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Promoting Smart Farming based-Digital Business Technology in the Context of Agricultural Transformation in Indonesia

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ABSTRACT

This paper aims to discuss the development of smart farming in the context of agricultural transformation and is supported by the advancement of Information and Communication Technology (ICT). The Indonesian Ministry of Agriculture (MoA) has formulated the strategy to develop an independent, self-reliant, and modern agriculture through combining precision agriculture with digital information technology and is defined as smart farming. Currently, there are several types of digital farming that have been initiated and implemented by the MoA in some areas of Indonesia. Among other things are Integrated Cropping Calendar (Katam) and Agriculture War Room (AWR) platforms. The country is well-positioned to take advantage of the ICTs since a large majority of farmers have reliable access to the internet and use it daily. It can be linked to an electronic network-based finger which is called digital business technology. However, certain conditions are necessary for Indonesia's innovation system to be efficient and thriving in the medium and long term basis to continue generating significant contributions to productivity, growth, prosperity, and the quality of life of the country's population. Hence, it is required a government policy to promote further development in terms of expanding investments in infrastructures, increasing the capacity of the farmers to access and utilize technology, developing a framework to provide confidence to all stakeholders, and facilitating potential users to the implementation of smart farming in the country. Since the implementation of smart farming as an initial practice in Indonesia, it is expected that young people become a pioneer in promoting smart farming in Indonesia through providing incentives, improving agricultural land credit accessibilities, expanding networks and information, and strengthening the capacities. This is strategically implemented through the Public-Private Partnerships (PPPs) scheme.

Keywords: agriculture, digital technology, smart farming, business, Indonesia

INTRODUCTION

Indonesia's Gross Domestic Product (GDP) has grown at a rate of 5.96% per year during 1990-2020. Along with the GDP growth, the structural transformation was indicated by a declining share of agriculture from 21.5% in 1990 to 12.7% in 2020. However, agriculture employment had decreased slowly from 51% in 1990 to 33% in 2020 (Sudaryanto *et al*., 2021). This observation indicated that Indonesia experienced an unbalanced transformation, characterized by a decrease in the agricultural sector's contribution to GDP faster than the decline in labor.

Structural transformation also involves agricultural transformation characterized by a shift from subsistence to commercial and more diversified production systems. Agricultural transformation involves shifting grain base production toward high-value commodities (Huang and Shi, 2020). The

share of high-value commodities in the total value of agricultural production has indicated a marked increase from 40.6% in 1990-1999 to 50.2% in 2010-2019 (Sudaryanto *et al*., 2021). This observation indicates that the structure of agricultural production has shifted from staple food and low-value agriculture (food crops) toward the production of high-value and more commercialized commodities, such as horticulture, perennial crops, and livestock. This transformation also changes farmers' orientation from mere subsistence toward more commercialized and market-oriented.

The agricultural transformation was driven by an accelerated increase in agricultural productivity. Over the past three decades, the growth of high-value commodities production was higher than that of food crops. For example, egg production showed the highest growth of around 13% per year, followed by beef (10%), palm oil (9%), and orange (5.5%). On the contrary, the production of staple food showed lower growth during the same period. Most notably, rice production only grew at 1.8%, but maize production grew strongly at 5%, driven by accelerated maize demand for animal feed.

According to the concept of agricultural transformation, the Indonesian Ministry of Agriculture (MoA) has formulated the strategy to develop an independent, self-reliant, and modern agriculture. A significant instrument to promote modern agriculture is by developing Agriculture 4.0 or smart agriculture. Agriculture 4.0 is precision agriculture combined with digital information technology, namely big data, mobile internet, and cloud computing. Implementation of Agriculture 4.0 is defined as Smart Agriculture, Smart Farming, Precision Agriculture, and Precision Farming. The approach and application of precision farming systems will support a sustainable agro-food sector. In the Strategic Plan of the MoA, the development of smart agriculture was also described as the strategy to maintain national food security (MoA, 2020).

This paper aims to discuss the perspective insight of smart farming development in agricultural transformation and is supported by the advancement of Information and Communication Technology (ICT) in Indonesia. After the introduction, the paper describes the development of digital technology in agriculture followed by a related legal and policy framework, including constraints and challenges. Finally, the paper addresses some conclusions and policy implications.

CORE CONCEPT

The core concept of promoting smart farming in the context of agricultural transformation in Indonesia can be simply illustrated in Figure 1. Smart farming is developed based on the advancement of ICTs through promoting agricultural transformation to increase agricultural productivity toward agro-food sustainability. This requires the development of digital business technology in agriculture involving public and private partnerships supported by policy and legal framework.

