019-2020 to 2023-2024. In 2019-2020, the sector contributed a significant portion of the national economy, reflecting its continuing role as a cornerstone of economic activity. This contribution increased slightly in 2020-2021, indicating modest growth in agricultural output relative to other sectors. There was a notable peak in the

percentage in 2021-2022, when agriculture accounted for the largest share, suggesting either strong sectoral performance or comparatively weaker growth in other industries. However, the contribution declined in 2022-2023 before rising again in 2023-2024, underscoring agriculture's sensitivity to production cycles, climatic conditions, and broader economic trends. Overall, the data demonstrate that agriculture remains a vital component of Myanmar's economy, consistently contributing a significant share to GDP despite year-to-year variations driven by both domestic and external factors.

〈Table 1-3〉 The percentage share of GDP by the agriculture sector

Unit: absolute values in percent

Year	Agriculture contribution to GDP (%)
2019-2020	13.1
2020-2021	14.0
2021-2022	16.8
2022-2023	13.8
2023-2024	14.5

Source: CSO(2024).

3. Policies and regulations

The Ministry of Agriculture, Livestock, and Irrigation (MOALI) has introduced a range of policies aimed at enhancing private sector participation and attracting foreign investment in Myanmar's agricultural sector. Although Myanmar does not yet have a dedicated smart farming policy, several national agricultural strategies indirectly

support the adoption of modern technologies across farming, livestock, and fisheries.

3.1. The Agricultural Policy (2016)

The Agricultural Policy (2016) issued by MOALI sets out eleven objectives, of which objectives 5), 6), and 11) are directly linked to technology transfer, financial assistance, local and foreign investment, and private sector collaboration (MOALI, 2018). These objectives emphasize access to modern farming technologies, mobilization of local and foreign investment, and strengthened value chain linkages. Taken together, they create institutional entry points for the expansion of digital agriculture and future development of smart farming initiatives. The objectives are as follows:

1) To improve food security and safety, as well as nutritional status.
2) To ensure that farmers fully enjoy their rights and to improve their economic well-being.
3) To consolidate small scale farmers, livestock keepers and fisher folks into groups or cooperative societies, with the aim of modernizing and improving sector-wide performances through newly acquired knowledge and experience, while enhancing women's participation.
4) To plan and implement programs concerning rural road construction, rural infrastructure development, management of land use, and small- scale production industry, with the intention of sustaining rural development and uplifting the socioeconomic conditions of rural populations.

5) To facilitate access to required technologies and financial assistance (grant, support, loan) from local and external sources to further develop crop, livestock, fisheries and cooperative sectors.

6) To enhance access to local and external investments in the agricultural sector.

7) To enhance the production of high-quality grain, meat, and fish products for external markets.

8) To support the development of agro-based industries, small scale enterprises, traditional weaving, indigenous handicraft (including 10 PAN) and livelihood activities.

9) To strengthen cooperative enterprises and the cooperative system more broadly.

10) To promote effective linkages among production, services, trade, and consumers, with the objective of improving and developing the entire value chain.

11) To support collaboration among concerned departments as well as government versus private organizations to ensure that all stakeholders involved in poverty alleviation program can participate, sustainable agriculture sector development program, and rural development program.

3.2. Agricultural Development Strategy (ADS) and Investment Plan (2018-2030)

The Agricultural Development Strategy (ADS) and its accompanying Investment Plan (IP) represent the primary framework for guiding

agricultural transformation in Myanmar over the period from 2018 to 2030. They were introduced by the Ministry of Agriculture, Livestock, and Irrigation (MOALI) as a systematic approach to operationalize the Agricultural Policy (2016) and to align multiple sectoral strategies and donor-driven projects under one coherent roadmap.

Myanmar's agricultural policy underpinning the ADS envisions that by 2030, the country will achieve an inclusive, competitive, food and nutrition secure, climate change-resilient, and sustainable agricultural system that contributes to the socio-economic well-being of farmers, rural communities, and the national economy as a whole. The ADS has multiple key purposes:

1) To consolidate and implement different plans, strategies, and initiatives developed by multiple stakeholders.

2) To provide a systematic framework for policy implementation, linking agricultural priorities with the Investment Plan.

3) To coordinate across programs, projects, and donor activities, and to harmonize foreign aid to the sector.

4) To strengthen dialogue with both domestic and international investors in order to promote agricultural transformation (MOALI, 2018).

The ADS is built on three strategic pillars, each aligned with specific objectives:

1) Governance and Institutions enhanced governance and institutional capacity for agricultural development; 2) Productivity increased productivity and incomes of farmers through improved technologies, inputs, and sustainable practices; and 3) Competitiveness and Market Linkages stronger value chain connections, better access to markets,

and improved competitiveness in both domestic and international trade.

During the first implementation phase (2018-2023), emphasis was placed on mechanization, input access, and extension services, which indirectly create entry points for smart farming. While the ADS does not explicitly mention IoT-based farming or precision agriculture, its modernization agenda and emphasis on productivity improvement open the door for future integration of digital technologies. In particular, the ADS encourage mechanization across crops and regions, which overlaps with the adoption of drones, automated equipment, and sensor-based irrigation. It also prioritizes improved extension services, which can gradually shift toward digital platforms, mobile-based advisories, and real-time information systems. By focusing on competitiveness, the ADS pushes the sector toward compliance with international standards, which in turn require advanced monitoring, traceability, and smart farming solutions.

Other key policy frameworks also support smart farming indirectly. The Myanmar Climate- Smart Agriculture Strategy (2015-2025) promotes adoption of innovative and resilient technologies that reduce climate vulnerability, particularly in crop management and water use efficiency. While it focuses on adaptation and resilience, many recommended practices such as water-saving irrigation and crop monitoring overlap with smart agriculture.

Similarly, the Digital Economy Development Master Plan (2019-2030) identifies agriculture as one of the priority sectors that would benefit from ICT-based services. This plan envisions a broader digital transformation across the economy, where agriculture is seen as a sector that can be

modernized via the use of e-commerce, data systems, and farm-level digital solutions.

Together, these documents illustrate that while smart farming is not yet a stand-alone policy objective, it is being gradually embedded within broader agricultural and digital strategies. Myanmar's policy landscape is therefore evolving in a way that leaves significant space for the integration of IoT, automation, and precision farming in the future.

3.3. Tax incentives for investment in Myanmar

The rules and regulations governing investment in Myanmar's agricultural sector are formulated within the framework of the Myanmar Investment Law (MIL) 2016. This law, which merged the 2012 Foreign Investment Law and the 2013 Citizens' Investment Law, aims to stimulate both local and foreign investment through a range of tax incentives and regulatory guarantees. The MIL provides the principal legal basis for investment incentives, including those applicable to agriculture and agritech. Its provisions are set out in Chapter XVIII: Exemptions and Reliefs (Articles 75-83) and are administered by the Myanmar Investment Commission (MIC) (Myanmar Investment Law). The main incentives are as follows:

Income tax exemption (Article 75):

Zone (1) - less developed regions: 7 years

Zone (2) - moderately developed regions: 5 years

Zone (3) - developed regions: 3 years

Since most agricultural regions fall under Zone (1) or Zone (2),

agribusiness investing in smart farming technologies are eligible for longer tax holidays.

Customs duty and internal tax exemptions (Article 77): Investors are exempted from duties and taxes on imported machinery, equipment, instruments, spare parts, and construction materials not available domestically. This provision directly applies to agricultural machinery, irrigation equipment, sensors, drones, greenhouses, and other smart farming tools.

Customs duty relief for re-export (Article 78): Investors who re-export raw materials or partially manufactured goods are eligible for duty relief.

Accelerated depreciation (Article 79): Investors may depreciate capital assets at rates determined by the MIC, thereby reducing taxable income more rapidly. For agritech projects, this provision facilitates faster cost recovery for high-value smart farming equipment.

Deduction of R&D and training expenses (Article 80): Expenditures related to research, skills training, and technology transfer can be deducted from assessable income. This indirectly supports the introduction of smart farming practices by lowering the financial burden on firms engaged in innovation.

Tax exemption for reinvested profits (Article 81): Profits reinvested within one year in the same or similar business activity may be exempted from income tax. This encourages agribusinesses to expand operations, potentially reinvesting into smart farming technologies.

Although the law does not explicitly mention "smart farming" or "digital agriculture," its broad reference to "machinery, equipment, and materials" provides a legal framework within which investors can apply for tax

incentives and customs reliefs when adopting new technologies in agriculture.

3.4. Current regulatory situation

At present, the regulatory environment in Myanmar does not include a dedicated framework for smart farming or precision agriculture. Instead, smart farming initiatives operate within broader legal and policy frameworks for agriculture and investment. The Myanmar Investment Law, administered by the MIC, remains the cornerstone for incentives and regulatory approval. Policies such as the ADS (2018-2030) and the Climate-Smart Agriculture Strategy (2015-2025) provide the development direction, but without detailed technical regulations for digital or automated farming. The Digital Economy Development Master Plan (2019-2030) creates an enabling environment by promoting ICT in agriculture, but the translation into farm-level guidelines, standards, or legal protections remains limited.

As a result, while there are entry points and enabling provisions, Myanmar lacks dedicated regulations for issues such as data privacy in farm monitoring, standards for drones and sensors, or certification for smart farming equipment. In practice, the adoption of smart farming technologies depends on how broadly investors and farmers can interpret the existing provisions under MIL and national strategies.

Thus, Myanmar's regulatory framework for smart agriculture remains at an early stage, shaped primarily by general agricultural and investment policies rather than a dedicated smart farming law. However, the gradual

embedding of digital agriculture into existing strategies suggests that more formal regulations may emerge in the medium term, especially as international investment and donor-supported projects in precision agriculture continue to expand.

4. Private sector and international cooperation case

Private sector engagement and international cooperation have become increasingly important in shaping Myanmar's agricultural transformation. The integration of advanced technologies into a traditional farming system requires significant investment, technical knowledge, and innovative delivery mechanisms areas in which the private sector and development partners can play a catalytic role. Recognizing this, the Ministry of Agriculture, Livestock, and Irrigation (MOALI) has promoted public-private partnerships (PPP) through key policy frameworks such as the Agricultural Policy (2016) and the Agricultural Development Strategy (ADS, 2018-2030). These frameworks emphasize the importance of digital solutions, improved infrastructure, and cross-sector partnerships to overcome the structural challenges faced by farmers.

4.1. Digital agricultural extension

At present, the most visible form of private sector participation is in the area of digital agricultural extension services. According to the Myanmar

Agricultural Performance Survey (MAPS), conducted by the International Food Policy Research Institute (IFPRI), the private sector has overtaken the public sector as the primary provider of both in-person and digital advisory services. 〈Table 1-4〉 shows extension services delivered by different providers between 2020 and 2023. In the 2020 monsoon season, 25 percent of farmers accessed private agents, compared with 21 percent relying on the public sector and 13 percent turning to NGOs. Although the political crisis following the 2021 coup reduced access to all providers, private sector digital platforms proved more resilient. By 2023, digital services primarily delivered through Facebook pages, mobile applications, and social enterprise platforms accounted for nearly 18 percent of farmer access. Importantly, much of this digital content was not limited to simple product advertising but included technical guidance, production advice, and market information. This helped farmers gradually accept and trust digital platforms as credible sources of agricultural extension (IFPRI, 2024).

〈Table 1-4〉 Extension services delivered by different providers (2020-2023)

Unit: percent

Year/Season	Public	Private	NGO	Digital	Any Extension
Monsoon, 2020	20.6	24.8	12.7	15.6	41.3
Monsoon, 2021	14.8	18.5	8.8	15.1	34.4
Monsoon, 2022	14.1	18	9.5	14.7	32.4
Dry, 2021	17.5	23.1	10.7	13.8	37.4
Dry, 2022	15.7	21.6	8.8	14.9	36.9
Dry, 2023	13.2	18.5	6.4	18.2	37.6

Source: IFPRI(2024).

4.2. Mobile applications for Myanmar farmers

In Myanmar, digital agricultural extension services are delivered predominantly via Facebook, followed by online group platforms, agricultural apps, and call centers operated by agricultural input companies and social enterprises. The rapid rise of digital agriculture is most visible in the growing ecosystem of mobile applications tailored to Myanmar's farming communities. Farmers across the nation are increasingly using mobile applications to enhance productivity and improve livelihoods. These applications provide crucial services that address common challenges in agriculture and offer solutions for market access, crop management, and financial services (Thar et al., 2020). Their development represents a significant advancement in agricultural extension services. Both private companies and government agencies have contributed to this growing digital ecosystem. The applications cater to various needs, from basic information services to complex decision-making tools, and their widespread adoption demonstrates the agricultural community's readiness for digital solutions. 〈Table 1-5〉 presents the current landscape of agricultural mobile applications in Myanmar, showing varying levels of adoption based on the apps' functionality and accessibility. Applications with Myanmar language support consistently achieve higher download numbers, highlighting the importance of local language accessibility in promoting sustained use by farmers.

〈Table 1-5〉 Mobile applications for Myanmar farmers

Unit: percent

No.	Application Name	Developer	Primary Functionality	Key Features	Downloads	Language Support
1	Greenway	Greenovators Co. Ltd	Comprehensive platform	Digital records trading, market info	100,000+	Myanmar
2	Htwet Toe	Myanma Awba Group	Information portal	Weather, prices, pest advice, trading	100,000+	Myanmar
3	Thuta Myay	MPT	Multi-purpose platform	Agri-info, prices, weather, entertainment	10,000+	Myanmar
4	Site Pyo Yay	Myanmar Dev Apps	Production guidance	Production tech, articles, fertilizer info	10,000+	Myanmar
5	Golden Paddy	Impact Terra	Farmer benefit platform	Loans, advisory, risk alerts, market info	10,000+	Myanmar
6	Taung Thu Oo Gyi	Pro-X Software Dev	Land management	Land measurement, farm valuation tools	10,000+	Myanmar
7	Industrial Farming	Agriculture Mech. Dept.	Machinery guidance	Machine selection, financing, operation	5,000+	Myanmar
8	Quality Seeds	Seed Division	Seed trading	Seed trading, demand forecasting	5,000+	Myanmar
9	Awba Channel	Myanma Awba Group	Content platform	Educational content, farming techniques	1,000+	English
10	Awba Soil Cares	Myanma Awba Group	Soil management	Soil analysis, fertilizer recommendations	1,000+	English

Source: Adapted from Digital Agriculture Initiative Annual Report (MOALI, 2020) and developer data (2019-2020). Download figures are estimates from Google Play Store(https://play.google.com/store), retrieved: 2025. 9. 15.; Developer Reports(https://www.developerreport.com/), retrieved: 2025. 9. 15.

High-adoption applications (100,000+ downloads) such as Greenway and Htwet Toe offer comprehensive services, with Greenway serving as a complete digital farming assistant, enabling record-keeping and market access. On the other hand, Htwet Toe provides essential real-time information, including weather forecasts and market prices. These applications succeed by addressing multiple farmer needs through single platforms.

Medium-adoption applications (10,000+ downloads) include Thuta Myay, Site Pyo Yay, Golden Paddy, and Taung Thu Oo Gyi; they focus on specific needs. Site Pyo Yay offers specialized production technologies and agricultural articles, while Taung Thu Oo Gyi provides practical land measurement and valuation tools. In addition, Golden Paddy connects farmers with financial services and risk management tools (Techwire Asia, 2023. 10. 23.).

Government-supported applications show moderate adoption levels for example,Industrial Farming (5,000+ downloads) helps farmers with machinery decisions and financing options. Meanwhile, Quality Seeds (5,000+ downloads) facilitates seed trading and demand forecasting. These applications represent important public-sector digital initiatives.

Specialized applications such as Awba Channel and Awba Soil Cares Adviser (1,000+ downloads) serve specific functions. While these applications provide valuable specialized knowledge, they reach a smaller audience, which can be attributed to an English-language interface and narrow focus areas.

The distribution of applications shows that farmers prefer comprehensive, Myanmar-language solutions. Applications that address immediate

practical needs tend to achieve higher adoption rates. Overall, the expansion of these digital tools represents significant progress in Myanmar's agricultural digitalization journey.

4.3. The Development Partner (DP) funded projects

In parallel with private sector innovation, international cooperation and development partner (DP) investments have provided crucial financial and technical support to Myanmar's agricultural sector. 〈Table 1-6〉 presents Development Partner (DP) funded projects in MOALI departments during 2010-2015, as well as the anticipated projects for the period 2016-2022 under four major categories such as (1) infrastructure; (2) production enhancement; (3) capacity development of education, extension and farm organizations; and (4) policy, regulations, and governance. Between 2010 and 2015, DP investments in Myanmar's agricultural sector totaled US$131.35 million, with infrastructure particularly irrigation rehabilitation and maintenance accounting for nearly half of total spending. During 2016-2022, investment was projected to rise by almost 280 percent to US$499.61 million. Infrastructure continued to dominate with US$269.09 million (53.9 percent) allocated to it, of which US$248.93 million went specifically to irrigation. Other significant investments included production enhancement (US$77.05 million), capacity development for education, extension, and farmer organizations (US$ 89.40 million), and policy, regulation, and governance reforms (US$ 64.06 million). These figures underscore the

international community's recognition that Myanmar's agricultural modernization requires not only physical infrastructure but also strong institutions, skilled human resources, and transparent regulatory systems.

