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SYSTEMATIC EVIDENCE EVALUATION ON INDUSTRY 4.0 DIGITAL TECHNOLOGIES IN INDONESIAN FOOD AND AGRICUTURAL SECTOR AND ITS IMPLICATION ON PRE- AND POST-COVID-19 PANDEMIC

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ABSTRACT

The Covid-19 pandemic has disrupted agro-food supply chains and a substantial shift in demand and composition of food and agriculture commodities.One of the strategies to address the disruption is by applying digital technologies in food and agriculture sector, and during the pandemic, digitisation and digitalisation have been accelerated by the GoI as one of the strategies for economic recovery. This study systematically mapped the studies and the applications of digital technology use in the food and agriculture sector, and analyzed the implications of the Covid-19 pandemic on digital technologies research and applications of the sector. A systematic review evidence evaluation was harnessed for this study to obtain data, which subsequently was translated into a thematic map and an interactive map.

The study showed that Covid-19 has hampered some food and agriculture activities but has positively accelerated digital technologies for the sector. Digital technologies, studied and utilized for Indonesia's food and agriculture sector, are primarily websites, the internet of things (IoT), GPS and GIS technology, artificial intelligence (AI), big data, and robotic. About 22.83% of reviewed literature discussed the ripple effects of the pandemic on digitalized food and agriculture sector in Indonesia. Digital studies are still concentrated on the island of Java, as seen at this interactive map: https://agriculture40studies.gis.co.id/ although internet penetration and the proportion of individuals using the internet have increased in the last five years.

This study reported that the Government of Indonesia (GoI) had issued national initiatives and policies supporting digital technologies in the food and agriculture sectors. However, a minimal number of both initiatives and policy has mainstreamed the Covid-19 pandemic. An interactive map of digital agriculture companies can be found at this link: https://agriculture40companies.gis.co.id/ and most of the companies are in the form of farmers advisory, mechanization platforms, digital marketplace, e-commerce, traceability, food delivery, and peer-to-peer lending. These applications are primarily concentrated in Java island and have benefited digital technologies, such as IoT, blockchain, artificial intelligence, smartphone or android, mobile apps, GPS/GIS, and drones. Start-up companies have applied strategic measures to cope with the pandemic implications, and some activities of the companies are suspended.

The GoI has initiated the transformation earlier than the establishment of ASEAN Digital Transformation initiatives. These strategies and agendas at the regional level were made during the pandemic and one of the recovery measures to deal with the effects of the Covid-19 pandemic. To date, regional "call for action" initiatives on agriculture digitisation and digitalisation are still limited although these initiatives have integrated national strategies and agendas from ASEAN Member States (AMSs), especially Indonesia. ASEAN agriculture 4.0 initiatives need to be more actualized to the ground supported with good management of project lifecycle to achieve the intended deliverables.

Keywords: digital agriculture, studies and applications, GIS mapping, Covid-19 pandemic implications

1. INTRODUCTION

1.1 Background

As of 12 January 2021, according to WHO (2021) there have been 89,416,559 confirmed cases of Covid-19, including 1,935,028 deaths. In Southeast Asia region, Indonesia has the highest Covid-19 onfirmed cases of about 836,718 and acumulative death of 24,343. In Indonesia, this pandemic has exacerbated the disruptions on food systems, which include food security and nutrition, food and livestock production, fisheries, natural resource management, food safety, animal-to-human health risks, transboundary pests and diseases, food supply chains and regional food trade. The exacerbated condition is because of the imposed incomplete lockdowns, severe restriction of human mobility, and widespread economic distress. According to Amanta et al. (2020), during the Covid-19 pandemic; in Indonesia, employment in agriculture was expected to contract by 4.87% and domestic agricultural supply by 6.20% and imports would decrease by 17.11% while import prices were expected to rise by 1.20% in the short term and by 2.42% in 2022.