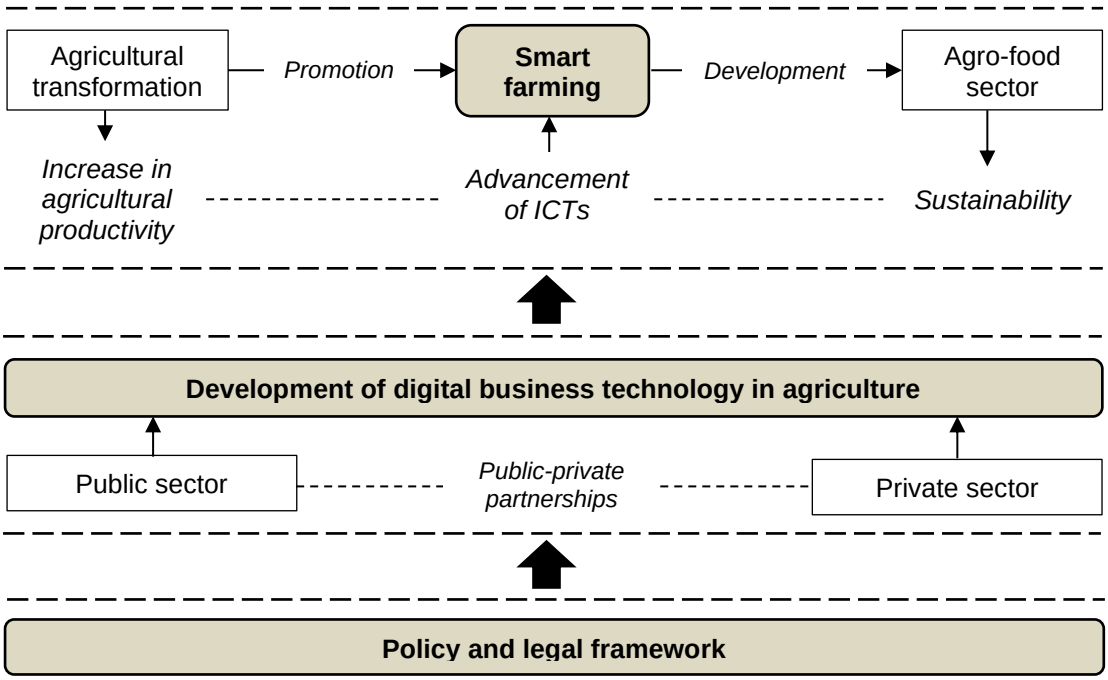

Figure 1. Core concept of promoting smart farming in the context of agricultural transformation in Indonesia

DEVELOPMENT OF DIGITAL TECHNOLOGY IN AGRICULTURE

Information technology

The use of information technology can be at the core of improving efficiency towards enhancing connectivity and increasing competitiveness in the agricultural sector. In other words, agriculture is being "digitalized" in various ways. Nevertheless, the process depends upon considerable extents of public policies and actions (ADB, 2020).

In the case of Indonesia, agricultural development is implemented towards industrial agriculture, from traditional farming to a modern agricultural system (MoA, 2020a). This concept is in line with the Industrial Revolution 4.0, in which the development of agriculture is characterized by producing agricultural products following its need, containing a high economic value, productivity, and being environmentally friendly (Rafani and Sudaryanto, 2020). Currently, there are several forms of digital farming that have been initiated and implemented by the MoA in some areas, such as Blockchain for modern off-farm agriculture, Agri-drone sprayer, Drone surveillance/drone for land mapping, soil and weather sensors, intelligent irrigation systems, Agriculture War Room (AWR), and Siscrop/information systems (Rachmawati, 2020).

AWR is designed as part of the Strategic Command for Agricultural Development (Kostratani) under IoTs and applies using an artificial intelligence system. It collects all primary data related to agricultural development at the farm level, designs to increase the role of the Agriculture Extension Center (BPP) at a sub-district level, and involves a multi-stakeholder platform that is heavily related to agriculture. AWR also gathers remote sensing information using the sentinel 2 of the satellite of the National Institute of Aeronautics and Space (Lapan) with a resolution of 10 meters x 10 meters. To accelerate the function, MoA has to put CCTV in 5,000 sub-districts all over Indonesia. In conclusion, AWR is the facility or system where competent Ministry authorities develop a strategic policy under the support of a real-time database.