〈Table 1–6〉 DP funded projects during (2010–2015) and anticipated projects (2016–2022)

Investment Category and Program	2010–2015 (US$ million)	2016–2022 (US$ million)	2016–2022 (%)
(1) Infrastructure			
New irrigation	960,504	15,086,805	5.6%
Rehabilitation/ upgrade of existing irrigation	60,212,790	248,933,737	92.5%
Agro processing	1,031,577	1,132,163	0.4%
Other investments	1,258,152	3,939,217	1.5%
Sub–total	63,463,023	269,091,922	100%
(2) Production enhancement			
Seeds	2,555,131	8,120,384	10.5%
Soil nutrient management/fertilizers	2,888,546	7,879,871	10.2%
Plant protection	–	1,004,608	1.3%
Agricultural mechanization	4,222,917	9,919,671	12.9%
Access and use of new agricultural practices	5,533,323	10,785,912	14%
Water management practices	2,446,734	5,132,985	6.7%
Other climate smart agriculture practices	113,469	20,249,969	26.3%
Other programs	870,204	13,957,042	18.1%
Sub–total	18,630,324	77,050,443	100%
(3) Capacity development of education, extension and farm organizations			
Ag Extension	8,492,952	25,749,982	28.8%
Veterinary services	499,088	12,928,521	14.5%
Fisheries/aquaculture extension	3,397,459	16,545,984	18.5%
University curriculum development	725,000	3,355,913	3.7%
Agricultural producer cooperatives	1,553,170	2,644,690	3%
Water user groups	701,552	9,581,144	10.7%
Sector associations/ trade associations/interest groups	1,509,059	1,478,437	1.6%
Other programs	12,727,810	17,117,261	19.2%
Sub–total	29,606,091	89,401,930	100%

Investment Category and Program	2010–2015 (US$ million)	2016–2022 (US$ million)	2016–2022 (%)
(4) Policy, Regulations, Governance			
Land access and management	8,414,595	2,675,299	4.2%
Water management	740,561	661,947	1%
Fishery resource management	746,382	51,074,074	79.7%
Sanitary and phytosanitary issues	705,207	948,957	1.5%
Food safety and traceability	705,207	948,957	1.5%
Gender related	648,860	646,370	1%
Agricultural policy, value chains, ag inputs, and others	7,691,872	7,108,674	11.1%
Sub–total	19,652,684	64,064,278	100.5%

Source: MOALI(2018).

4.4. The Sustainable Enterprises and Agricultural Development (SEAD) Project

Another illustrative example of international cooperation blended with private sector leadership is the Sustainable Enterprises and Agricultural Development (SEAD) Project jointly developed by Ooredoo Myanmar and the United Nations Development Program (UNDP). Instead of engaging directly in farming, Ooredoo leveraged its strengths in ICT infrastructure to support agriculture through digital extension. The partnership was formalized in late 2019, with project implementation beginning in 2020. The SEAD project targeted 130 villages in Myingyan and Nyaung U townships in the Dry Zone, equipping government departments such as the Department of Agriculture (DoA), Department of Agricultural Research (DAR), Livestock Breeding and Veterinary Department (LBVD), and Department of Meteorology and Hydrology (DMH) with ICT devices

and training facilities. By integrating telecom expertise with local extension networks, the project improved farmers' access to digital advisories, weather forecasts, and sustainable farming practices.

SEAD project highlights several lessons: First, telecom and ICT companies can diversify into agriculture, not by farming directly but by providing enabling infrastructure and services. Second, partnerships with local ministries and research institutes are critical to ensure that digital initiatives align with national policies and reach farmers effectively. Third, blended finance models combining private investment with donor funding can help scale pilot projects into broader programs. Finally, the initiative demonstrates how digital agriculture can be framed not only as a tool for productivity but also as a strategy for climate resilience and rural development.

Overall, Myanmar's experience indicates that both private sector innovation and international cooperation are indispensable in advancing smart farming. While private companies drive digital transformation through mobile apps, platforms, and ICT services, development partners ensure the financial and institutional support necessary for scaling. Moving forward, a balanced model of collaboration where private innovation, government regulation, and donor financing converge will be critical in unlocking the full potential of smart agriculture in Myanmar.

While Myanmar does not yet have a fully developed national "Smart Agriculture Master Plan," this project illustrates how pilot programs can align with government priorities in agriculture modernization and climate-resilient farming. Equipment distribution and staff training also suggest that national and subnational governments are increasingly open

to budget allocations that combine traditional extension services with digital innovations (UNDP, 2020. 7. 21.).

4.5. Greenhouse farming project

The greenhouse horticulture market is growing steadily in Myanmar due to growing demands from local consumers for safe, fresh and high-quality products. To improve the productivity of quality crops— especially tomatoes, cucumbers, and bell peppers the adoption of greenhouse cultivation techniques is gaining popularity among local farmers, international and domestic companies, and NGOs. Local and foreign investors have numerous opportunities to invest in Myanmar's greenhouse horticulture market due to its potential for high demand in the future, although the sector is currently limited by a lack of technology and financing (Padhi, 2022).

Since 2015, a group of Dutch horticulture companies Larive International, Rijk Zwaan, Koppert, Priva, VEK, and Delphy have supported the development of Myanmar's horticultural industry in Heho, Southern Shan State, Myanmar. They collaborated with local public agencies, private associations, and the State Agriculture School in Heho to share technical knowledge and production technologies. In addition, they established a 3,000m2 demonstration greenhouse and provided training, technical support, and modern equipment to local farmers. The project aimed to introduce sustainable horticultural practices and strengthen the technical capacity of Myanmar's growers.

Greenhouse-grown horticulture products such as tomatoes, bell peppers, and various types of lettuce and herbs were supplied to local retail chains such as City Mart and Metro. The greenhouse consortium was supported by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and implemented under the develoPPP.de program of the German Federal Ministry for Economic Cooperation and Development (BMZ)(Hortidaily, 2019. 5. 14.).

However, following the 2021 political crisis, many European investors and companies suspended operations or refrained from new investments. As a result, most large-scale international greenhouse initiatives including this demonstration project have either concluded or been placed on hold. Despite these challenges, several local enterprises continue to promote greenhouse cultivation. For example, the Fresco Myanmar Company Limited is the leading producer of European vegetables in Myanmar, with its main production facility in Shan State, Myanmar. Fresco operates modern greenhouses using Dutch hydroponic technology covering approximately 10,000m2 and produces lettuces, tomatoes, and bell peppers in a hydroponic protected environment.

Moreover, a local bank and the Italian NGO CESVI launched a partnership in Heho, Southern Shan State on November 26, 2025, aiming to support farmers and SMEs through sustainable agricultural financing. This collaboration provides loans for greenhouse and irrigation systems and promotes contract farming models that link farmers with agribusinesses such as Fresco and Farmwise. The initiative aims to improve year-round cultivation, increase productivity, and strengthen value chains in the region.

5. Acceptance and constraints

5.1. Barriers to the adoption and operation of smart farms

Smart farming refers to the use of advanced technologies such as IoT-based sensors, drones, precision irrigation, automated greenhouses, and mobile applications for data-driven decision making. Most of these technologies rely on digital tools particularly smartphones and internet connectivity to collect, process, and share agricultural information. In principle, smart farming can improve productivity, reduce risks, and make farming more sustainable. However, in Myanmar, the adoption of such techniques is hindered by several critical barriers.

A. Limited digital literacy and aging farmers

One major roadblock is limited digital literacy among smallholder farmers, who make up the majority of the agricultural workforce. About 70-75% of Myanmar's farming population is above 40 years old, while only 25-30% are below 40 (Harper et al., 2017). Most farmers are in their 40s to 60s and have limited experience with smartphones, mobile applications, or sensor-based devices, making it difficult to operate smart farming tools.

B. Low education levels

Education levels significantly influence the ability to adopt modern technologies. In Myanmar, only 10% of farmers in the dry zone and 25% in the Delta region have completed middle school or higher. Even among

younger farmers, overall educational attainment remains modest, which limits their ability to use advanced digital tools effectively (Harper et al., 2017).

C. High costs and limited access to finance

Smart farming technologies such as drones, sensors, and automated irrigation systems are expensive. Most small-scale farmers lack the financial resources or access to affordable credit that would allow them to invest in these technologies, making large-scale adoption difficult. Therefore, high costs of IoT devices significantly hinder their adoption in the agricultural sector (Dutta, 2023).

D. Weak rural infrastructure

Infrastructure limitations are another significant barrier. Poor internal coverage, unreliable electricity supply, and a lack of technical support services reduce the effectiveness of digital farming solutions. For instance, 63% of farmers cite a lack of smartphones and internet access as a major obstacle, while 20% report insufficient digital knowledge (Thar et al., 2020). Although Myanmar has four major telecom operators MPT, ATOM, Ooredoo, and MyTel operating with 26,778 towers and 68,832 km of fiber networks, (ASEAN, 2024), connectivity in rural and remote areas remains inconsistent.

Despite mobile penetration having increased(from 80% mobile phone ownership and 30% internet penetration in 2018 to 133.6% mobile phone ownership and 45.9% internet penetration in 2022), challenges persist due to uneven infrastructure development and connectivity issues in

remote regions (Thar et al., 2020; Kemp, 2022). Although the percentages for mobile phone and internet usage in Myanmar are not low, various challenges remain, including infrastructure limitations, connectivity issues in remote areas, lack of a unified policy framework, the need for a comprehensive implementation plan, and concerns about institutional capability and the quality of human resources(ASEAN, 2024).

E. Institutional and policy constraints

Government extension services and support for modern technologies remain weak. The absence of a unified policy framework and limited institutional capacity hinder coordinated efforts to promote digital agriculture. Farmers are often hesitant to adopt new technologies without trusted demonstrations, leading to resistance and skepticism.

5.2. The availability and acceptance of extension services by regions

Myanmar's agricultural sector has faced major challenges since 2020; first due to mobility restrictions during the COVID-19 pandemic and later due to the 2021 military coup. The coup triggered widespread violence, slowed economic activity, weakened public service delivery, caused rapid currency depreciation, and led to international trade restrictions. In addition, the sector has been affected by limited access to mobile and internet services, frequent electricity shortages, more stringent regulations, and rising costs.

The International Food Policy Research Institute (IFPRI) conducted the Myanmar Agricultural Performance Survey (MAPS) to examine the availability and acceptance of agricultural extension and crop advisory services, which are essential for technology adoption and farm productivity. The study employed a nationally representative phone survey of more than 5,000 farmers, alongside key informant interviews and secondary data collection in four major agro-ecological zones to investigate the spatial differences in farmers' access to extension services. These zones include the Delta region (Ayeyarwady, Bago, Mon, and Yangon), the Coastal region (Rakhine and Tanintharyi), the Central Dry region (Mandalay, Magway, Nay Pyi Taw, and Sagaing), and the Hills and Mountains region (Chin, Kachin, Kayah, Kayin, and Shan). The study evaluates farmers' access to, acceptance of, and constraints related to agricultural extension services, distinguishing between in-person (public, private, and NGOs) and digital (mainly social media and apps) services.

The results show that overall, farmers' acceptance of extension services already low compared to neighboring countries before the crisis declined further during the crisis years. In the monsoon season in 2020, 41 percent of farmers reported receiving agricultural advice, but this fell by 9 percentage points to 32 percent by the monsoon of 2022. In-person extension delivery declined most sharply, while digital extension proved more resilient, maintaining user levels during 2021 and recovering thereafter. By the dry season of 2023, 26 percent of farmers used in-person services compared to 20 percent using digital services. These figures suggest that although digital advisory systems have gained importance, traditional face-to-face services remain more common.

Acceptance varied considerably across Myanmar's agro-ecological zones. Farmers in the Delta region were the most engaged, with 44 percent using some form of extension during the 2023 dry season; of this, 30 percent accessed in-person, while 24 percent opted for digital services. In contrast, the Hills and Mountains region and the Dry Zone recorded the lowest levels of access, with only one-third of farmers using any advisory services and fewer than 18 percent relying on digital platforms. Coastal farmers fell between these extremes, with almost 40 percent using extension services. These regional patterns underline that both geography and connectivity shape differences in acceptance, with more urbanized and agriculturally intensive areas better integrated into extension systems.

〈Table 1-7〉 Extension service availability by region

Unit: percent

Region	Any Extension	In-Person	Digital
Delta	43.5	30.3	23.6
Coastal	39.9	27.0	21.2
Hills & Mountains	34.0	23.4	17.0
Dry Zone	33.0	23.0	17.8
National Average	37.6	26.1	20.0

Source: IFPRI(2024).

services, especially digital platforms that require literacy. Farm size was another determinant, as farmers with larger plots reported higher uptake in both in-person and digital services. Gender disparities were also apparent male farmers accessed extension 8 percent more than their female counterparts, even when education levels were controlled. Age also played a role, with older farmers favoring in-person services, while

younger farmers showed greater acceptance of digital platforms. This generational difference highlights the graduate transition toward digital farming advice, though traditional systems still remain vital for older rural populations.

Conflict and insecurity presented major constraints for acceptance. Farmers in townships under martial law about 13 percent of all townships used all extension services at rates 8 percent lower than those in secure areas. In the most insecure zones, reliance on in-person extension fell by 11 percent, reflecting both mobility restrictions and safety concerns. Interestingly, digital extension use was not significantly lower in these insecure regions, suggesting that online advisory platforms provided a form of resilience where physical contact was risky or impossible. Nonetheless, the quality of digital access was uneven due to frequent internet shutdowns, electricity shortages, and high data costs after 2021.

The overall picture is one of non-inclusiveness. Extension systems whether digital or in-person remain biased toward larger, better-educated, male farmers in less remote and more secure areas. Female farmers, smallholders, and those living far from urban centers are consistently excluded. Regional disparities persist, with Delta farmers enjoying significantly higher levels of access than those in the Dry Zone or the Hills and Mountains region. At the same time, the decline of public sector extension activities which fell by more than 50 percent in terms of events organized and pamphlets distributed between 2019 and 2022 forced farmers to rely increasingly on private sector initiatives. While private companies and social enterprises have taken a leading role in developing Facebook pages, chatbots, and mobile apps, these services

cannot yet fully compensate for gaps in inclusiveness and infrastructural constraints.

The findings suggest important implications for smart farming adoption in Myanmar. First, digital advisory platforms show strong potential, particularly in conflict-affected areas where physical extension is difficult; however, scaling requires improved electricity supply, internet coverage, and digital literacy. Second, inclusivity gaps must be addressed by tailoring services to women, less educated farmers, and remote communities. Third, while private sector initiatives are dynamic, public institutions and NGOs are essential in ensuring that extension services reach beyond commercial interests and cover disadvantaged groups. Finally, innovations such as AI-based chatbots and interactive platforms are emerging but remain underutilized; greater piloting and investment in these tools could widen farmer acceptance and resilience to future crises (IFPRI, 2024).

6. Implications and Outlook

6.1. Smart farming technologies in high demand in Myanmar

Recent research and pilot initiatives in Myanmar highlight a growing interest in smart farming technologies, particularly those based on digital tools, automation, and IoT applications. Although still in their early stages, these initiatives highlight the technologies most likely to be in

demand in the future, especially as the country grapples with climate change, resource constraints, and the need to modernize its agriculture.

A. IoT-based weather and farm monitoring

One important area of research is climate risk management. Thway et al. (2025) developed an IoT-based smart weather monitoring and notification system that integrated LSTM prediction models with real-time sensors to forecast floods and weather conditions; this was done using Taikkyi Township as a case study. Farmers received daily updates and forecasts through Telegram groups, which helped them prepare for weather variability and reduce potential crop losses. Although still in the prototype stage, this system illustrates how real-time digital services can strengthen resilience to climate shocks.

Another line of research examined IoT interoperability and accessibility, developing a semantic web-enhanced middleware framework that integrated multiple communication protocols (Bluetooth, Zigbee, WiFi) into a unified platform. Unlike conventional IoT systems, which are often too technical for farmers, this framework supported a single-click configuration and the automatic annotation of sensor data (e.g., soil moisture, temperature, humidity). Tested with 20 sensors monitoring soil moisture and pollution levels it reduced system setup time and enabled non-IT users including farmers to operate IoT systems effectively, indicating strong potential for wider adoption by smallholders (Htaik et al., 2018).

B. Automated and semi-automated greenhouse systems

Controlled-environment agriculture is another promising area. Thwe et al.(2019) proposed a GSM-based automatic greenhouse control system that used Arduino boards and sensors to regulate temperature, humidity, soil moisture, and lighting, transmitting data and alerts via SMS. Similarly, Hlaing & Soe(2019) designed an automated greenhouse system for the Mawlamyine region using soil moisture and temperature sensors, actuators (heaters, coolers, pumps), and microcontrollers to maintain stable conditions. Both prototypes highlighted how smart greenhouse solutions could improve yields even with Myanmar's challenging climate. However, high initial investment, infrastructure needs, and reliance on partial automation remain major obstacles.

Related to this, experimental work on IoT-based smart irrigation systems for high-value crops such as strawberries demonstrated improved water efficiency and year-round production through automated climate control and nutrient management (Htet et al., 2021). Likewise, hydroponic systems with fuzzy logic controllers have been tested in the process of regulating temperature and humidity in areas with water scarcity (Thazin et al., 2019). These systems, though still prototypes, reveal the strong potential of smart irrigation and hydroponics to support more efficient farming of greenhouse vegetables and fruits.

C. Aquaponics and resource-efficient systems

Complementing greenhouse systems, researchers also developed a Crop Health Monitoring System based on aquaponics and IoT automation, which integrated ESP32 microcontrollers, GSM routers, solar panels, and

real-time sensors (pH, temperature, soil moisture, humidity), as well as cameras for crop and weed detection. By recycling water and optimizing nutrient delivery, the prototype achieved 50% water savings, reduced fertilizer inputs, and improved crop yields. It successfully cultivated leafy vegetables and medicinal plants alongside fish, showing how aquaponics can enhance sustainability, urban farming, and climate adaptation in Myanmar (Yee et al., 2024).

D. Digital extension and communication tools

Beyond hardware and automation, digital communication tools have become increasingly important. As traditional extension services are limited, Goeb et al. (2025) tested a digitally supported extension system combining SMS with a lead-farmer-supported hybrid model. This approach helped maintain the flow of agricultural information during crises and conflict, although its effectiveness depended heavily on digital literacy, mobile network reliability, and farmers' trust in the information source.

E. AI-driven crop health management

Another emerging research area concerns the use of IoT and AI applications for crop health management. Early-stage systems that use environmental sensors and AI algorithms for plant disease detection have been developed to diagnose crop conditions and provide real-time recommendations to farmers via mobile platforms (Win, 2018). While still experimental, these technologies signal the potential of AI-enabled

precision to reduce crop losses and improve farm management practices in Myanmar.

Taken together, these examples illustrate that Myanmar's agriculture is gradually opening up to digital and automated solutions, with the following technologies showing the highest potential demand in the next 5-10 years: IoT-based weather and farm monitoring systems, automated and semi-automated greenhouse systems, smart irrigation and hydroponic farming systems, aquaponics and resource-efficient systems, mobile and SMS-based digital extension tools, and AI-driven crop disease detection platforms. 〈Table 1-8〉 presents a summary of local research on the adoption of smart farming in Myanmar.

〈Table 1-8〉 Summary of smart farming research and prototypes in Myanmar

Technology focus	Study/ Project	Key Features	Benefits	Limitations/ Challenges
IoT-based weather monitoring	Thway et al. (2025)	IoT sensors + LSTM model; Telegram alerts for farmers	Improved weather forecasts, reduced crop losses	Prototype only; depends on internet access and farmer adoption
IoT middleware (semantic web)	Htaik et al. (2018)	Integrated Zigbee, WiFi, Bluetooth, semantic annotation, single-click setup	Enabled non-IT farmers to use IoT, Improved interoperability	Early-stage, requires infrastructure
Automated greenhouse (SMS-based)	Thwe et al. (2019)	Arduino + sensors, GSM/SMS alerts	Maintains stable climate, remote monitoring	High cost, limited automation
Automated greenhouse (Mawlamyine)	Hlaing & Soe (2019)	Sensors + actuators (pumps, heaters, coolers), microcontrollers	Improved crop productivity under local climate	Investment, Infrastructure reliance
IoT-based smart irrigation (strawberries)	Htet et al. (2021)	IoT drip irrigation, humidity/temperature sensors, cooling pads, fans	Water efficiency, year-round production	Prototype, affordability concerns

Technology focus	Study/ Project	Key Features	Benefits	Limitations/ Challenges
Hydroponics with fuzzy logic	Thazin et al. (2019)	Fuzzy controllers regulating temp & humidity	Suitable for water-scarce regions, higher precision	Still experimental
Aquaponics system (IoT-enabled)	Yee et al. (2024)	ESP32 GSM, solar, crop + fish system, cameras for weed detection	50% water saving, reduced fertilizer, higher yields	Needs capital, scaling challenges
Digital extension (SMS+ lead farmer)	Goeb et al. (2025)	Hybrid SMS & lead farmer communication	Maintains info flow during crises, scalable	Dependent on literacy & network reliability
AI-based crop disease detection	Win (2018)	Sensors + AI for disease identification	Real-time diagnosis, reduces losses	Still experimental, limited datasets

Source: Author's compilation.

Myanmar's agricultural sector toward digitalization and automation. Early-stage prototypes such as IoT-enabled weather monitoring and AI-based crop disease detection—demonstrate the potential of smart technologies in improving resilience, resource efficiency, and productivity. Meanwhile, applied systems such as automated greenhouses, IoT-based irrigation for strawberries, and aquaponics show practical ways in which these technologies can enhance crop yields and conserve water. Across all initiatives, several recurring challenges emerge including high initial investment costs, dependence on reliable infrastructure (electricity, internet), and gaps in farmers' digital literacy.

Despite these constraints, the studies collectively indicate strong interest and growing demand for smart farming solutions, particularly for high-value crops, controlled-environment agriculture, and digital advisory services. This environment presents significant opportunities for international cooperation. For example, countries such as Korea may

contribute affordable IoT kits, smart greenhouse technologies, mobile-based extension platforms, and AI-driven diagnostic tools, helping Myanmar fast-track the adoption of smart agriculture while addressing infrastructural and educational gaps. Overall, the evidence suggests that, with strategic support and investment, smart farming technologies can play a transformative role in Myanmar's agricultural modernization over the next 5-10 years.

6.2. Opportunities and challenges

The development and adoption of smart farming in Myanmar are shaped by a combination of opportunities and constraints. On the one hand, growing interest in digital and automated technologies has created pathways for improving agricultural productivity, resilience, and sustainability. On the other hand, structural challenges related to infrastructure, affordability, human capacity, and institutional support limit the pace and scale of adoption.

6.2.1. Opportunities

Myanmar's agriculture sector faces persistent problems, including climate variability, declining soil fertility, and labor shortages due to rural-urban migration. These challenges have led to the demand for technologies that can reduce input waste, improve yields, and ensure year-round production. IoT-based irrigation, automated greenhouse

management, and AI-supported disease detection directly address these needs, making them attractive for farmers who are increasingly aware of the potential benefits.

Although still at an early stage, research from Myanmar's universities and technical institutes has demonstrated the feasibility of applying IoT, AI, and automation in agriculture. For instance, prototypes of smart greenhouses, aquaponics systems, and weather monitoring platforms developed by university teachers and students have demonstrated that Myanmar has a vast pool of emerging talent capable of adapting global technologies to local contexts. These initiatives, though small in scale, indicate a strong academic foundation to support future development.

Given Myanmar's status as a developing country, smart farming lucrative opportunities for collaboration with international partners such as Korea, Japan, and China, as well as with international organizations (FAO, World Bank, and ADB). These partners can contribute both financial resources and technical expertise, helping bridge gaps in Myanmar's infrastructure and research and development (R&D) Joint research projects, training programs, and technology transfer initiatives could accelerate progress while ensuring that solutions remain context-appropriate.

The Agricultural Development Strategy (ADS 2018-2030) emphasizes productivity, competitiveness, and sustainability. Although smart farming is not yet mainstream in government programs, it aligns closely with ADS goals such mechanization, digital extension, and improved resource management. This policy environment creates an opportunity to integrate smart farming into broader modernization plans, especially as the government seeks to attract private investment in agriculture.

6.2.2. Challenges

Myanmar's digital and physical infrastructure remains underdeveloped. Limited access to reliable electricity, poor internet connectivity in rural areas, and insufficient logistics systems make it difficult to implement IoT-enables technologies. Even when prototypes show promise in laboratory or university settings, scaling them to village-level applicability is often not feasible under present infrastructure conditions.

Many smart farming technologies require substantial initial investments in hardware, sensors, and connectivity solutions. For smallholder farmers, who dominate Myanmar's agricultural landscape, these costs are prohibitive. Without subsidies, credit support, or cost-sharing mechanisms, large-scale adoption is unlikely.

Farmers in Myanmar are diverse in terms of age, education, and exposure to technology. While younger farmers may be more comfortable using smartphones or SMS-based tools, older generations lack the digital literacy required to operate advanced IoT platforms or interpret sensor data. Extension systems are underdeveloped and unable to fill this gap at present.

Most of the smart farming research in Myanmar is carried out by university teachers and students at public universities, particularly technological universities. While these institutions demonstrate creativity and technical skill, they face serious budget limitations. Projects often rely on inexpensive microcontrollers and basic sensors, restricting the scope of experimentation. More importantly, university projects are often conducted in isolation, with limited opportunities for commercialization, field testing, or farmer engagement. This gap underscores the

need to strengthen R&D through better funding, industry partnerships, and international collaboration.

Private agribusinesses in Myanmar have shown little engagement with smart farming initiatives compared to neighboring countries. Without active participation from the private sector, scaling university prototypes into market-ready solutions is difficult. International donors and NGOs have been more active, but their projects are often pilot-focused rather than commercially driven.

While the ADS provides a broad modernization framework, there is no dedicated roadmap for smart farming. Issues such as intellectual property protection for local innovations, regulatory standards for digital agriculture devices, and structured subsidies for smart farming have not yet been definitively addressed. Without a supportive regulatory environment, entrepreneurs and farmers may hesitate to invest in new technologies.

Myanmar's universities and research centers require sustained technical assistance to move from experimental prototypes to scalable technologies. Partnerships with foreign universities, development agencies, and private companies could provide access to advanced equipment, training in AI and data science, and exposure to international best practices. Collaboration is also essential to ensure that innovations are demand-driven and farmer-centered rather than remaining confined to academic laboratories.

6.3. Data and policy limitations

In Myanmar, greenhouse farming is currently operated and developed mainly by the private sector and NGOs rather than by the public sector. In addition, the official statistical records on greenhouse farming such as cultivation areas, yield, and other production indicators have not yet been publicly announced. Therefore, Myanmar currently lacks comprehensive statistical data on greenhouse and vertical farming, even though there is growing interest. Moreover, the government has not introduced clearly defined smart farming policies and agricultural roadmaps in Myanmar.

There are several reasons for these limitations. First, government agricultural policies and strategies such as the Agricultural Development Strategy (2018–2030) and the Climate-Smart Agriculture Strategy (2015–2025) focus primarily on climate resilience and productivity improvement rather than on the direct promotion of smart farming technologies. These frameworks emphasize sustainable land management, irrigation efficiency, and climate adaptation; however, they do not include specific indicators or reporting systems for smart farming such as greenhouses or vertical farming.

Second, the Department of Agriculture (DOA) and the Department of Agricultural Research (DAR) have limited budget allocations for monitoring high-technology farming systems, which are still considered experimental and confined to small-scale projects. Most available data come from individual companies, donor-supported pilot programs, or university-led research rather than from national statistics.

Third, the adoption of smart farming technology is still in an early stage

in Myanmar. Nevertheless, the government's broader agenda for agricultural modernization and digital transformation outlined in the Digital Economy Development Master Plan (2019-2030) and the Agricultural Policy (2016) creates an enabling environment for the future development of smart farming. With appropriate investment, technical assistance, and capacity-building programs, Myanmar could gradually integrate controlled-environment agriculture into its agricultural modernization strategy.

2 Smart Agriculture in Vietnam: Current Status, Policies, and Implications

1. Introduction

Agricultural production plays a central role in Vietnam's economic and social development. Despite ongoing structural transformation and the rapid growth of industry and services, agriculture, forestry, and fisheries still account for around 12-14% of the national GDP and employ nearly one-third of the labor force (Phan Nguyen et al., 2025b). The sector not only provides food security for over 100 million people but also underpins rural livelihoods, with the majority of households in rural areas depending on farming as their main source of income.

Vietnam is widely recognized as a leading exporter of agricultural commodities, ranking among the world's top producers of rice, coffee, cashew nuts, pepper, rubber, and aquaculture products (Kien et al., 2023). Agricultural exports significantly contribute to foreign exchange earnings,

generating over US$50 billion annually and thereby strengthening the country's trade balance. Beyond its direct economic contributions, agriculture also supports industrial growth by supplying raw materials for food processing, textiles, and other agro-based industries, while fostering rural development and reducing poverty through participation in value chains and the creation of employment opportunities.

However, the sector faces numerous challenges and difficulties. Productivity growth remains uneven, with smallholder farmers operating on fragmented plots and facing constraints such as limited access to capital, technology, and modern farming techniques (Tran & Tortajada, 2022). Market volatility, price fluctuations, and trade barriers expose farmers to economic risks, while weak linkages between production, processing, and distribution negatively impact competitiveness. Environmental concerns—including soil degradation, overuse of chemical inputs, and water pollution—threaten long-term sustainability(Nguyen et al., 2020a). In addition, climate change poses severe risks, particularly in the Mekong Delta and Central Highlands, where salinity intrusion, drought, and floods directly impact yields and household incomes (Hoang, 2021). Institutional constraints, including inadequate rural infrastructure, insufficient extension services, and limited adoption of digital technologies, further hinder the modernization of the sector.

To address these pressing challenges, Climate-Smart Agriculture (CSA) has emerged as a strategic approach for Vietnam. CSA integrates practices and technologies that simultaneously aim to increase productivity, build resilience to climate change, and reduce greenhouse gas emissions (Nguyen et al., 2015). Examples include water-saving irrigation

systems, stress-tolerant crop varieties, integrated pest management, precision farming, and digital tools for climate and market forecasting. By promoting efficient resource use and strengthening adaptation capacity, the CSA offers pathways for smallholder farmers to overcome productivity barriers while safeguarding environmental sustainability (Le et al., 2019). Moreover, CSA aligns with Vietnam's national commitments to green growth and low-carbon development, creating opportunities to enhance competitiveness in global value chains (Nguyen, 2022).

Building on previous research and reports, this study presents an integrated assessment of Vietnam's agricultural production status, with a focus on the transition towards Climate-Smart Agriculture (CSA). It explores current CSA adoption levels across key regions, identifies the major barriers to scaling such as limited access to finance, fragmented landholdings, insufficient extension services, and policy implementation gaps and highlights the implications for national agricultural transformation. Importantly, the study emphasizes the need to develop a robust CSA market ecosystem that connects farmers with technology providers, financial institutions, agribusinesses, and policymakers (Huang et al., 2022). Strengthening this ecosystem will not only accelerate the adoption of climate-resilient and low-emission practices but also create new opportunities for investment, innovation, and value chain upgrading. As a result, Vietnam could enhance the competitiveness of its agricultural sector, ensure long-term sustainability, and position itself as a regional leader in the development of climate-smart food systems.

2. Market size and growth potential

The development of smart farming in Vietnam has gained increasing momentum over the past decade, supported by national policies, donor interventions, and private sector investment. Nevertheless, adoption patterns remain heterogeneous across subsectors and regions, reflecting both opportunities for growth and persistent structural barriers.

As shown in ⟨Table 2-1⟩, Lam Dong province represents the most advanced hub of smart farming adoption, particularly in greenhouse horticulture. Current estimates indicate approximately 4,476 ha of greenhouse cultivation and nearly 66,000 ha classified as high-tech agriculture. Technologies such as hydroponics, fertigation, and automated climate control have been introduced largely through public-private partnership projects and major private enterprises (e.g., Dalat Hasfarm). These investments have contributed to the province's competitive advantage in high-value export crops, including flowers and vegetables. However, the sector faces challenges related to high capital requirements and environmental concerns associated with concentrated greenhouse gas development. Consequently, future growth potential lies in the expansion of modular, energy-efficient systems that reduce costs and mitigate environmental externalities.

〈**Table 2-1**〉 CSA Adoption in Major Agricultural Fields of Vietnam

Sector	CSA Practices Adopted	Scale of Adoption	Key Drivers	Main Challenges
Horticulture (Lam Đồng)	Greenhouses, hydroponics, fertigation, automated climate control	About 4,476 ha greenhouses; 66,000 ha high-tech agriculture	Export demand, PPP projects, private investment (e.g., Dalat Hasfarm)	High costs; environmental concerns over greenhouse gas density
Rice (Mekong Delta)	AWD irrigation, precision fertilizer use, low-emission production, MRV for carbon credits	Program targets 1 million ha by 2030	Government policy (MARD), carbon finance potential	Farmer training, financing, and infrastructure gaps
Aquaculture	IoT water-quality sensors, automated feeding, AI disease monitoring, and aquaponics	Expanding in shrimp/pangasius farms; aquaponics at pilot scale	Export market compliance (SPS/TBT), efficiency gains	Cost of technology, technical know-how, and disease risks
ICT & Traceability	5G/NB-IoT, QR/GS1 barcodes, RFID, blockchain pilots	Nationwide rollout, especially in fruit & seafood chains	Digital agriculture policy, donor support (World Bank, UNDP)	Fragmented platforms, regulatory complexity, and rural coverage gaps

Source: Various research and reports.