Indonesia is well-positioned to take advantage of the ICTs. A large majority of farmers have reliable access to the internet and use it daily. Around two-thirds use smartphones and are active on social media. However, while general digital adoption is high, farmers are not yet maximizing technologies for business purposes. Most farmers still rely on networks of peers and family or friends for agricultural information. Only about a fifth use social media to buy or sell, with even fewer active on digital business technology (Soon *et al.*, 2021). Accordingly, it is a challenge to develop smart farming in Indonesia.

Seminar and Sarwoprasodjo (2019) study found that the farmers search information through an ICT such as WhatsApp application to support their farming activities. Members could ask anything in the group, and if other members happened to know the answer or solution, they could explain it in the WhatsApp group. They also sold their products through this group. WhatsApp groups were majorly used in Indonesia to share knowledge about agroecology, seek information and access to local seeds, and promote their products through the most dominant information needed by members from each region.

Digital business technology

The contribution of digital business technology by the business sector in Indonesia can be seen in Table 1. The three largest contributory sectors were wholesale and retail trade, vehicle repair and maintenance, followed by provisions of accommodation, food, and drinks, and mining and quarrying, processing industry, namely about 75%. However, the extent of agriculture e-commerce contribution was relatively minor (less than 1%).

Table 1. Contribution of digital business technology by the business sector in Indonesia, 2019

Digital business technology business sector	Contribution (%)
Agriculture, forestry, and fisheries	0.76
Mining and quarrying, processing industry	10.27
Procurements of electricity, gas/hot water steam, and cold air	0.17
Water, waste, and recycling managements	0.06
Construction	0.24
Wholesale and retail trade, vehicle repair and maintenance	48.42
Transportation and warehousing	6.65
Provisions of accommodation, food, and drinks	17.55
Information and communication	3.78
Financial and insurance activities	0.72

Real estate	0.25
Company services	3.48
Education	0.75
Human health and social activities	0.45
Other services	6.45
Total	100.00

Source: BPS, 2020

Indonesia has taken the necessary steps to support digital business technology. Table 2 illustrates the potential implications of technologies in this sector-based variety of opportunities and exploiting challenges following global technology trends.

Table 2. Potential implications of technologies in the digital business technology sector in Indonesia

Global technology trends	Opportunities	Challenges
▪ Global expansion of infrastructure for information and communication technology enabling wider internet and mobile phone penetration; ▪ Wider global availability of digital content providers and internet platforms; ▪ New digital payment solutions enabling secure online transactions; and ▪ Retailers adopting an omnichannel approach, integrating physical and virtual stores	▪ Expanding the number of consumers that Indonesian firms can reach, particularly in rural areas away from traditional retail centers; ▪ Digital business technology platforms reducing physical infrastructure and capital investment requirements for new business creation; and ▪ Direct contact with customers enabling more exact product and service customization for local needs, both urban and rural.	▪ Policymakers need to anticipate disruptive impacts on displaced businesses and employees and anticipate market changes; ▪ Legislation to protect labor rights is required for last-mile delivery personnel; ▪ Consumer protection regulation musd be extended to cover digital business technology platforms; ▪ Safeguards against monopolies should be considered; and ▪ Privacy and cyber security rules and policies need updating.

Source: MoF, 2020

Digital business technology could be crucial to provide citizens with benefit from a broader range of consumer goods and services and increase the interest of potential consumers for businesses. In 2020, the gross merchandise volume (GMV) of digital business technology in Indonesia's market amounted to around US$32 billion and was forecasted to reach about US$82 billion by 2025. For the time being, however, Indonesia has a good position in terms of GMV of digital business technology among the ASEAN countries (Figure 2). It is expected that 221 million people will be using digital business technology by 2025 (Statista, 2020).