The Mekong Delta is central to Vietnam's smart rice initiatives, particularly through the 1 Million Hectare Low-Emission, High-Quality Rice Program (2023-2030), as shown in 〈Table 2-1〉. This program promotes alternate wetting and drying (AWD) irrigation, precision fertilizer use, and the establishment of carbon credit monitoring, reporting, and verification (MRV) systems. Data from the Vietnam Access to Resources Household Survey (VARHS) in 〈Table 2-2〉 illustrates that adoption of improved seeds remains high (82-90% during 2012-2018), while the use of organic fertilizers is less consistent, ranging from 18-51% of households depending on the type and source. These patterns underscore the potential

for scaling low-emission practices, provided that complementary investments in farmer training, financing, and infrastructure are prioritized.

〈Table 2-2〉 CSA Adoption in rice production in some regions of Vietnam

Variable	2012		2014		2016		2018		All	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Adoption Chemical Fertilizer (1: Yes; 0: No)	0.96	0.20	0.96	0.19	0.96	0.20	0.99	0.10	0.97	0.18
Adoption Improved Seeds (1: Yes; 0: No)	0.84	0.37	0.87	0.34	0.82	0.39	0.90	0.30	0.86	0.35
Adoption of Organic fertilizer prepared by the household (1: Yes; 0: No)	0.51	0.50	0.46	0.50	0.43	0.50	0.29	0.45	0.42	0.49
Adoption of Organic fertilizer bought from Others (1: Yes; 0: No)	0.21	0.41	0.16	0.36	0.21	0.41	0.15	0.35	0.18	0.38

Source: Calculated by the author from VARHS(Phan Nguyen et al., 2025b).

Nationwide rollout of digital tools, including QR/GS1 barcodes, RFID tags, and blockchain pilots, has begun to reshape value chain governance, particularly in fruit and seafood exports. Empirical evidence in 〈Table 2-3〉 related to lotus production in Central Vietnam demonstrates that traceability adoption significantly improves household welfare, with measurable gains in revenue, productivity, and output price. However, the fragmentation of digital platforms, regulatory complexity, and uneven rural internet coverage pose significant challenges. The sector's growth potential, therefore, is tied to the consolidation of platforms, strengthening of regulatory clarity, and expansion of rural digital infrastructure.

〈Table 2-3〉 Effect of traceability adoption on household welfare in lotus production in Central Vietnam

VARIABLES	Revenue	Productivity	Output Price
	Coef.	Coef.	Coef.
Adoption traceability (Yes = 1; Otherwise, = 0) – Matched	31.315**	0. 759**	0.333**
	(15.442)	(0.364)	(1.630)
Observations	360	360	360

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Source: Author's calculation from previous research(Phan Nguyen et al., 2025a).

The adoption of improved and climate-resilient seed varieties illustrates another dimension of smart farming growth. Data from the Mekong region in 〈Table 2-4〉 reveal that high-quality seeds are used by 51% of farmers, while adoption rates for salt-tolerant (29%) and drought-tolerant (28%) rice varieties are increasing. These figures point to rising demand for innovative inputs aligned with climate adaptation, highlighting opportunities for international collaboration in seed development and precision input technologies.

〈Table 2-4〉 Various seeds used in rice production in the Mekong region

Variable	Obs	Mean	Std. dev.
Traditional Seed	401	0.38	0.49
High-quality seed	401	0.51	0.50
insect-resistant varieties	401	0.06	0.24
Salt-tolerant rice varieties	336	0.29	0.46
Drought-tolerant rice varieties	336	0.28	0.45

Source: Author's data collection in 2022.

Overall, the Vietnamese smart farming market is characterized by differentiated opportunities across subsectors. Expansion will be driven by three interrelated factors: (i) policy alignment, with government programs—such as the Agricultural Restructuring Plan (2021-2025) and

the 1 Million Hectare Rice Program, which may provide an enabling environment; (ii) market incentives, particularly from export-oriented horticulture and aquaculture that require compliance with global standards; and (iii) technology diffusion, contingent upon bridging knowledge, financing, and infrastructure gaps, especially among small-holders. Taken together, Vietnam offers a fast-growing and strategically important smart farming market in Southeast Asia, with substantial potential for greenhouse technologies in Lam Đồng, climate-smart rice in the Mekong Delta, aquaculture monitoring in coastal provinces, and ICT-enabled traceability across value chains.

The available data ⟨Table 2-5⟩ highlight that Vietnam's smart farming market is underpinned by substantial investment programs and strong sectoral drivers. In the Mekong Delta, the government has committed nearly US$2.7 billion to the "1 Million Hectares High-Quality, Low-Emission Rice" program, already demonstrating cost savings and emission reductions in pilot sites. In Lam Dong, a leading horticultural province, the rapid expansion of 4,476 ha of greenhouses and more than 66,000 ha of hi-tech farming showcases significant private and public investment in controlled-environment agriculture. The floriculture segment alone is valued at US$603 million in 2025, with exports exceeding US$100 million annually, reflecting Vietnam's growing role in the regional flower trade. Similarly, aquaculture, accounting for 58% of national fisheries production, is projected to generate over US$10 billion in exports in 2025, creating demand for IoT-based monitoring and AI-driven disease control. On the digital front, Decision 100/QD-TTg targets at least 30% of enterprises applying traceability standards by 2025, with pilot projects such as e-traceability for dragon fruit already in

operation. Considering the fact that there are 8.58 million farming households and 28 million ha of farmland, the baseline adoption potential is vast, suggesting that Vietnam's smart agriculture market is poised for sustained and diversified growth.

⟨Table 2-5⟩ Market size and growth potential

Segment	Indicator	Value	Year	Source
Smart/low-emission rice (Mekong Delta)	Required capital for the "One Million Hectares High-Quality, Low-Emission Rice" program	~US$2.7 billion (to 2030)	2024	https://vietnamnews.vn/economy/1658466/viet-nam-requires-2-7-billion-for-one-million-hectares-of-high-quality-rice.html
	Status	Program approved, pilots show yield gains, cost savings, and emission cuts	2024–2025	https://www.irri.org/news-and-events/news/vietnam%E2%80%99s-1-million-hectare-rice-program-shows-promising-results
Hi-tech horticulture (Lam Dong/Da Lat)	Greenhouse area in Lam Dong	~4,476 ha (Da Lat ~57%)	2025	https://van.nongnghiepmoitruong.vn/da-lats-flower-industry-and-the-consequences-of-greenhouse-d421254.html
	Hi-tech agriculture area	~66,000–66,873 ha (≈20–21% of total farmland)	2023–2024	https://en.sggp.org.vn/lam-dong-province-sets-example-of-high-tech-agriculture-development-post110730.html
Floriculture/hi-tech flowers	Vietnam floriculture market size	US$603 million (2025); projected US$779 million (2030)	2025/2030	https://www.mordorintelligence.com/industry-reports/floriculture-market-in-vietnam
	Flower export value	⟩US$100 million per year	2025	https://en.vietnamplus.vn/vietnams-flower-export-turnover-surpasses-100-million-usd-mark-post319120.vnp
Smart aquaculture (IoT water monitoring, AI disease control)	Fisheries production & share of aquaculture	9.5 million tons, aquaculture ≈58%	2024	https://seafood.vasep.com.vn/why-buy-seafood/fishery-profile
	Seafood exports	⟩US$10 billion forecast (2025, approaching US$11 bn of 2022)	2025	https://www.seafood.media/fis/worldnews/worldnews.asp?day=6&id=133150&l=e&monthyear=&ndb=1+target%3D&special

Segment	Indicator	Value	Year	Source
Digital traceability (QR/ Blockchain/ RFID)	National policy target	Decision 100/QD–TTg (2019); by 2025 ≥30% of enterprises will apply traceability standards	2019–2025	https://documents1.worldbank.org/curated/en/099724310182330688/pdf/IDU03bd6b7680aa0804d260a4120c0c008620286.pdf
	Pilot	e-traceability system for dragon fruit (Binh Thuan, supported by UNDP)	2023	https://www.undp.org/vietnam/news/e-traceability-transformative-step-towards-climate-responsible-agriculture
Baseline context	Total farm households & farmland (potential market for digital adoption)	8.58 million households; 28 million ha farmland (11.34 million ha crops)	2025	https://www.agroberichtenbuitenland.nl/actueel/nieuws/2025/04/24/as14–vietnam

Source: Author's compilation.

3. Policies and regulations

3.1. Policy Frameworks and Programs

The policies and programs summarized in ⟨Table 2-6⟩ demonstrate Vietnam's strengthening institutional commitment to mainstreaming Climate-Smart Agriculture (CSA) into both sectoral and national development frameworks. These initiatives reflect a multi-level policy mix, ranging from national strategies to sector-specific programs and project-based interventions.

First, overarching strategies such as the National Target Program on

Climate Change and Green Growth (from 2011 to present) provide an enabling framework for CSA by linking agricultural transformation with low-carbon development and resilience-building objectives. The inclusion of agriculture alongside forestry and energy highlights official recognition of the sector's dual role as both a source of emissions and a site for climate adaptation (Flor et al., 2021; Linquist et al., 2015).

Second, sectoral restructuring efforts under the Agricultural Restructuring Plan (ARP) 2021-2025 integrate CSA into value chain upgrading, diversification, and digital agriculture. This demonstrates a shift away from purely production-focused policies toward approaches that combine climate resilience with competitiveness and high-value exports (Hariyati et al., 2024).

Third, more targeted interventions such as the 1 Million Hectare Low-Emission, High-Quality Rice Program (2023-2030) illustrate the government's focus on flagship commodities. The program operation-alizes CSA principles through water-saving technologies (Alternate Wetting and Drying), precision fertilizer application, and carbon market mechanisms. Importantly, it links climate objectives with international trade competitiveness, particularly for rice exports from the Mekong Delta (Wang et al., 2023).

Fourth, international commitments under the Nationally Determined Contributions (NDCs, 2022 update) reinforce CSA's strategic role by setting measurable emission reduction targets. The incorporation of agriculture into MRV (Monitoring, Reporting, and Verification) systems and carbon markets provides both an accountability framework and opportunities for technology transfer and climate finance (Jiang et al., 2017).

Fifth, project-based initiatives such as the VnSAT Project (2015-2022) have had concrete on-the-ground impacts, particularly in rice and coffee systems. By combining farmer training, replanting, and irrigation efficiency measures, VnSAT has not only reduced emissions but also enhanced smallholder resilience and productivity. The project's scale (140,000 ha of rice cultivation and 63,000 ha of coffee cultivation) demonstrates the potential of donor-supported interventions to catalyze national policy uptake (Anh Duc et al., 2012).

Finally, the government's reliance on Public-Private Partnership (PPP) programs in horticulture and aquaculture reflects an important trend of mobilizing private investment for CSA. The adoption of high-tech greenhouses, ICT-based disease monitoring, and compliance with export standards illustrates how CSA can be positioned as a driver of market access and value addition (Nguyen et al., 2020b).

Overall, the mix of framework policies, sectoral strategies, commodity-specific programs, and PPP initiatives suggests a multi-pronged approach to CSA in Vietnam. However, several challenges remain: ensuring coherence across initiatives, scaling successful pilots (e.g., VnSAT) nationwide, and balancing short-term productivity gains with long-term sustainability. The emphasis on rice and coffee is understandable given their strategic importance however, at the same time, expanding CSA adoption to other subsectors (livestock, maize, smallholder horticulture) will be critical to meeting Vietnam's climate and development goals (Jiang et al., 2017).

3.2. Subsidies, Tax Incentives, and Regulatory Reforms

Vietnam has developed a set of concrete policy instruments that directly incentivize the adoption of CSA and smart farming. Decree 57/2018/NĐ-CP is a cornerstone measure, offering exemptions and reductions in land and water-surface rent to enterprises for extended periods. It also provides post-investment subsidies in the form of interest-rate support, allowing local governments to reimburse the gap between concessional and commercial borrowing rates. These mechanisms substantially reduce the effective capital costs of high-tech agriculture, from greenhouses in Lam Đồng to smart aquaculture in the Mekong Delta.

Complementary measures under Decree 116/2018 expand access to agricultural credit, enabling high-tech projects to borrow up to 70% of project value without collateral. Targeted initiatives, such as the 1 Million Hectare Low-Emission, High-Quality Rice Program (2023-2030), further align financial incentives with climate objectives by combining state investment with carbon finance. Pilot results in 2025 indicate not only yield and income gains but also the potential for farmers to benefit from verified carbon credits. Similarly, Decree 109/2018/NĐ-CP on organic agriculture institutionalizes support for certification, labeling, and the use of a national organic logo, providing additional incentives for sustainable production.

Fiscal policy also plays a key role. Enterprises investing in priority sectors or in "extremely difficult areas" are eligible for corporate income tax (CIT) incentives, including a 10% CIT rate for 15 years, four years of full tax exemption, and a 50% reduction over the following 9 years. These

incentives have proven effective in attracting private capital into smart horticulture and aquaculture ventures, while also encouraging innovation in digital agriculture and renewable energy integration.

The regulatory environment has been updated to accommodate technology-driven farming. The Land Law 2024, effective from 2025, introduces new rules for land-use rights, transfer ceilings, and valuation, facilitating longer leases and farm consolidation—conditions necessary for scaling up high-tech clusters. Digital agriculture is supported by the Personal Data Protection Decree (13/2023) and the forthcoming Personal Data Protection Law, which establishes clear guidelines for processing farm-level and consumer data. At the same time, Decision 100/QĐ-TTg (2019) established the national traceability portal, which has become central to compliance in fruit, seafood, and rice export chains. Finally, the Law on Cooperatives 2023 strengthens farmer organizations, enabling them to pool resources for CSA investments and negotiate better access to credit and markets.

Taken together, these subsidies, tax incentives, and regulatory reforms underscore Vietnam's attempt to combine financial support with institutional modernization. While these policies create an enabling environment for CSA and smart farming, their effectiveness will ultimately depend on implementation—particularly on ensuring that smallholder farmers, who dominate Vietnam's agriculture, can access and benefit from these opportunities.

〈Table 2-6〉 Lists of Policies from the Government to Improve the CSA

Policy /Program	Year	Key Objectives	Target Sectors	Main Instruments /Actions	Outcomes /Progress
National Target Program on Climate Change and Green Growth	From 2011 to the present	Promote sustainable land use, low-carbon development, and resilience building	Agriculture, forestry, energy	Funding for adaptation projects, green technology promotion, and low-carbon farming incentives	Framework for CSA integration into national climate policy
Agricultural Restructuring Plan (ARP) 2021-2025	2021	Enhance value chains, high-tech agriculture, and climate resilience	Rice, coffee, aquaculture, horticulture	Diversification, digital agriculture, sustainable intensification	Stronger link between CSA and sector competitiveness
1 Million ha Low-Emission, High-Quality Rice Program	2023-2030	Develop climate-smart rice with emission reduction targets	Mekong Delta rice	AWD irrigation, precision fertilizer, carbon credit MRV systems	Target to reduce 10 Mt CO_2eq. by 2030; boost rice exports
Nationally Determined Contributions (NDCs)	2022 update	Reduce GHG emissions by 30.2% by 2030	All sectors, with agriculture as the key	MRV, carbon markets, technology transfer	Clear CSA-linked emission reduction targets
VnSAT Project (World Bank)	2015-2022	Improve the sustainability of rice and coffee	Mekong Delta, Central Highlands	Farmer training, replanting, water-saving irrigation	140,000 ha rice, 63,000 ha coffee replanted with CSA practices
PPP Programs in Horticulture & Aquaculture	2015-present	Attract private sector co-investment in CSA	Lam Dong horticulture, seafood chains	Greenhouses, ICT, disease monitoring	Expanded high-tech greenhouse area; improved export compliance

Source: FAO(2023); World Bank(2023); Socialist Republic of Vietnam(2022).

Beyond government policies, private enterprises and international organizations have played a pivotal role in driving CSA and smart farming adoption in Vietnam.

Private sector initiatives: In Lam Đồng, Dalat Hasfarm has invested over

USD 150 million in greenhouse horticulture since the 2000s, covering more than 320 hectares of flowers and vegetables. The company applies hydroponics, automated fertigation, and climate control technologies, generating annual export revenues exceeding USD 60 million. Performance indicators include a 20-25% reduction in pesticide use, yield increases of 15-20%, and consistent compliance with EU/Japan SPS standards. Other domestic enterprises such as TH Group and VinEco have expanded smart agriculture into dairy and vegetable production, with reported yield gains of 20-30% compared to conventional farming.

International donor projects: The VnSAT Project (2015-2022), funded by the World Bank with a budget of USD 300 million, supported climate-smart rice and coffee systems. Results included the adoption of CSA practices on 140,000 hectares of rice in the Mekong Delta and 63,000 hectares of coffee in the Central Highlands. Independent evaluations showed average income increases of 15-17% per household and reductions in fertilizer use of 15-20%, contributing to emission reductions of an estimated 1.5 million $tCO_2eq.$ over the project period.

FAO and UNDP programs: FAO's "Climate-Smart Agriculture for Resilience" program has piloted stress-tolerant rice varieties and water-saving irrigation across 10,000 smallholder farms in the Mekong Delta, reporting yield stability during drought years and a 30% reduction in irrigation water use. Meanwhile, UNDP's blockchain-based traceability pilots in the seafood sector have improved transparency in pangasius exports, leading to a 10-12% price premium in certified supply chains.

Public-Private Partnerships (PPPs): In aquaculture, PPPs between Viet Uc Seafood Corporation and Norwegian technology providers have

introduced IoT water monitoring and AI disease management. Trials on 2,000 ha of shrimp farms demonstrated productivity gains of 12–15%, along with a 20% reduction in mortality rates. Similarly, joint ventures in Lam Đồng's greenhouse clusters show that combining provincial incentives with foreign capital (Netherlands, Japan, and Korea) has accelerated technology transfer and expanded the high-tech horticulture area by over 4,000 ha within a decade.

Taken together, these cases demonstrate that private sector capital and international cooperation not only complement government policies but also provide measurable performance improvements. Key indicators include yield increases, cost savings, input efficiency, emission reductions, and higher export revenues. These outcomes underline the importance of scaling PPP models and donor-funded CSA interventions to strengthen Vietnam's resilience and competitiveness.

4. Acceptance and constraints

4.1. Financial and Investment Barriers

One of the most critical constraints in scaling up Climate-Smart Agriculture (CSA) in Vietnam is limited access to finance. Smallholder farmers, who dominate agricultural production, often lack collateral and are considered less creditworthy, making it difficult for them to secure loans for climate-resilient technologies such as drip irrigation, green-

houses, or precision farming tools (Lan et al., 2018). Although government and donor programs provide some subsidies and grants, they are fragmented and cannot meet large-scale demand. The high upfront costs of CSA technologies discourage widespread adoption, especially among low-income rural households (Duc Truong et al., 2022).

4.2. Institutional and Policy Gaps

Vietnam has introduced numerous policies to promote CSA, such as the Agricultural Restructuring Plan (2021-2025) and the 1 Million Hectare Low-Emission Rice Program. However, implementation remains uneven since overlaps between ministries, weak enforcement at the local level, and limited coordination between state agencies and private actors create institutional bottlenecks (Halbherr et al., 2021; Trung et al., 2020). In many cases, farmers are unaware of existing CSA support policies due to ineffective dissemination of information. Furthermore, land fragmentation exacerbates the difficulty of implementing CSA measures at scale, especially in the Mekong Delta and Northern provinces (Bien et al., 2021).

4.3. Technical and Knowledge Barriers

Adopting CSA requires technical know-how that many farmers currently lack. Limited extension services and inadequate training programs result in low awareness of CSA benefits and improper use of new

technologies (Duc Truong et al., 2022). For instance, while alternate wetting and drying (AWD) irrigation for rice can save water and reduce methane emissions, many farmers hesitate to adopt it due to fear of yield loss. Similarly, digital tools for traceability and climate forecasting remain underutilized due to gaps in digital literacy. Research-extension linkages are weak, meaning that innovations from research institutions are not effectively transferred to farming communities (Aggarwal et al., 2018).

4.4. Infrastructure and Market Limitations

Supportive infrastructure is crucial for the adoption of CSA. Essential components such as irrigation systems, rural roads, and storage facilities are often lacking in remote and mountainous regions of Vietnam, which hinders farmers' access to markets, inputs, and technical support (Bien et al., 2021; Duc Truong et al., 2022). Even when CSA products such as organic produce or low-emission rice are cultivated, farmers face substantial challenges in marketing their output due to weak value chains and a lack of certification systems (Duc Truong et al., 2022). Without reliable markets and price incentives, the economic motivation for adopting CSA practices remains limited, as farmers are hesitant to invest in CSA without assured returns (Aggarwal et al., 2018).

4.5. Social and Behavioral Constraints

Socio-cultural factors significantly impact the adoption of CSA in Vietnam. Risk aversion among farmers cultivates a reluctance to experiment with unfamiliar practices, as they often depend on traditional farming methods handed down through generations. The presence of gender disparities further exacerbates challenges in CSA adoption, creating additional barriers for women farmers in accessing land, credit, and training opportunities. Additionally, there is weak collective action among farmers, as limited success in forming cooperatives impedes the pooling of resources for CSA investments (Mosso et al., 2022).

4.6. Climate and Environmental Uncertainties

CSA is designed to address climate variability, yet unpredictable weather patterns and extreme events sometimes undermine its effectiveness (Aggarwal et al., 2018; Lan et al., 2018). For example, salinity intrusion in the Mekong Delta has outpaced the adaptive capacity of many CSA practices. At the same time, prolonged droughts in the Central Highlands pose a threat to both water-saving irrigation systems and coffee production. The uncertainty of climate change impacts discourages farmers from making long-term investments in CSA practices without strong institutional guarantees or insurance mechanisms (Lan et al., 2018).

4.7. Farmer Acceptance and Sectoral/Regional Differences

The adoption of climate-smart agriculture (CSA) practices in Vietnam's Mekong region, horticulture, aquaculture, and coffee sectors shows varying levels of acceptance, driven by regional, sectoral, and socio-economic factors.

Rice in the Mekong Region: Acceptance of climate-smart rice practices in the Mekong Delta is relatively high, bolstered by robust government backing through the 1 Million Hectare Low-Emission Rice Program. Farmers are increasingly open to adopting alternate wetting and drying (AWD) and precision fertilizer application, particularly where training and extension services are accessible. However, challenges persist: land fragmentation hinders large-scale mechanization, limited access to credit restricts investments in irrigation infrastructure, and salinity intrusion undermines farmers' confidence in long-term CSA commitments (Duc Truong et al., 2022; Ha & Bac, 2021).

Horticulture in Lâm Đồng: In Lâm Đồng, greenhouse vegetable and flower growers, especially medium- and large-scale farmers, show strong enthusiasm for smart farming. Private enterprises such as Dalat Hasfarm and public-private partnership (PPP) programs have accelerated the adoption of hydroponics and climate control systems. However, financial barriers, particularly the high initial investment costs (US$100,000-150,000 per hectare), limit smallholder participation. Additionally, environmental concerns such as greenhouse gas waste accumulation shape community perceptions and pose sustainability challenges (Do et al., 2024).

Aquaculture in Coastal Provinces: In coastal regions, the use of IoT-based water quality monitoring and automated feeding systems is growing, though adoption varies by farm scale. Large, export-oriented shrimp and pangasius farms readily embrace these technologies to meet sanitary and phytosanitary/technical barriers to trade (SPS/TBT) compliance. In contrast, smallholders often rely on traditional methods due to high equipment costs and limited digital literacy. Disease risks further deter farmers from trusting unfamiliar technologies during outbreaks, slowing broader adoption (Ngoc et al., 2021).

Coffee in the Central Highlands: In the Central Highlands, acceptance of CSA practices such as water-saving irrigation and coffee varietal replanting under the Vietnam Sustainable Agriculture Transformation (VnSAT) project is moderate but is gaining traction. Farmers recognize benefits such as improved yield stability and coffee quality (Hung Anh et al., 2019). However, barriers include inadequate irrigation infrastructure, high upfront replanting costs, and the absence of clear price premiums for certified coffee, which dampen enthusiasm (Nguyen & Sarker, 2018).

Cross-Cutting Patterns Regions with strong donor or PPP engagement, such as Lam Đồng and the Mekong Delta, exhibit higher CSA adoption due to better access to finance, training, and markets (Duc Truong et al., 2022). Conversely, smallholders in remote areas face significant hurdles, including low digital literacy, poor infrastructure, and weak market incentives to produce CSA products (Bien et al., 2021). Gender disparities also persist, with women farmers often encountering greater barriers to training and credit access (Duc Truong et al., 2022).

Overall, export-oriented horticulture and aquaculture sectors demon-

strate the highest acceptance of CSA practices, while rice and coffee systems dominated by smallholders face acute challenges due to land fragmentation, financial constraints, and infrastructure gaps. These variations underscore the need for tailored CSA policies and extension services that address sectoral and regional differences (Pham et al., 2019).

〈Table 2-7〉 Constraints and Barriers for CSA Adoption in Vietnam

Category	Key Barriers	Implications
Financial & Investment	• High upfront costs of CSA technologies • Limited access to credit/loans • Insufficient subsidies/grants	• Low adoption among smallholders; dependence on donor-funded projects; widening inequality gap
Institutional & Policy	• Overlaps and gaps between ministries • Weak local-level enforcement • Limited coordination with the private sector	• Policies remain fragmented; support programs fail to reach target farmers
Technical & Knowledge	• Limited extension services and training • Low awareness of CSA benefits • Poor digital literacy	• Farmers are hesitant to adopt CSA practices, misuse technologies, and have low diffusion of innovations
Infrastructure & Market	• Poor irrigation and rural infrastructure • Weak value chains and certification systems • Limited consumer awareness of CSA products	• Higher transaction costs, weak market incentives, and reduced profitability of CSA investments
Social & Behavioral	• Risk aversion and preference for traditional methods • Weak farmer cooperatives • Gender disparities in access to resources	• Unequal participation, low collective action, and a slower adoption pace
Climate & Environmental	• Uncertainty of climate variability • Salinity intrusion, droughts, floods • Insufficient insurance mechanisms	• Reduced confidence in CSA; high vulnerability of long-term investments

Source: World Bank(2023); FAO(2023); UNDP(https://www.undp.org/vietnam/news/e-traceability-transformative-step-towards-climate-responsible-agriculture), retrieved: 2025. 9. 14.

5. Implications and Outlook

This report has examined the development of smart farming and Climate-Smart Agriculture (CSA) in Vietnam, highlighting both opportunities and persistent constraints. Evidence indicates that CSA adoption is advancing across key sectors, such as greenhouse horticulture in Lam Đồng, low-emission rice in the Mekong Delta, coffee replanting in the Central Highlands, and aquaculture innovations along coastal regions. Government strategies, including the Agricultural Restructuring Plan (2021-2025), the One Million Hectare Low-Emission Rice Program, and updated Nationally Determined Contributions (NDCs), provide a strong policy foundation for integrating CSA into national climate and agricultural agendas. International initiatives, such as the VnSAT project and various PPP programs, further demonstrate the potential of blending public, private, and donor resources to accelerate technology diffusion.

Despite this progress, significant barriers continue to limit CSA's full potential. Financial constraints remain critical, with high upfront investment costs restricting access for smallholders. Institutional and policy gaps, weak extension services, and insufficient digital literacy slow down technology transfer. Poor infrastructure, fragmented value chains, and limited consumer awareness reduce the profitability of CSA products, while socio-cultural factors and climate uncertainties discourage farmers from making long-term commitments. Looking ahead, policy efforts should prioritize three areas. First, enhancing inclusive finance mechanisms (e.g., green credit, carbon finance, and blended finance schemes) to reduce adoption costs and incentivize farmer participation.

Second, strengthening institutional coordination and extension systems to ensure that CSA policies are effectively implemented, widely communicated, and tailored to local contexts. Third, building resilient market ecosystems by improving certification systems, consumer awareness, and digital infrastructure to create stronger demand for climate-smart products.

Vietnam's smart farming and climate-smart agriculture (CSA) sector is poised for substantial growth over the next five to ten years, with market estimates projecting a value between USD 2.5 and 3 billion by 2025, along with an annual growth rate of 15 to 20%. This makes the sector one of the fastest-growing agritech markets in Southeast Asia. Notable developments are anticipated in various fields, particularly in Lam Đồng and the Mekong Delta.

In Lam Đồng, the current area dedicated to greenhouses is approximately 4,476 hectares, complemented by around 66,000 hectares of high-tech agriculture. This area is expected to grow significantly by 2030, stimulated by increasing demand for high-value vegetables and ornamental flowers. The implementation of energy-efficient greenhouses and modular hydroponic systems is anticipated to enhance environmental sustainability while improving productivity, aligning with innovations that improve agricultural practices in Vietnam and beyond (Thi, 2024).

In the Mekong Delta, ongoing initiatives such as the One Million Hectare Low-Emission Rice Program, which involves a USD 2.2 billion investment for the period from 2023 to 2030, aim to promote smart irrigation technologies, including alternate wetting and drying (AWD), drip

irrigation, and other precision systems. It is projected that over one million hectares of rice paddies will incorporate low-emission water management practices by 2030, potentially enabling a reduction of around 10 million tons of CO_2 equivalent emissions annually(Flor et al., 2021; Ho & Shimada, 2019).

Moreover, the adoption of agricultural product traceability measures is anticipated to accelerate significantly, with QR codes, RFID, and blockchain technologies projected to cover a substantial fraction of fruit and seafood exports by 2030. Evidence from current agricultural supply chains, particularly in seafood, indicates that implementing traceability can lead to revenue increases for households and premium prices for exporters(Dang et al., 2021; Kim Dang et al., 2020).

Despite being in the early stages of development, smart livestock farming is emerging in Vietnam, mainly within the poultry and dairy sectors. The use of digital monitoring techniques through IoT sensors for tracking feed, water consumption, and animal health has demonstrated potential productivity gains and reduced antibiotic usage, showcasing a trend toward more sustainable livestock management(Nguyen et al., 2022; Sharifuzzaman et al., 2024).

Opportunities for collaboration with South Korea are significant throughout these sectors. South Korea is a natural partner for Vietnam in advancing Climate-Smart Agriculture (CSA) and smart farming, given its technological expertise and strong agritech track record. Cooperation can draw on Vietnam's large agricultural base and Korea's advanced technologies and financing mechanisms. In horticulture, Korean modular and energy-efficient greenhouse systems could be

scaled in Lam Đồng through joint ventures, reducing costs and accelerating the adoption of hydroponics and vertical farming. In aquaculture, Korea's IoT-based monitoring, AI-driven disease detection, and biosecure hatcheries can boost productivity and help Vietnam's shrimp and pangasius sectors meet export standards. Digital agriculture offers another avenue: partnerships on blockchain, QR/RFID, and farm-level data platforms could enhance traceability and interoperability between the two countries' supply chains. In livestock, Korea's experience with smart pig and poultry farming provides models for Vietnam's growing dairy and poultry industries, addressing sustainability and biosecurity challenges. Long-term cooperation should also focus on capacity building and research. Joint training, university-industry projects, and applied research on stress-tolerant crops or precision irrigation can strengthen Vietnam's technical base. Korean ODA and green finance tools (KOICA, KEXIM, and Green Climate Fund) further provide platforms for blended financing of CSA projects. Overall, deeper collaboration with Korea could accelerate Vietnam's transition to climate-smart, technology-driven agriculture, delivering shared benefits in innovation, investment, and competitiveness.

The implications for search are significant in light of the anticipated advancements in Vietnam's smart farming sector. Continued coordination of subsidies, tax incentives, and regulatory reforms is crucial for granting smallholder farmers access to smart technologies. Additionally, blended finance and green credit mechanisms will be essential to address the high upfront costs associated with adopting advanced agricultural practices (Sharifuzzaman et al., 2024; Nguyen et al., 2023).

In conclusion, Vietnam's smart farming sector is on the brink of rapid transformation, driven by advances in greenhouse cultivation, hydroponics, smart irrigation, traceability systems, and livestock innovations. Heightened collaboration with South Korea can effectively position both nations at the forefront of sustainable agritech development in Asia, providing mutual benefits in trade, investment, and climate resilience.

3 Smart Agriculture in Indonesia: Current Status, Policies, and Implications

1. Introduction

1.1. Background

Indonesia is a tropical country rich in biodiversity, including diverse germplasm resources. However, as an agricultural nation, it faces significant challenges in increasing productivity amid ongoing land conversion and the impacts of climate change. In addition, the government must address the growing food demand of an expanding population. According to Statistics Indonesia, with a fertility rate of 2.18, the Indonesian population is projected to reach 328.93 million by 2050, representing a 22.02% increase from the 2020 Population Census (SP2020) figure of 269.58 million (Statistics Indonesia, 2023b). This demographic growth presents substantial challenges in ensuring adequate food supply and achieving national food security.

〈Figure 3-1〉 Trends in Indonesia's Population and Growth Rate (2015–2025)
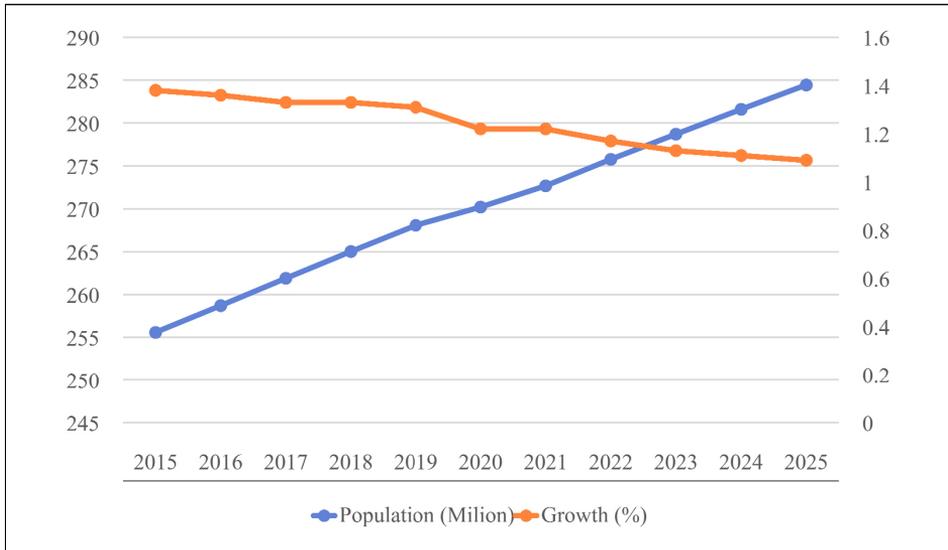
Source: BKKBN(2024).