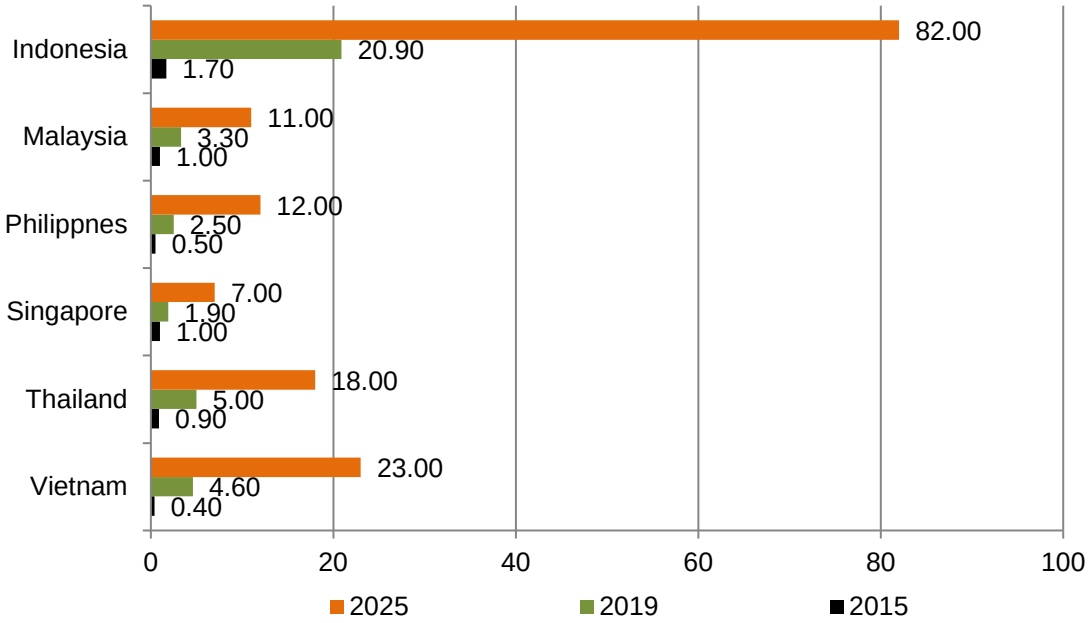

Figure 2. GMV of the digital business technology market in the ASEAN region in 2015 and 2019 with a forecast for 2025 (US$ billion)
Source: Statista, 2020

Digital agricultural intervention in Indonesia has been growing significantly. The presence of Ag-tech start-ups focused on creating opportunities and improving agriculture supply chain to be more efficient and profitable. Loukos and Tricarico (2019) grouped the Ag-tech start-ups into three types of solutions, namely: (1) Digital tools for commercial agribusiness in optimizing last-mile operations and developing reliable supply chains; (2) Digital tools that improve access to markets for producers and enhance supply chain efficiency by formalizing last-mile procurement activities; and (3) Digital tools for centralized data collection with the objective to increase farmers' access to data, make data more accessible, improve data analytics and offer better data-driven decisions for stakeholders. Few examples for those digital platforms can be seen in Table 3.

Table 3. Company's digital agricultural intervention platforms in Indonesia

Company	Platform	Remark
Koltiva	Supply chain ecosystem	Develops FarmCloud mobile app, which provides farmers access to all information collected by their working-partners such as extension officer (FarmXtension), agriculture input provider (FarmRetail), trader (FarmCloud) for farm and sales data, transactions, and record on transactions for traceable and certified commodities (FarmGate). Farmers can use their smartphone to login and access all data and information.
TaniHub	Business model	Helps farmers to have a fair price and reliable payment on their commodities, creates direct links between crop producers and buyers by eliminating "transactional costs" player within the supply chain, engages with modern retailers such as Lottemart, Giant and Hero; and hotels, as well as TaniXpress for managing logistics and distributions
HARA	Business ecosystem	Assists agribusiness or cooperatives to share their own data and encourage the farmers (that they are working with) to share data. The objective of this format is to open access to credit from financial institutions or to give opportunity for providers of agriculture-related content to develop more accurate, robust, localized and

		tailored to farmer needs

Source: Loukos and Tricarico, 2019

Even though the contribution of agriculture, forestry, and fisheries ranks third to Indonesia's national Gross National Product (GDP), the extent of internet users within these sectors is quite low, namely 2.77%, or about 6.01% of the aggregate internet users of the country (Table 4). However, it is expected that the number of internet users, particularly the young generation (millennial group) involved in smart farming, would increase along with digital economy development in the country.

Table 4. Internet users and sector contribution to GDP (%)

Business Sector	Internet User	Contribution to GDP
Information and communication	86.87	4.20
Financial and insurance services	83.19	4.48
Government administration, defense, and social security	73.94	3.86
Educational services	66.64	3.54
Health services and social activities	66.57	1.34
Company services	62.88	2.16
Electricity and gas supply	62.22	1.41
Real estate	58.16	3.01
Transportation and warehousing	43.91	5.81
Wholesale and retail trade, repair, and maintenance of cars	31.02	13.25
Other services	27.02	2.19
Processing industry	25.93	19.94
Mining and quarrying	23.14	7.50
Provision of accommodation and food-drinks	22.25	3.02
Water supply, garbage treatment, and waste recycling	21.26	0.31
Construction	26.35	10.99
Agriculture, forestry, and fisheries	2.77	12.96
Aggregate	46.12	100.00

Source: Bachtiar *et al*., 2020 based on Data of National Socioeconomic Survey (*Susenas*) 2019

DIGITAL TECHNOLOGY IN THE PUBLIC SECTOR

The implementation of digital technology in Indonesia's public sector includes certain institutions. They are, among other things, the Ministry of Agriculture, Ministry of Village Development of Disadvantage Region and Transmigration, and Universities.