Another major challenge facing Indonesian agriculture is the aging population of farmers and the low interest of younger generations in pursuing agricultural careers(Ambarwati et al., 2025; Anandita & Patria, 2016). Yet, skilled human resources remain a crucial element in advancing agricultural development. Moreover, the aging of the farming population poses an additional obstacle to the adoption of new technologies within the sector(Widiyanti et al., 2023).

Furthermore, Indonesia continues to face ongoing land conversion. According to data from the Ministry of Agriculture, over the past five years, approximately 79,000 hectares of agricultural paddy fields have been converted to non-agricultural purposes (Ministry of Agriculture, 2025. 2. 24.). Another study reports an even more alarming rate of agricultural land conversion (ALC), reaching 187,720 hectares per year (Rondhi et al., 2018). This persistent land conversion poses a potential

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threat to the government's efforts to achieve national food security.

To address the diverse problems and challenges currently facing the agricultural sector, as well as those anticipated in the future, the Indonesian government, through the Ministry of Agriculture, has developed a strategic plan for agricultural development (Regulation of the Minister of Agriculture, the Republic of Indonesia). One of its key strategies is the promotion of modern agriculture through the adoption of precision agriculture and smart farming. This initiative is aimed not only at modernizing agricultural technology but also at enhancing efficiency and productivity in Indonesian agriculture.

Smart farming defines as an innovative approach to agricultural management that leverages modern techniques and technologies at multiple levels of production. It offers solutions to key challenges such as meeting increasing food demands while coping with the decline in available farm labor (Navarro et al., 2020). Smart farming can also be defined as an advanced approach to agriculture that leverages modern technologies to boost efficiency, productivity, and sustainability. It not only seeks to meet the increasing food demands of a growing population but also emphasizes conserving natural resources and reducing the effects of climate change (Mahto et al., 2024).

In agricultural technology studies, the concept is often referred to as digital farming. While smart farming involves digital technologies that enable farmers to make rapid and informed decisions from planting to harvest, digital farming emphasizes process efficiency, whereas smart farming is more closely associated with productivity, crop quality, and long-term agricultural sustainability(Gokomodo, 2024).

This report provides a concise description of the development of smart farming implementation in Indonesia, including market share, growth potential, regulations and policy, technology adoption and the various forms of smart farming applied in the agricultural sector. It serves as a comprehensive report on the development and future projection of smart farming application in Indonesia.

1.2. Methodology of the Report

1.2.1. Research Design

This report employs a qualitative-descriptive approach to analyze the development of smart farming in Indonesia and farmers' perceptions of its implementation. The report aims to understand the context, barriers, and opportunities for smart farming adoption using secondary data and a literature review of previous studies.

1.2.2. Data Sources

The report relies on two main sources of information:

Secondary Data: Drawn from Statistics Indonesia (BPS), the Ministry of Agriculture (Kementerian Pertanian), IPB University, and government policy documents such as the Renstra 2020-2024 and the Agriculture 4.0 Roadmap. Reports from FAO, the World Bank, and ADB were also used, along with media and industry articles on pilot projects. These sources

provide an overview of technology adoption, external drivers and barriers, and contextual statistics.

Literature Review: Covers journal articles, conference papers, and local case studies, including fieldwork such as in Aceh Province and Bantul Regency. The review also uses theoretical models like Diffusion of Innovation, the Technology Acceptance Model (TAM), and the Unified Theory of Acceptance and Use of Technology (UTAUT) to frame how farmers adopt technology. This allows comparison between regions and supports the development of a conceptual framework.

1.2.3. Analytical Approach

The analysis combines descriptive mapping of trends, thematic grouping around issues like costs and infrastructure, and cross-country comparisons to highlight lessons for Indonesia.

1.2.4. Validity and Reliability

Validity is ensured by using only credible and official sources, with triangulation applied to cross-check findings. Reliability comes from consistent reporting of data and results.

1.2.5. Expected Output

The report will provide an overview of smart farming progress in Indonesia, insights into farmer perceptions, and policy recommendations to strengthen adoption.

2. Market Size and Growth Potential

Over the last decade—especially from 2021 to 2025—Indonesia has seen a surge in investment in smart farming and agritech sectors. One of the leading aquaculture startup, eFishery, raised US$200 million in Series D funding, while Sayurbox in the horticulture sector secured US$120 million in Series C (TechCrunch, 2023. 7. 7.). These large investments reflect the growing appeal and potential of smart farming in Indonesia's agricultural future. The following section presents details on the market size, adoption rate, and market potential of smart farming in Indonesia.

2.1. Market Size and Investment

The 2023 Agricultural Census reported a total of 29.34 million Individual Farming Enterprises (UTP), of which 6.18 million were millennial farmers aged 19-39, representing approximately 21.93 percent of all farmers in Indonesia (Statistics Indonesia, 2023a). This tech-savvy demographic plays a pivotal role in advancing technology adoption and smart farming, thereby driving agricultural productivity and sustainability in the country.

Investment in Indonesia's smart farming sector has grown significantly in recent years, driven primarily by various government initiatives and the increasing adoption of agricultural technologies. Notable programs include the US$100 million ICARE project, supported by the World Bank, and the US$125 million Horticulture Development in Dryland Areas

Sector Project (HDDAP), financed by the ADB and IFAD, which have further stimulated sectoral growth(ADB, 2024; IFAD, 2024; World Bank, 2024). Scheduled for completion in 2029, the HDDAP aims to support 25,000 farmers by enhancing climate resilience, innovation, and efficiency in Indonesia's smart greenhouse market, thereby positioning the sector for long-term expansion (Yahoo Finance, 2025. 2. 27.).

In private sector, the Aquaculture has become the biggest driver of smart farming investment in Indonesia. eFishery stands out as one of the most successful startups, raising around US$200 million in Series D funding in 2023 and reaching unicorn status—proof of the sector's strong commercial appeal (AgFunderNews, 2023. 5. 25.).

Moreover, the horticulture supply chain has also attracted significant capital. Sayurbox, which connects farmers directly to consumers, secured US$120 million in Series C funding in 2022 to expand its network and strengthen its agrifood system (Forbes, 2022. 3. 22.). While not strictly "on-farm IoT," this investment has pushed demand for technologies like sensors, greenhouses, and traceability tools. In parallel, the Horticulture Development in Dryland Areas Sector Project (HDDAP)—worth US$125 million and jointly funded by ADB and IFAD—aims to strengthen the horticultural sector from production through to market access. The initiative is designed to enhance climate resilience, productivity, and profitability in dryland areas, while integrating digital technology to improve seed registration and traceability (ADB, 2024; IFAD, 2024).

In addition, the US$100 million Agriculture Value Chain Development (ICARE) project, financed by the World Bank, focuses on building sustainable and inclusive agricultural value chains. It closely aligns with Indonesia's national policies by promoting climate-smart agricultural

practices that support the country's Nationally Determined Contributions (NDC) toward climate change mitigation and adaptation (World Bank, 2024).

Overall, the ecosystem is rapidly growing, with about 250-270 active agritech companies working on solutions ranging from market access and farmer fintech to IoT precision tools and cold logistics. Many have already received funding, showing that both on-farm and off-farm smart farming solutions are gaining ground.

The agricultural IoT segment—covering smart greenhouses, precision farming, livestock, and aquaculture—has also seen steady revenue growth from 2021 to 2025. Even though full market data is limited, the large inflows of investment in aquaculture and horticulture, combined with the rise of agritech startups, show that smart farming in Indonesia has strong and growing market potential.

2.2. Area of Smart Farming Adoption

Currently, there is no official publication from the Indonesian government or state institutions that provides national statistics on the area utilizing smart farming initiatives. Therefore, estimates of smart farming adoption rely on four indicators: (1) the land area used for pilot projects; (2) the distribution of digital village programs; (3) the national horticultural area as a denominator—since this sector has the highest number of smart farming applications; and (4) survey and tracking results from various regional projects.

For example, the Ministry of Village Development, Disadvantaged Regions, and Transmigration (Kemendes-PDTT) has reported a 250ha smart farming pilot project implemented across multiple regions—including Garut, West Pasaman, Sukabumi, Situbondo, Dairi, Brebes, Banyuwangi, Badung, Ponorogo, East Lombok, Cianjur, and Malang (Direktorat Jenderal Pembangunan Desa Tertinggal, 2019). The Ministry of Agriculture has also introduced innovations utilizing satellite imagery for smart farming, aimed at boosting productivity and anticipating natural disasters (Rachmawati, 2020).

Moreover, The National Research and Innovation Agency (BRIN)—in collaboration with the Korean Government through the Korea Institute of Science and Technology-Gangneung Institute of Natural Products (KIST-Gangneung)—is developing a 2,000m2 Smart Greenhouse and Smart Farming Technology project located in the Soekarno Science and Technology Area (KST) in Cibinong. The project commenced in December 2024 and is targeted for completion in 2025 (BRIN, 2024).

The development of Smart Greenhouse (SGH) technology has also been undertaken by the Ministry of Agriculture through several pilot projects. One example is a 384 m² pilot site in Padang, West Sumatra, initiated by the Directorate General of Horticulture. This area is used to cultivate various fruits and vegetables—including melons—and has demonstrated the ability to produce high-quality commodities (Ministry of Agriculture, 2023. 2. 1.). The SGH technology aims to modify the microclimate through the application of sensors and fertigation automation systems. The concept incorporates several planting methods—such as drip irrigation, the Dutch bucket system, and the NFT hydroponic system. Another smart

greenhouse initiative from the Ministry of Agriculture involves project assistance provided to the Jaya Tani Farmers Group at the Agro Edu Wisata (AEW) Markaz Komobid in Serang, Banten Province. This project comprises a three-span greenhouse measuring $8 \times 3 \times 24$ m(864 m²) (Ministry of Agriculture, 2024. 5. 13.).

In addition to developing smart greenhouses, the Ministry of Agriculture has also launched an Indoor Vertical Farming pilot project to support the Precision Agriculture 4.0 program. The project, initiated by the Center for Agricultural Land Resources Research and Development (BBSDLP), utilizes artificial UV lighting technology as a substitute for sunlight. Furthermore, this innovation employs rockwool as a growing medium, delivers precise nutrients through PVC piping systems, and eliminates the use of pesticides. Consequently, the project promotes environment-friendly agricultural practices (Ministry of Agriculture, 2021. 9. 10.).

Furthermore, IPB University, in collaboration with 'IPET (the Korea Institute of Planning and Evaluation for Technology in Food, Agriculture, and Forestry)' and 'KosFarm (the Korea Smart Farm R&D Foundation)', is developing a Smart Greenhouse and Plant Factory utilizing advanced, environment-friendly technology. This initiative is part of the Smart Agriculture Innovation Technology Development Program, and the smart technology applied here includes Sherpa Ray, a lighting system featuring dynamic light control technology. The light spectrum can be adjusted (tuned) according to the specific needs of plants at various growth stages. Meanwhile, the Smart Greenhouse under construction adheres to industrial standards and is equipped with circulation fans and a fogging

system designed to regulate air temperature and humidity effectively(IPB University, retrieved: 2025. 8. 16.).

Additionally, the Digital Village program in West Java, reported by the FAO, highlights the application of smart farming, smart fisheries, and smart livestock technologies in several villages, reflecting growing—yet unquantified—adoption (FAO, 2023. 3. 7.). According to data from the Ministry of Villages Development (Kemendes PDT), by 2024, approximately 14,000 villages in Indonesia had adopted the digital village program, or E-Village, with varying levels of digital technology implementation (Antara, 2024. 11. 30.).

To estimate smart farming development in Indonesia, Statistics Indonesia reports that the national horticultural harvest area for seasonal vegetables and fruits is at least 100,000 ha per year (Statistics Indonesia, 2024). If the current penetration of smart farming technologies (such as IoT and greenhouses) is assumed to be less than 1%, the adoption area would be about 1,000 ha. Based on current trends, this could expand substantially, reaching 3-5% penetration—or approximately 3,000-5,000ha—within the next 3 to 5 years.

〈Table 3-1〉 Market Share of Smart Farming Development in Indonesia

Sector	Smart Farming Application	Investment/Project	Market Share (Estimation)	Sources
Smart Aquaculture and Horticulture	IoT-based auto-feeder systems, biomass analytics, integrated input-financing-market platforms	eFishery US$200 million Series D funding, and Sayurbox (horticulture) US$120 million Series C investment. The Horticulture Development in Dryland Areas Sector Project (HDDAP)—worth US$125 million and jointly funded by ADB and IFAD	45-55%	ADB(2024); AgFunderNews (2023. 5. 25.); Forbes (2022. 3. 22.); IFAD(2024); eFishery(2019).

Sector	Smart Farming Application	Investment/Project	Market Share (Estimation)	Sources
Smart Greenhouse /Indoor Farming	Automated greenhouses, hydroponics, climate control systems, farm management platforms	The US$100 million Agriculture Value Chain Development (ICARE) project by the World Bank BRIN and KIST−Gangneung) 2,000−square−meter Smart Greenhouse and Smart Farming Technology project Ministry of Agriculture Smart Green House and Indoor Vertical Farming Project	25–35%	BRIN(2024); Ministry of Agriculture (2023. 2. 1.); The World Bank(2024).
IoT−based On−Farm Systems (Open Field)	Soil and weather sensors, automated irrigation, agricultural drones	10.000 digital village program	15–25%	Antara (2024. 11. 30.); FAO (2023. 3. 7.).

Source: Author's compilation.

3. Policies and Regulations

The Indonesian government strongly supports the advancement of smart farming through strategic roadmaps and technical regulations. A comprehensive legal framework—comprising national laws, government regulations, and ministerial decrees—serves as the foundation for its implementation. The following section outlines key policies that shape and guide the development of smart farming in Indonesia.

3.1. Core Legal Framework

The development of smart agriculture and agricultural digitalization in Indonesia is supported by a comprehensive legal and policy framework encompassing farmer protection, data governance, electronic systems regulation, and rural development strategies. Traditional agricultural laws aimed at improving productivity and farmer welfare are increasingly complemented by regulations addressing digital transformation, data protection, and electronic system reliability. Together, the following laws and policy instruments constitute the core legal framework underpinning the adoption and expansion of smart farming and digital agricultural platforms in Indonesia.

A. Law No. 19/2013 on the Protection and Empowerment of Farmers (Undang Undang Nomor 19 Tahun 2013 tentang Perlindungan dan Pemberdayaan Petani) (Government of Indonesia, 2013).

This law provides the legal foundation for infrastructure support, financing, risk mitigation, and farmer empowerment, closely linked to mechanization and digitalization initiatives in agriculture.

B. Law No. 27/2022 on Personal Data Protection (UU 27/2022 tentang Pelindungan Data Pribadi (PDP)(Government of Indonesia, 2022).

This statute establishes guidelines for processing personal data, which is critical for digital agricultural platforms that collect and manage farmer and household data.

C. Government Regulation No. 71/2019 on the Implementation of Electronic Systems and Transactions (PP Nomor 71 tahun 2019 tentang Penyelenggaraan Sistem dan Transaksi Elektronik, PSTE)(Government of Indonesia, 2019).

This regulation set outs obligations and governance for electronic system providers, relevant to IoT/cloud-based smart farming platforms, including system security and reliability.

D. Decree of the Minister of Agriculture of the Republic of Indonesia Number 484/KPTS/RC.020/M/8/2021 Concerning the Strategic Plan of the Ministry of Agriculture for 2020–2024 (Keputusan Menteri Pertanian Republik Indonesia Nomor 484/Kpts/Rc.020/M/8/2021 Tentang Rencana Strategis Kementerian Pertanian Tahun 2020–2024) (Regulation of the Ministry of Agriculture, the Republic of Indonesia).

This decree provides guidelines on the development of precision farming and digitalization of agriculture.

E. Decree of the Minister of Villages, Development of Disadvantaged Regions, and Transmigration of the Republic of Indonesia Number 55 of 2024 concerning General Guidelines for Smart Village Development (Keputusan Menteri Desa, PDTT Republik Indonesia Nomor 55 Tahun 2024 Tentang Panduan Umum Pengembangan Desa Cerdas) (Regulation of the Minister of Village PDTT, the Republic of Indonesia).

This decree provides guidelines for developing smart villages, including the development of smart farming at the village level.

3.2. Roadmap and Policy Direction for Digital Agriculture

Indonesia's approach to digital agriculture is shaped by an integrated set of national programs, sectoral roadmaps, and village-based digital development strategies. These policy instruments collectively define the transition toward Agriculture 4.0, with an emphasis on mechanization, automation, data-driven farming, and the application of advanced digital technologies across agricultural systems. National-level initiatives are complemented by regional frameworks that facilitate experimentation and scaling of smart farming solutions at the local level.

A. Smart Farming 4.0 Program.

Smart Farming 4.0 Program is a flagship initiative by the Ministry of Agriculture promoting mechanization, automation, and the use of AI to increase agricultural efficiency and productivity (PPLP Ministry of Agriculture, 2024).

B. Roadmap for Agricultural Infrastructure and Facilities Development Towards Advanced, Independent, and Modern Agriculture (Roadmap Pembangunan Prasarana dan Sarana Pertanian Menuju Pertanian Maju, Mandiri dan Modern) (Ministry of Agriculture, 2021).

This roadmap provides strategic guidance for upgrading agricultural infrastructure and facilities, establishing a foundation for the widespread introduction of modern and digital farming technologies.

C. The Agriculture 4.0 Policy Framework.

The framework assesses the current status of Agriculture 4.0 implementation and underscores the importance of enhanced national strategies, inter-agency coordination, and multi-stakeholder collaboration to accelerate digital transformation in the agricultural sector (Mangurai et al., 2021).

D. The Digital Village Program.

The policy framework for the Digital Village program in Indonesia has evolved through several stages, beginning with Digital Village 1.0, which focuses on providing internet connectivity and basic digital services. In addition, Digital Village 2.0 emphasizes enhancing community digital literacy, while Digital Village 4.0 represents the final stage, utilizing Internet of Things (IoT) technologies to optimize village potential. This stage promotes the development of thematic villages, including agricultural, livestock, waste management, and multimedia villages, through the application of technologies such as smart farming in agricultural areas and smart feeders in livestock management (West Java Province, 2023).

At the regional level, complementary frameworks such as the Digital Village/Smart Village Master Plans support pilot projects in smart farming, fisheries, and livestock at village level. For example the Regional Regulation (Perda) of Dairi Regency of North Sumatra Province, Number 35 Year 2022 concerning Guidelines for Digital Village Development (Peraturan Daerah (Perda) Kabupaten Dairi Nomor 35 Tahun 2022

tentang Pedoman Pengembangan Desa/Kelurahan Digital) (Regional Government of Dairi, 2022).

3.3. Technical Regulations for IoT and Connectivity

Regulation of the Director General of SDPPI Ministry of Communication and Information (Peraturan Direktur Jenderal Sumber Daya dan Perangkat Pos dan Informatika (Dirjen SDPPI)) No. 03/2019 on technical specifications for cellular LPWA IoT devices. Implication: Vendors of smart farming devices must obtain type approval and ensure spectrum compliance (NB-IoT/LTE-M) in line with SDPPI regulations.

3.4. Tax Incentives and Investment Facilities

Policy on Tax Deduction for R&D (Minister of Finance Regulation Number 153/PMK.010/2020 concerning the Provision of Gross Income Reductions for Certain Research and Development Activities in Indonesia): allows additional deductions for R&D. Benefiting firms must develop sensors, algorithms, or farm management software (Regulation of the Minister of Finance, the Republic of Indonesia).

Customs and Import Duty Facilities: there are exemptions on certain agricultural machinery or investment goods.

VAT and Luxury Tax (PP 49/2022): VAT applies even to exempted imports, which should be considered in project cost planning.

Practical Note: Importing greenhouse kits or IoT components can qualify for fiscal incentives upon consultation with local tax/customs authorities.

3.5. Subsidies and Financing

- Technical Guidelines for Agricultural Machinery Assistance (2024): set rules for distribution of government machinery support, relevant to smart irrigation and automation tools.
- Ministerial Regulation No. 8/2024: umbrella regulation for agricultural assistance programs.
- KUR (People's Business Credit) for Agriculture: with a national ceiling target of IDR 300 trillion by 2025, designed to improve farmer/MSME access to affordable financing.
- Implication: Smart farming adoption is often supported through a mix of government assistance, KUR financing, and structured after-sales services.

3.6. Additional Sectoral Regulations

The Compilation of Agricultural Machinery Regulations (Director General of Agricultural Infrastructure and Facilities) serves as a reference for equipment standards and certification.

International partners (e.g., the Dutch embassy) have documented pilot

initiatives in drones and greenhouse technology, enriching Indonesia's smart farming practices.

In summary, the following highlights key regulations and policies shaping the development of smart farming in Indonesia.

A. Digital Compliance

Smart farming platforms and devices must comply with Government Regulation (Peraturan Pemerintah) No. 71/2019 regarding the implementation of electronic systems and transactions, as well as Law (Undang-Undang) No. 27/2022 (Personal Data Protection Law, PDP). These regulations require adherence to standards of data security, user consent, data retention, and cloud governance. Compliance ensures both legal certainty and trust in digital agricultural platforms.

B. Connectivity and Devices

All IoT-based smart farming tools, including sensors and automated devices, must conform to the Directorate General of SDPPI Regulation No. 03/2019, which specifies technical standards for cellular LPWA devices (e.g., NB-IoT/LTE-M modules). Certification is mandatory to ensure safety, interoperability, and spectrum compliance before devices are deployed in the field.

C. Financing and Fiscal Incentives

The government provides several financial schemes to lower barriers to adoption: Kredit Usaha Rakyat (KUR) - a subsidized loan facility for

farmers and MSMEs. Agricultural Machinery Assistance Programs – government subsidies for mechanization and automation equipment. R&D Super-Deductions (MoF Regulation No. 153/2020) – tax incentives for companies investing in agricultural technology innovation. These measures are designed to reduce the total cost of ownership, making smart farming more accessible to smallholders and startups.

D. Program Documentation and Strategic Alignment

Projects should be formally positioned within the Ministry of Agriculture's Smart Farming 4.0 program and Smart Village initiatives, as this alignment enhances opportunities for partnerships, scalability, and replication.

4. Private Sector and International Cooperation cases

4.1. Private Sector on Smart Farming Application

In several regions of Indonesia, smart farming has emerged through the adoption of technologies such as IoT-based sensors, monitoring applications, drones, and automated greenhouse systems (Agussabti et al., 2022; Fikri et al., 2023; Rachmawati, 2020). These innovations have primarily been introduced in pilot projects and commercial farms, offering opportunities to enhance efficiency and improve crop management. Notably, millennial farmers demonstrate greater openness to these

advancements compared to older generations. Their readiness stems not only from their familiarity with digital tools but also from their motivation to modernize agriculture and increase its competitiveness (Dewi et al., 2023; PPLP Ministry of Agriculture, 2024). This generational shift indicates that young farmers could play a central role in accelerating the diffusion of smart farming practices across Indonesia.

The following are several smart farming applications in Indonesia, each accompanied by a brief explanation:

4.1.1. Agriculture Sector

Sayurbox

Sayurbox is a digital-based agribusiness platform that enables customers to purchase a wide variety of fresh vegetables and fruits directly from local farmers and producers. Established in 2016, the company operates as a startup in the agricultural marketing sector and employs skilled data scientists. Currently, Sayurbox distributes vegetables, fruits, and other kitchen essentials to the Greater Jakarta (Jabodetabek) area, Surabaya, and Bali (Adelia, 2023. 11. 17.). The service is accessible through the Sayurbox mobile application, available on the Google Play Store and Apple App Store, as well as via its official website and partner stores on leading e-commerce platforms.

〈Figure 3-2〉 User Interface of Sayurbox Website
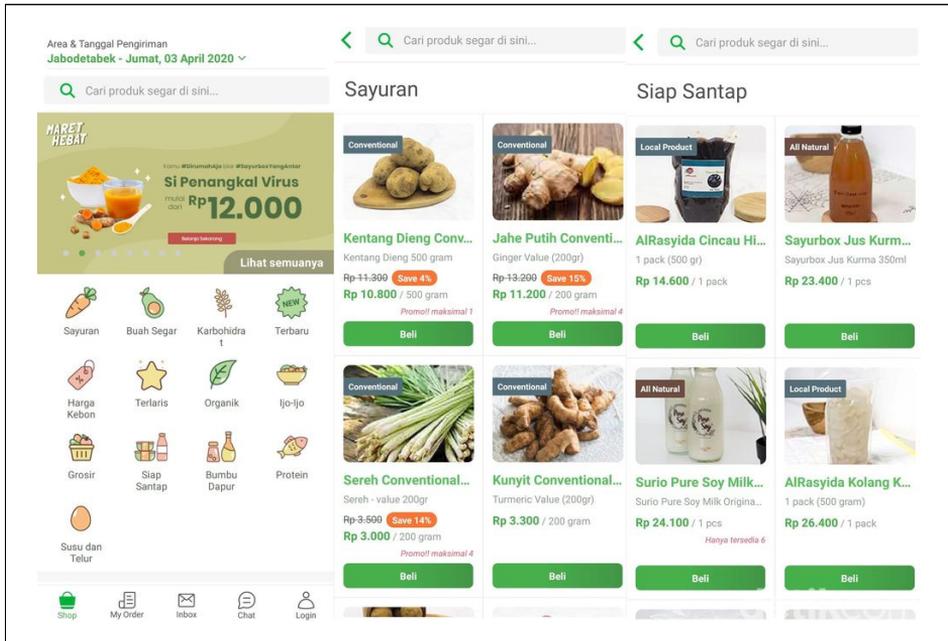
Source: Detiklnet(2020. 3. 31.).

RiTx Bertani

RiTx Bertani is an IoT-based Android application that integrates various Smart Farming 4.0 technologies. The application supports farmers by recording farming systems, selecting appropriate cultivation guidelines, and applying useful agricultural practices tailored to environmental conditions and crop requirements (MSMB Indonesia, retrieved: 2025. 9. 15.).

HARA

HARA is a blockchain-driven company offering traceability solutions for the agriculture and forestry sectors. By building a closed-loop

ecosystem, it supports sustainability and improves the well-being of all participants in the value chain. Guided by its vision of "making the invisible visible," HARA empowers farmers and stakeholders to achieve food sovereignty and better quality of life (HARA, retrieved: 2025. 9. 15.).

〈Figure 3-3〉 HARA Product
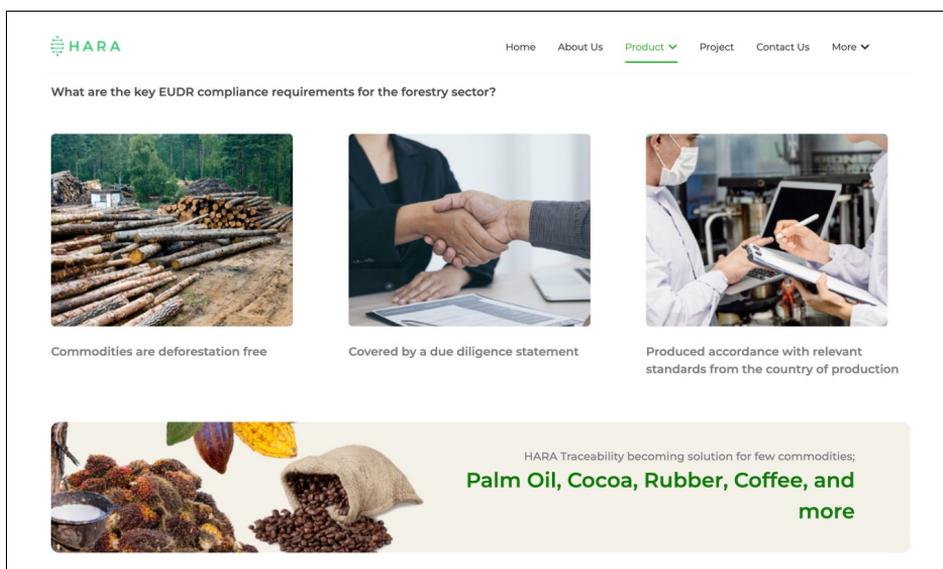
Source: HARA(https://www.hara.ag/?v=1760098993985), retrieved: 2025. 9. 15.

Koltiva

Koltiva is an agricultural startup providing innovative solutions in two key domains: agritech and climate. On the agritech side, Koltiva offers services such as land mapping, producer profiling, seed-to-consumer traceability, and training and mentoring by field experts and agronomists. These initiatives help farmers enhance productivity while promoting sustainable agricultural practices. On the climate front, the startup develops tools for greenhouse gas (GHG) measurement and assessment.

It also provides climate-aware agricultural support solutions, land use mapping, and risk alerts for its clients. Through these efforts, Koltiva contributes to the global agenda of addressing climate change (Wahid, 2023. 9. 22.).

Terra Drone

Terra Drone delivers precision solutions for agriculture, plantations, and forestry using cutting-edge drone technology. Its innovations aim to boost efficiency, cut labor costs, promote better environmental practices, and improve profitability for agribusinesses.

Agree

Agree, part of Telkom Indonesia, has been driving agricultural digitalization since 2019 by working with farmers, agribusinesses, lenders, universities, and government agencies to create a connected digital farming ecosystem. Its platform offers tools for managing crop schedules, monitoring weather and field conditions, and keeping track of farm finances (Telkom Indonesia, 2023. 11. 1.).

4.1.2. Finance

iGrow

iGrow is Indonesia's first peer-to-peer agricultural lending platform. It supports local farmers, optimizes underutilized land, and connects investors to produce high-quality agricultural products. Beyond its commercial objectives, iGrow embraces a broader mission: preserving

life on Earth. Its vision is to create food security that is both accessible and equitable for people worldwide (iGrow, retrieved: 2025. 8. 16.).

〈Figure 3-4〉 iGrow Peer to Peer Lending

Source: iGROW(https://igrow.asia/), retrieved: 2025. 8. 16.
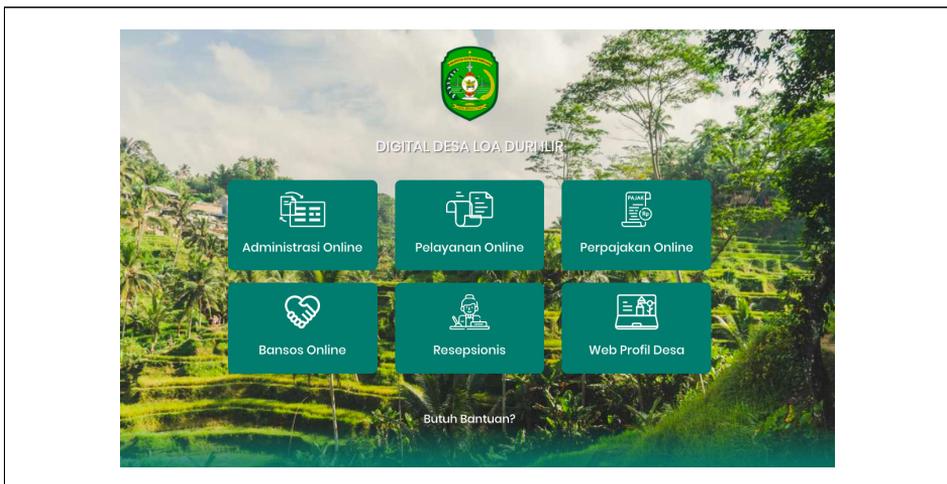
Crowde

Crowde is a financial technology startup in the agricultural sector that empowers farmers across Indonesia by providing access to capital and technology. Established in 2015, Crowde has disbursed more than IDR 1.024 trillion to 21,513 farmers located across Java, Sumatra, Kalimantan, and Sulawesi. The company operates a digital platform that connects over 20,000 investors with thousands of farmers nationwide.

Although many smart farming projects in Indonesia are driven by the private sector, the government and universities are also playing a vital role in advancing agricultural digitalization. The West Java Provincial Government's Digital Village program is a leading example, bringing smart farming tools and practices to rural communities. Meanwhile,

universities such as IPB (with Nutrigrads) and Brawijaya University (with Protector) have developed their own smart farming innovations, contributing to a growing number of pilot projects across the country.

The Digital Village initiative, developed by the West Java Provincial Communications and Information Office through the Regional Technical Implementation Unit (UPTD) for Digital Services, Data, and Geospatial Information (Jabar Digital Service), is being implemented across villages in West Java Province. The program aims to enhance agricultural productivity through the adoption of Internet of Things (IoT) technology. This application enables farmers to monitor land conditions—such as soil pH and irrigation—directly from their mobile phones. The technology is particularly beneficial during critical periods, such as the dry season, as it allows more efficient management of watering activities(West Java Province, 2024. 9. 6.).

〈Figure 3-5〉 Digital Village Service Website

Source: Digides(https://digitaldesa.id/#:~:text=DIGIDES%20adalah%20platform%20inovatif%20untuk%20pengelolaan%20desa,pelayanan%20administrasi%20desa%2C%20terutama%20di%20masa%20pandemi.), retrieved: 2025. 8. 16.

Loa Duri Ilir Village in Kutai Kartanegara Regency, East Kalimantan, has implemented a digital village model that provides a self-service system for the community integrated with the village service dashboard. Administrative and mailing services in Loa Duri Ilir Village can now be accessed within seconds through the online system. In addition, the village has successfully developed its own digital marketplace to support MSMEs and promote local products.