Ministry of Agriculture

The Ministry of Agriculture launched smart farming 4.0 that utilized big data (artificial intelligence) in developing digital technology for farmers. Smart farming is designed as a tool that helps farmers to work more efficiently; it is also measurable and integrated with a system. Connecting farmers to digital technology is a must, and it has been applied globally. Agricultural revolution 4.0 consists of the Internet of Things (IoT), artificial intelligence, human-machine interface, robotics, satellite imagery, and sensor imagery with 3D technology. The Indonesian Agency for Agricultural Research and Development (IAARD) has started implementing smart farming in 2007 by introducing Integrated Cropping Calendar (*Kalender Tanam/Katam*). In more detail, the technology that has been developed and parts of smart farming led by the government are as follows:

1. Integrated Cropping Calendar (*Katam*) has been developed since 2007 by The Research Center for Agriculture Climatology. *Katam* is a web-based application that integrates three sub-systems, namely data, model, and query. *Katam* is designed to integrate the cropping calendar at the sub-district level to secure the national rice production under the variation of climate conditions caused by climate change. Sub-system data required for *Katam* are spatial and tabular. Spatial data is a digital map with administrative boundaries and the size of the rice field area in Indonesia. Spatial data covered digital maps and land size for paddy in 33 provinces, 497 districts, and 6,769 sub-districts. Tabular data consists of five groups of data, namely: (1) cropping calendar and

estimated land size for planting area; (2) climate estimation; (3) total area that affected by a flood, drought, pests, and diseases; (4) rice varieties recommendation; and (5) recommended dosage for fertilizer application. Then, using computer modeling, the user using a query model to develop the requested planting calendar that integrate land size, rice varieties, climate, and the estimation in mitigating the possibilities for the incidence of a flood, drought, pests and diseases.

2. Indonesian Center for Agricultural Land Resources Research and Development (ICARD) has developed a drone for land mapping, especially DJI Inspire 1. Drones produce low emissions; thus, drones which are used in the agriculture industry are steadily growing. Research shows that using drones for land mapping is more effective and produces a better result than satellite imagery. The drones, also known as Unmanned Aerial Vehicles (UAVs), play an increasingly important role in precision farming. From the economic perspective, drones help agriculture professionals lead the way with sustainable farming practices while also protecting and increasing profitability. In designing the drone, the center combines the use of Global Positioning System (GPS) technology and geographic information system (GIS) tools to form a large part of these precision agriculture practices, allowing fine-scale monitoring and mapping yield and crop parameters data within fields.

In addition to the drones, ICALRD also collected data from Satellite Remote Sensing at sentinel 2 for land mapping. Data from the satellite imagery is used for land planning and designing land use policy in Indonesia. The total wetland area for paddy is eight million hectares, and remote sensing helps researchers collect biophysical data. This data set is used to determine land use policy. Having complete information and an accurate data set helps the center to produce better land-use policies for specific areas in Indonesia. It creates the effect of the policy. The advantages of high-resolution remote sensing technology are: (1) Produces unique data set; (2) Easy and effective; and (3) Able to produce complete data with high accuracy in a very short time and cost-effective (cheap).

One of the examples was using the drone spryer. This tool has technical specifications of carrying capacities of up to 20 liters for spraying one hectare of land in 10 minutes with spray speed of three kilometers per hour and a height of 1.5-2 meters from the ground surface resulting a working capacity of 1.2 hectares per hour (0.83 hour/hectare).

Ministry of Village Development of Disadvantage Region and Transmigration

Since 2018, the Ministry has introduced a Smart Farming 4.0 in Situbondo district, East Java province. Having collaboration with *PT Mitra Sejahtera Membangun Bangsa* (PT MSMB), the Ministry of Village Development of Disadvantage Region and Transmigration has developed a digital farming pilot project. Farmers have been introduced to Drone sprayers (pesticides and liquid fertilizer), drone surveillance (land mapping), and soil and weather sensors, which help farmers increase production and minimize loss. The project also provides farmers with digital business technology for their agricultural products. Innovative Farming technology helps decision-makers at the district level estimate the production, logistics, and marketing of agricultural products from their areas.