Protector

Protector is a mobile app created by Brawijaya University students to help farmers manage pests more effectively. The app comes with a range of features useful for rice farmers, such as pest detection via smartphone cameras, information on crop varieties, post-harvest practices, market prices, land use, research updates, and even a built-in calculator to estimate fertilizer needs. What makes Protector more advanced is its integration with IoT sensors that measure air temperature and soil moisture directly in the fields. Based on these readings, the app can predict which pests are most likely to appear under certain conditions, giving farmers valuable early warnings. Currently, the beta version of Protector can be downloaded from the Google Play Store by searching "Protector Tech"(Fillkom UB, retrieved: 2025. 8. 16.).

FERADS and NUTRIGADS

The FERADS Decision Support System is designed to assist farmers in determining precise fertilizer recommendations based on soil analysis. To maximize its effectiveness, the integration of irrigation sensors and

the use of alternative energy sources are essential to ensure accessibility across all agricultural regions in Indonesia. Furthermore, the FERADS program is complemented by the NUTRIGADS system, a machine that translates the fertilizer recommendations generated by FERADS into precise, remotely controlled fertilizer applications (PKHT IPB University, retrieved: 2025. 9. 15.).

〈Table 3-2〉 Private Sector Role on Smart Farming Development in Indonesia

Type of Service	Digital Technology Application	Application/Platform
Aquaculture Production	IoT-based auto-feeder systems, biomass analytics, farmer advisory	eFishery, Nurafarm, Jala
Agriculture Mechanization	IoT, digital software, drone, smartphone, and GIS	Agrodrone
e-Commerce	Smartphone, mobile apps, and website	Sayurbox, Warung Pangan, Aruna
Financial Technology	Peer to peer, crowdfunding	Eragano, Infishta, Crowde, iGrow
Traceability	Big data, AI, blockchain, and mobile apps	Hara, Koltiva

Source: Author's compilation.

4.2. International Cooperation on Smart Farming

The following provides a brief overview of several international collaborations in advancing smart farming in Indonesia—highlighting the actors, forms of collaboration, technological focus, as well as associated opportunities and challenges. Reliable references have been included for each key point.

4.2.1 Forms and Actors of Collaboration

Inter-institutional R&D Collaboration (G2G/R2R): The National Research and Innovation Agency (BRIN) has partnered with the Korea Institute of Science and Technology (KIST) and the Korea Invention Promotion Association (KIPA) to establish a Sustainable Smart Greenhouse (SSGH) in Indonesia. Covering approximately 2,000 m² at KST Soekarno (Cibinong), the initiative (2024-2025) is designed as a hub for sustainable agricultural research and technology development (BRIN, 2024).

- Campus-Government-Foreign Partner Collaboration: IPB University, in collaboration with the Korea Institute of Planning and Evaluation for Technology in Food, Agriculture, and Forestry (IPET) and the Korea Smart Farm R&D Foundation (KosFarm), has developed smart greenhouse and plant factory programs under the Smart Farm Innovation Technology Development Program since 2021 (IPB University, retrieved: 2025. 8. 16.).

- Since August 2021, the Ministry of Agriculture, through the Agency for Agricultural Extension and Human Resources Development (BPPSDMP), has collaborated with the Government of South Korea via 'EPIS Korea (the Korea Agency of Education, Promotion, and Information Service in Food, Agriculture, Forestry, and Fisheries)' to advance smart farming initiatives. The Memorandum of Understanding (MoU) encompasses the Project on Enhancing Millennial Farmers' Income by Adopting K-Smart Farm Technologies in Indonesia (Ministry of Agriculture, 2023. 5. 22., 2024. 4. 25.).

- Economic Partnerships and Trade Missions: Indonesia and the Nether-

lands have strengthened their collaboration in greenhouse horticulture through the 2025 Economic Mission, with an emphasis on food security.

- Technology Demonstration Projects: Japan's MAFF appointed Terra Drone in 2025 for a smart agriculture verification project in Indonesia, encouraging the trial and business expansion of drone and precision solutions.
- Multilateral Organizations: The FAO, through its Digital Villages Initiative, supports agricultural digitalization, including smart farming, fisheries, and livestock in West Java.
- Cross-border Corporate Partnerships: Telkom Indonesia collaborates with Scala (Japan) to enhance digital agriculture through improved market access and supply chain efficiency.

4.2.2 Technology Focus and Scope

- Controlled Environment Agriculture (CEA): Smart greenhouses and plant factories with climate control, automation, and sensors for high-value horticulture.
- Drones and Precision Agriculture: Land surveying, mapping, and targeted input applications.
- Digital Platforms and Connectivity: Market access, digital extension, and data integration for farmers.

4.2.3 Collaboration Models

Co-R&D and National Pilots: BRIN-KIST, IPB-Korea partnerships for technology development and testing.

- Economic Missions and Living Labs: Indonesia–Netherlands collaborations on horticulture, cold logistics, and post-harvest systems.
- Verification and Business Expansion: Terra Drone's precision agriculture pilots under MAFF Japan.
- Multilateral Partnerships: FAO's Digital Villages Initiative for community-based adoption.

4.2.4 Tangible Benefits for Indonesia

- Technology Transfer and Capacity Building: Access to advanced greenhouse and automation technologies.
- Adoption Acceleration: Verification trials reduce risks and demonstrate ROI.
- Ecosystem Strengthening: Partnerships link suppliers, universities, and governments for scaling up.

4.2.5 Key Challenges

- Sustainable Funding and After-sales Support: Many pilots lack long-term financing models and service continuity.
- Interoperability and Local Fit: Imported technologies require adaptation to tropical climates and local conditions.
- Human Resource Development: Ongoing training, vocational programs, and digital extension are necessary to ensure scalability.

5. Acceptance and Constraints

There has been no official publication of research findings from the government or related institutions regarding farmers' perceptions of smart farming implementation in Indonesia. The most recent official data released in the 2023 Agricultural Census only provides information on the number of farmers using digital or modern technologies, such as internet/ smartphone/information technology, drones, and artificial intelligence in agricultural activities, particularly in urban areas (urban farming).

According to the 2023 Agricultural Census, there are a total of 16.78 million millennial farmers age between 19-39 year, consisting of 14.94 million men (89%) and 1.84 million women (11%). The census also reports the number of urban farming activities, both household and individual. Specifically, there are 12.919 million household-based urban farming enterprises and 13.019 million individual urban farming enterprises (Statistics Indonesia, 2023a).

〈Figure 3-6〉 Number of Modern Farmers Using Digital Technology in 2023

Unit: million
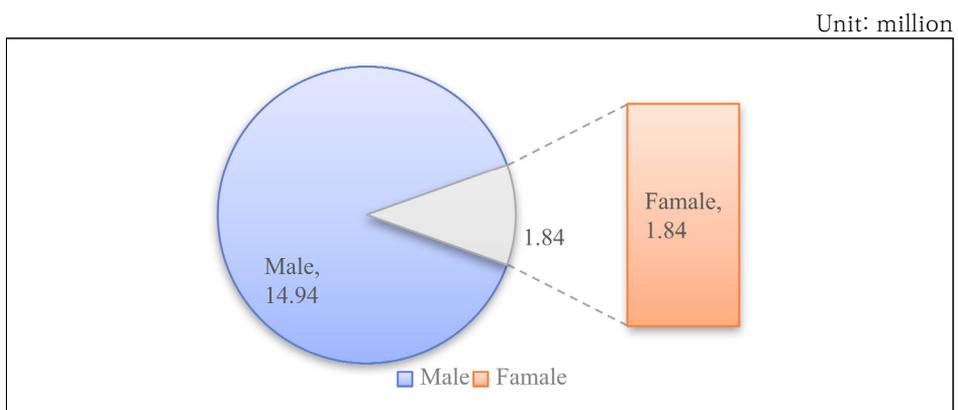
Source: Author's elaboration based on Statistics Indonesia (2023a).

With the rise of millennial farmers, digital penetration in Indonesia has also increased. According to the 2025 Internet Penetration Survey by the Indonesian Internet Service Providers Association (APJII), 80.66% of Indonesia's 229.43 million population is now connected to the internet. This figure marks a significant increase from 2018, when only 64.8% of the total population had internet access. Regionally, Java leads with the highest internet penetration rate at 84.68%, followed by Borneo/ Kalimantan, Bali, Sumatra, and Sulawesi, while Papua remains the region with the lowest connectivity at 69.26% (APJII, 2025).

〈Figure 3-7〉 Internet Penetration Rate by Region
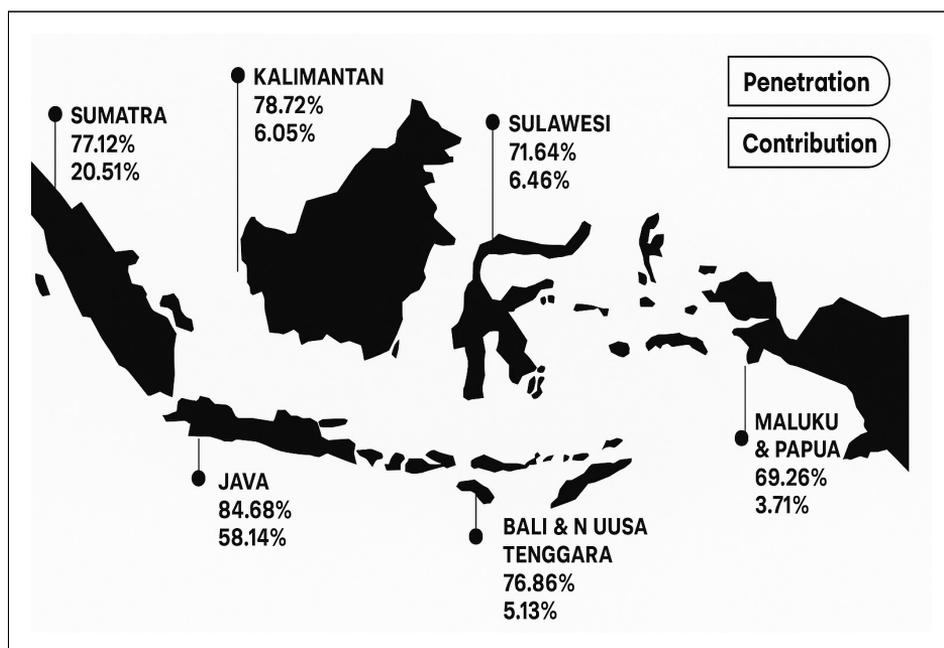
Source: APJII(2025).

5.1. Awareness and Readiness

Several studies have provided insights into how farmers in Indonesia perceive the adoption of smart farming practices.

Many farmers remain in the early stages of awareness that new technologies ("smart farming") can enhance efficiency and productivity. This reflects the innovation adoption framework, which suggests that changes in perception progress gradually—from awareness → interest → evaluation → trial → full adoption.

Farmers in Aceh Province generally hold positive perceptions of smart farming technologies, but their readiness to adopt them is constrained by limited economic and technical capacity (Agussabti et al., 2022).

A study in Bener Meriah Regency (potatoes), involving 70 farmers and 13 extension workers, found that the strongest perception of smart farming was its usefulness to farmers (high mean score). However, perceptions of its ability to reduce input costs were relatively low. The main barriers identified were high initial investment and the lack of demonstration sites or real-world applications.

In Bantul (Sumber Agung Village), Yogyakarta Province, a study on a "Smart-Eco Bioproduction" revealed that 71.26% of farmers expressed positive perceptions of environmentally friendly smart farming (Wastutiningsih et al., 2022).

Perceptions of government readiness in Bantul are also favorable (~79.57%), particularly in terms of outreach, equipment provision, and institutional support.

Overall, the literature suggests that perceived ease of use, perceived

usefulness, observability (the ability of farmers to see tangible results), and compatibility with local practices are critical variables influencing adoption decisions.

5.2. Attitudes Toward Risk and Trust

Some farmers remain skeptical of new technologies due to economic uncertainty, particularly concerns over whether substantial equipment investments will be recouped through yield improvements.

Trust in technology providers also plays an important role: farmers are more hesitant when vendors are unfamiliar or lack a local track record.

Generational differences further influence adoption. Younger or millennial farmers tend to be more open to technological innovation, while older farmers are typically more conservative. Global studies frequently identify age as a determinant of adoption, with younger individuals being more receptive to technology.

Farmers with greater openness to change recognize that high perceptions of risk, cost, and limited knowledge can hinder the adoption of smart farming technologies.

6. Implications and Outlook

Smart farming in Indonesia is showing encouraging progress, with strong interest especially from middle-income and millennial farmers. While farmers generally view agricultural technologies positively, adoption is still held back by challenges such as economic limitations, lack of skills, and weak infrastructure. To accelerate adoption and fully realize the benefits of smart farming, policies should focus on lowering costs, improving training, upgrading infrastructure, and strengthening local support systems—key steps to boost both food security and agricultural productivity.

6.1. Policy Implications

- Financing and Subsidies: Affordable financing options and equipment subsidies can help small-scale farmers overcome the heavy upfront costs of adopting smart farming(Purnawan et al., 2021).
- Capacity Building: Farmers and extension workers need hands-on training in digital tools, including IoT systems and automation(Giulivi et al., 2023; Manzeke-Kangara et al., 2024).
- Infrastructure Support: Expanding reliable internet and electricity in rural areas is key to making digital agriculture work effectively.
- Partnerships and Services: Stronger collaboration between universities, tech providers, and government can improve distribution channels, after-sales services, and local support.

- Inclusion of Smallholders and Youth: Special programs with incentives, credit access, and technical guidance are needed to encourage both smallholder farmers and the younger generation to embrace smart farming.

6.2. Key Challenges

- High Costs: The significant initial investment required remains a major barrier for small-scale farmers(Wilheppi et al., 2023).
- Human Capacity: Many smallholders lack the technical knowledge and skills needed for adoption(Harisudin et al., 2023).
- Infrastructure: Internet and electricity access remain unstable and uneven across rural areas(Dewi et al., 2023).
- Marketing and After-Sales Support: Farmers remain concerned about the lack of clarity regarding after-purchase services, equipment insurance, and local support (Mariyono, 2019).

6.3. Outlook

6.3.1. Current Position (2025)

Smart farming adoption in Indonesia remains in the pilot or cluster stage, but its implementation is gradually expanding. FAO has documented the integration of smart farming, fisheries, and livestock within the Digital Villages initiative in West Java.

Investment momentum is strong. eFishery raised US$200 million in Series D funding, positioning smart aquaculture as the most prominent driver of adoption through IoT-enabled auto-feeders, analytics, and integrated services.

Controlled Environment Agriculture (CEA) is emerging. Market projections estimate Indonesia's indoor farming market will reach approximately US$82.6 million by 2030 (CAGR ~5.7%), with smart greenhouses projected to grow at a CAGR of 10.1% (2024-2030).

At the policy level, Smart/Agriculture 4.0 has been mainstreamed into national programs for agricultural machinery, human resource training, and agricultural digitalization, supported by cross-ministerial coordination for modernization and upskilling.

6.3.2. Key Drivers (2025-2030)

- Food security & production expansion: The planned 3 million ha land expansion and modern production centers create opportunities for scaling up devices such as sensors, automated irrigation, drones, and CEA systems—provided standards are embedded in project design.
- Capital & business models: Investments in aquaculture and horticulture encourage bundled offerings of hardware, SaaS, after-sales, and financing solutions, reducing entry barriers for farmers.
- International partnerships: Collaborations with Korea, the Netherlands, Japan, and FAO accelerate technology transfer in CEA, drone applications, and digital village development.

6.4. Collaboration Opportunities with South Korea on Smart Farming in Indonesia

South Korea possesses a highly advanced agricultural technology ecosystem, including greenhouse climate control systems, IoT-based sensors, automation, crop robotics, and AI-driven farm management platforms. The integration of research capacity, systems engineering, and strong manufacturing industries positions Korea as a strategic partner for technology transfer and localized adaptation in Indonesia.

6.4.1. Possible Areas of Collaboration

- Joint Research and Pilot Projects: Indonesia and Korea could build smart greenhouses or plant factories together, testing local crops while applying Korean climate control and automation systems. IPB or Cibinong could serve as key hubs for these trials.
- Training and Knowledge Exchange: Indonesian farmers and extension officers could be trained directly by Korean experts, either in Korea or through local workshops hosted by Korean agricultural universities.
- Technology and Equipment Integration: Korean suppliers of sensors, controllers, and robotic systems could partner with Indonesian distributors to deliver and maintain equipment, ensuring it is adapted for tropical use.
- Government-Led Demonstration Programs: Both governments could fund large-scale pilot programs, such as the proposed Indonesia-Korea Smart Farming Pilot in West Java, East Java, and Sumatra.

- Startup and Business Partnerships: Korean agritech companies could partner with Indonesian startups, creating joint ventures that design IoT and AI solutions tailored to Indonesian farming conditions.
- Data Sharing and Digital Platforms: Cloud-based services could integrate Korean agricultural models, such as weather predictions and irrigation systems, into Indonesian apps to support farmers with real-time decision-making.

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해외 스마트농업 현황 및 정책과 시사점:
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Current Status and Policies of Smart Agriculture Overseas and Policy Implications:
Myanmar, Vietnam, and Indonesia

한국농촌경제연구원