Smart farming had been implemented by local government and community by combining plantation and agriculture (both food crops and horticulture) anchored in the principle of community-based integrated farming systems in terms of technology, institution, diversity, and network substances. The implementation of this system was able to detect the circumstance conditions such as utilizing the weather modeling and soil mass structure analysis toward increasing productivity and efficiency.

Universities

Wageningen University is one of the overseas universities that has started to work collaboratively with IPB Universities. The project called Smart-In-Ag (Smart Indonesian Agriculture) is a collaborative partnership with State Agriculture Polytechnic in Kupang and industrial partners, namely Single Spark, e-Fishery, WorldFish, and Dairy Pro Indonesia. INREF and LPDP fund the project. The project focuses on dairy and fish production in Indonesia. The objective is to improve dairy and fish production efficiency, animal welfare, and environmental impact by using smart farming technologies. Those technologies are sensors, Information and Communication Technologies (ICT) systems, Global Position Systems (GPS), the IoTs Management Information Systems (MIS), and cloud computing. These technologies are used interchangeably to collect, store, and analyze data from fish and dairy farms in Indonesia.

DIGITAL TECHNOLOGY IN THE PRIVATE SECTOR

The involvement of the private sector in Indonesia's smart farming activities is imperative, especially in line with encouraging innovation and modernization as well generating added value. However, the role of the private sector is relatively quite limited. Some best practices are discussed below.

PT Great Giant Pineapple

PT Great Giant Pineapple (GGP) has implemented smart farming based on the concept of Corporate Shared Value (CSV) through partnership with farmers and farmer groups through the Farm Business Cooperative (Pangestika and Hohary, 2020). This concept was implemented through an application based on the IoTs called "E-Grower" started in August 2018. It covers an area of 337 hectares with a total of 423 farmers in four districts in Lampung province who are partners of PT GGP that can be monitored in real time including the number of harvests to be exported. The application formulates a working formula that becomes a guide for farmers in carrying out their agricultural activities adjusted to the standards of PT GGP's production activities. It provided 15 units of android mobile phone with the e-grower application installed to the farmer's group leader, because there some farmers were unable to operate the mobile phone.

Oil palm plantation

In 2018, a fertilizer company (PT Pupuk Kaltim) launched an innovation in the application of precision agriculture called "*PreciPalm*" or Precision Agriculture Platform for Oil Palm as the first satellite-based precision agriculture solution for oil plantations in Indonesia. It aims at determining recommendations for precision fertilization by using satellite technology to identify, analyze, and process diverse information spatial and temporal aspects of oil palm plantations (bumn.go.id. 2020).

In the first quarter of 2019, the *PreciPalm* was implemented through field trials at the state-owned plantation holding companies (PTPN 3, PTPN 5, and PTPN 7). This platform is currently under the commercialization stage at corporations and farmers of oil palm plantations. In 2020, PT Pupuk Kaltim carried out the training to increase the competence of human resources in the fields of precision agriculture, remote sensing, and GIS that are required to operate the *PreciPalm* application. This is expected to provide agro services solutions as an added value focused on customer orientation. In collaboration with Bogor Agricultural University (IPB), the *PreciPalm* platform can be categorized as one of the smart farming concepts to optimize agricultural yields in quality and quantity, with efficient use of resources.

Others

In the case of small-scale levels, there are two examples that can be illustrated (Pangestika and Hohary, 2020). First, smart farming is called the "*Lumile*" application at Bale Hydroponic in Salatiga, Central Java province. This application aims to determine the best dosage of water and nutrients in the hydroponic system based-smartphone. Second, the smart farming application called "Hope" was developed by the Youth Aero-modeling Club based-auto pilot drone to carry out watering the farmer fields in Temanggung, also in Central Java province. Even though the utilization of *Lumile* and *Hope* applications was still limited, it would be potentially developed toward the Industrial Revolution 4.0.

Above all, the smart farming in Indonesia can be simply implemented through smartphone application since mobile phone has utilized by many people particularly farmers who open up to various agricultural technologies. This is expected to motivate young farmers to get them involved in the agricultural sector which recently tends to be degraded in the country, while the majority of farmers are old with low educational level.

POLICY AND LEGAL FRAMEWORK

Legal framework

Agriculture production

There are some laws and regulations which serve as legal bases in formulating innovative farming programs, namely Government Regulation of The Republic of Indonesia Number 26/2021 Concerning Agricultural Management, Law Number 22/2019 Sustainable Agricultural Cultivation System, Law Number 22/2019 concerning Sustainable Agricultural Cultivation Systems (State Gazette of the Republic of Indonesia Number 201/2019). These four legal bases concerning the support of technological assistance, capital, labor, and agricultural management to produce agricultural commodities to achieve food sovereignty by paying attention to the carrying capacity of ecosystems,

mitigation, and adaptation to climate change in order to realize an advanced, efficient, resilient, and sustainable agricultural system.

The application of agricultural information system technology in Indonesia shall consider doing the following: (1) Utilize information and communication technology; (2) Data security and confidentiality; (3) Standardize data and information; (4) Integration; (5) Ease of access; (6) Traceability; and (7) Ethics, integrity, and quality. Administratively, Law Number 11/2020 on Job Creation has mandated the mechanism for determining the type of business licensing in Indonesia using a risk-based approach to simplify the licensing process while still using the OSS System.

Agriculture land use

Implementation Rules of Law Number 19/2013 concerning the Protection and Empowerment of Farmers (State Gazette of the Republic of Indonesia Number 131/2013, Supplement to the State Gazette of the Republic of Indonesia Number 5433) have been issued with Government Regulation Number 65/2019 concerning Guaranteed Agricultural Land Areas. There are no legal differences between the land use for traditional agricultural and smart farming activities in Indonesia. Planning for the use and revitalization of smart farming land in Indonesia is regulated in several specific laws.

Agricultural marketing

The Indonesian government issued Government Regulation Number 80/2019 concerning Trading through Electronic Systems digital business technology) on the market side. This regulation is the parent legal basis for all digital business technology activities in various sectors in Indonesia, including agriculture products. According to Article 4, the value of digital business technology activities in Indonesia must follow the principles of: (1) Goodwill; (2) Prudence; (3) Transparency; (4) Trustworthiness; (5) Accountability; (6) Sustainability; and (6) fairness. The MoA has also issued MoA Regulation Number 15/2021 concerning Standards for Business Activities and Products in the implementation of business licensing to avoid risks and ensure the safety of consumers who use goods and services. Therefore, Good Agricultural Practices (GAP) is important, which is regulated in the MoA Regulation Number 48/2009.

The legal basis for smart farming production and marketing through digital business technology activities in Indonesia is still in the formation stage in line with the conditions of community activities. Thus, the laws above provide concepts and fundamental values to carry out smart farming activities and digital business technology agriculture products in Indonesia.

Policy framework

The MoA has formulated five programs in achieving agricultural development goals, namely: (1) Enhance production capacity; (2) Diversify local food; (3) Strengthen food reserve and food logistics; (4) Develop modern agriculture; and (5) Implement action program to triple the export value. Program number four (modern agriculture) is characterized by the promotion of smart farming.

To promote the initiative on agriculture 4.0, the MoA has developed a document on the Grand Design of Agriculture 4.0 implementation (MoA, 2020b). This document serves as a reference for all work units within MoA to formulate action programs related to this initiative. The document also serves as an instrument for coordination, integration, and synergy of government, community, and business actors in digitalization efforts toward agriculture 4.0. According to this document, agriculture 4.0 should be framed in the development of agriculture zoning.

Challenges

Certain conditions are necessary for Indonesia's innovation system to be efficient and thriving in the medium and long-term basis to continue generating significant contributions to productivity, growth, prosperity, and the quality of life of Indonesia's population. The strength, weakness, opportunity, and threat (SWOT) analyses for these conditions are described in Table 5. These include the agricultural sector in the country.

Table 5. Strength, weakness, opportunity, and threat of Indonesia's innovation system

Analysis	Description
Strength	Entrepreneurial activity has scored some successes, such that Indonesia hosts several unicorns worth more than US$20 billion
Weakness	Technological assistance for training, market research, and contract research and development (R&D) are limited across the country
Opportunity	It has an attractive market due to its large population with the potential to

	become the largest digital business technology market in Southeast Asia
Threat	Considerable diversity exists among Indonesia's regions and communities horizontally (inter-sector, inter-region) and vertically (income inequality)

Source: MoF, 2020)

Indonesia has a relatively larger digital economy market potential compared to some neighboring countries. This great potential also provides an excellent expectation for Indonesia to increase income, expand job opportunities, and facilitate inter-regional connectivity. However, the data also show that the rapid increase in internet users in recent years has not been correlated with GDP growth. One of the reasons is the high digital divide in Indonesia, which makes the proportion of internet users still below 50%. Some other constraints for further development of smart farming are: (1) Limited and unequal ICT infrastructures; (2) Inadequate capacity of the farmers to access and utilize smart farming technologies; and (3) Insufficient regulatory framework to enabling business communities and protect ICT users.

There are some aspects to be concerned about in the midst of great expectations with the implementation of smart farming in the Indonesian agricultural sector. ***First***, the connectivity of the internet has not yet reached all agricultural areas, especially in eastern Indonesia in some remote regions. ***Second***, the majority of farmers are old with a low level of education and low ability to use digital technology facilities. ***Third***, farmers have less affordability to digital technology tools in line with financial resources. ***Fourth***, due to limited land ownership, farmers perceive that using modern technology would not be cost-effective and inefficient. Another fundamental challenge is related to the average age of Indonesian farmers who are currently over 45 years old or can be categorized as X generation, baby boomers, and traditional (silent) who were born between 1928 and 1980. This generation can have limited knowledge of digital technology. On the other hand, the Y and Z generations (millennial and native digital) who were born from 1981 to 2010 are relatively familiar with digital technology, but only 3% of them want to continue family farming (Pangestika and Hohary, 2020). In addition, by implementing smart farming, farmers will be able to acquire the highest quality of agricultural products with minimal chemical residues. However, some farmers are reluctant to implement smart farming since they perceive that this digital technology will soon replace or get rid of the role of human labor.

CONCLUSION AND POLICY IMPLICATION

The development of ICTs in Indonesia has been accelerated, indicated by the percentage of internet users, in particular in specific sectors such as wholesale and retail trade, vehicle repair and maintenance, accommodation, food and drinks, and mining and quarrying, processing industry; however, the percentage of internet users in the agriculture sector is still low, less than one percent. This observation indicates that the prospect of ICT utilization in agriculture is still huge, which provides opportunities and challenges for both the public and private sectors. The improvement of internet connectivity is crucial to promote smart farming-based-digital business technology support the development. However, since the country has a large area comprising of thousands of islands, this substance should be gradually implemented through pilot projects.

The private sector has responded to this development in digital business technology, including the marketing of agricultural products. Moreover, this development has been accelerated during the COVID-19 pandemic in response to the government policy to restrict people's mobility, which motivates both sellers and buyers to do online transactions.

Consistent with the ICT development in agriculture, the implementation of smart farming has also been limited. This smart farming development has been constrained by limited ICT infrastructure, particularly in the lagging regions, the limited capacity of potential users, and the cost of ICT services. Therefore, government policy to promote further development of smart farming, areas should focus on expanding investment in ICT infrastructures, increase the capacity of the farmers to access and utilize smart farming technology, improve the capability of extensionists in digital technology facilities to assist farmers in implementing smart farming activities, and develop a regulatory framework to provide confidence to all stakeholders on implementing ICT business and facilitate potential users to the implementation of smart farming.

Up to present, the implementation of smart farming can be categorized as an initial practice in Indonesia. Since the majority of farmers are old with a low level of education and low ability to use digital technology facilities, the young farmers seem to be the hope for the agricultural transformation in Indonesia, especially to adopt the digital or smart technologies for farming. The particular effort and

programs to help young farmers and to attract young newcomers provided or planned by the Indonesian government are suggested as follows. ***First***, provide special incentives to change the perception of young people about farming. ***Second***, improve access to agricultural land and credit. ***Third***, expand networks and information. ***Fourth***, strengthen the capacity through designated farm demonstration as interesting and profitable agribusinesses so that farmers should be able to work hand in hand without feeling left out from smart farming practices.

It is believed that young people should also consider the fact that working in the agricultural sector is physically demanding. Consequently, technology is the best opportunity of addressing the problem. Universities and research institutions are suggested to generate a high priority in agricultural technology development based-improving efficiency, cost-effectiveness, and profitability. One of the strategic policy implementations is through the development of the Public-Private Partnerships (PPPs) scheme.

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AUTHORS' CONTRIBUTIONS

Tahlim Sudaryanto reviewed and edited the paper; Wahida collected and analyzed data and contributed to paper writing; Helena J.Purba supported data collection and contributed to paper writing; Iqbal Rafani designed and performed the paper, collected and analysed data, wrote and edited the paper; Effendi Andoko collected and analyzed data and wrote the draft paper

COMPETING INTEREST

Tahlim Sudaryanto, Wahida, Helena J.Purba, Iqbal Rafani, and Effendi Andoko declare that they have no conflict of interest