However, the presence of Covid-19 pandemic has brought about the acceleration implementation of industry 4.0 digital technologies, including internet of thing (IoT), articficial intellegence (AI), big data, blockchain, 5G, big data analytics, cloud and edge computing, cybersecurity, immersive technology, and robotics. For instance, related to digital pattern in six countries of Southeast Asia, 47% of consumers decreased offline purchases and 30% increased their online spending (Yendamuri et al. 2020). Furthermore, the incresing trend of digital technology uses also affects young people, and according to Broom (2020) nearly nine out of 10 young people increased their use of at least one digital tool during the pandemic, especially for the use of online shopping, food delivery services, e-banking and e-wallet apps. Besides it is affecting all the citizens in the Southeast Asia, Indonesia has also taken an advantage to respond the Covid-19 pandemic by utilizing digital technologies in some important sectors. For instance, Indonesia has the potential to increase its economic productivity through digitization by US$121 billion by 2025 and Indonesian online shoppers had increased to 85 million people during the pandemic, from 75 million in the pre-COVID-19 era (Parama 2020).

In term of food and agriculture sector, the Government of Indonesia has implemented the use of digital technologies 4.0 although it is very slow to actualize. Handoko (2016) reported that the Communications and Information Ministry launched the 1,000 Digital Startup Movement initiative in cooperation with KIBAR with aim to realize Indonesia's potential for the Digital Energy of Asia by 2020 through the creation of 1,000 tech startups. Some of such startups include farmer advisory (e.g. eFishery, KARSA, NeuraFarm), mechanization platforms (e.g. Sentragro, AgroDrone), digital marketplace (e.g. TaniHub, Chilibeli, Kedasayur), traceability (e.g. HARA, Koltiva) and peer-to-peer lending (e.g. Crowde, iGrow, Tanijoy) (The World Bank 2020). Furthermore, during the Covid-19 pandemic, digital technologies 4.0 have become a tremendous opportunity for the Government of Indonesia to expedite the application of digital tools in agriculture sector. Indonesia's Ministry of Cooperatives and SMEs has encouraged SMEs in the

agriculture sector to go digital to weather the coronavirus pandemic and to expand their market reach (Kompas 2020). It is also supported by the change of Indonesia citizens in changing their behaviour to massively use digital tools. Mc Kinsey & Company (2020) surveyed food retail in Indonesia during the Covid-19 pandemic, and the result showed that about 33% increase in the use of online market after the Covid-19, and prior and during the Covid-19 the use is only 16%.

For the novelties of this study, to date, there have been no studies on the implications of the Covid-19 pandemic on the uses of digital technologies 4.0 for food and agriculture in Indonesia. The applications of digital technologies 4.0 during the pandemic for food and agriculture industries have been not yet also studied. Although some agri-tech startups have embarked the utilization of digital technologies as mentioned in the above, such as Crowde, iGrow, Tanijoy, TaniHub, Chilibeli, and Kedasayur. However, some studies on digital technologies 4.0 use were researched by many researchers although the studies were not interlinked to the occurence of the Covid-19 pandemic. For instance, Dyanasari (2018) studied about the application of digital technology to increase agricultural production in Indonesia. Christianawati (2019) also studied about the possible bilateral economic cooperation and stabilization between Indonesia and South Korea through digital farming. Soegoto et al. (2020) also researched on the developments of information technology and digital startup sector of agriculture in Indonesia.

Reviewing the above explanations, it can be surmised that it is very pivotal to study the current status of digital technologies 4.0 uses for Indonesia food and agriculture sector during and post-Covid-19 pandemic, and how the technologies 4.0 can respond the Covid-19 disruptions on the sector. In addition, the study and industry mapping of food and agriculture digital technologies 4.0 will be beneficial to ascertain of how the distributions of the technologies in Indonesia, and to investigate gap analysis between digital technology studies and applications in Indonesia.

1.2 Objectives

In this research, the objectives of this study are:

1. to investigate all studies and applications of industry 4.0 digital technologies in Indonesian food and agricutural (livestock, crops, fishery, and forestry) sector,
2. to provide research and industry mapping of the utilization of digital technologies 4.0 in food and agriculture sector, and
3. to identify research and industry gaps that happens between food and agriculture studies and industrial applications, and the implications of digital technologies 4.0 use on Covid-19 pandemic.

1.3 Study Framework

Framework of this study will include 4 stages, including: background/problems identification, method of the study (systematic evidence evaluation: literature review and review mapping; interview; and survey), outputs that will be carried out, and outcomes that will be attained. This framework can be concisely seen in the following figure 1:

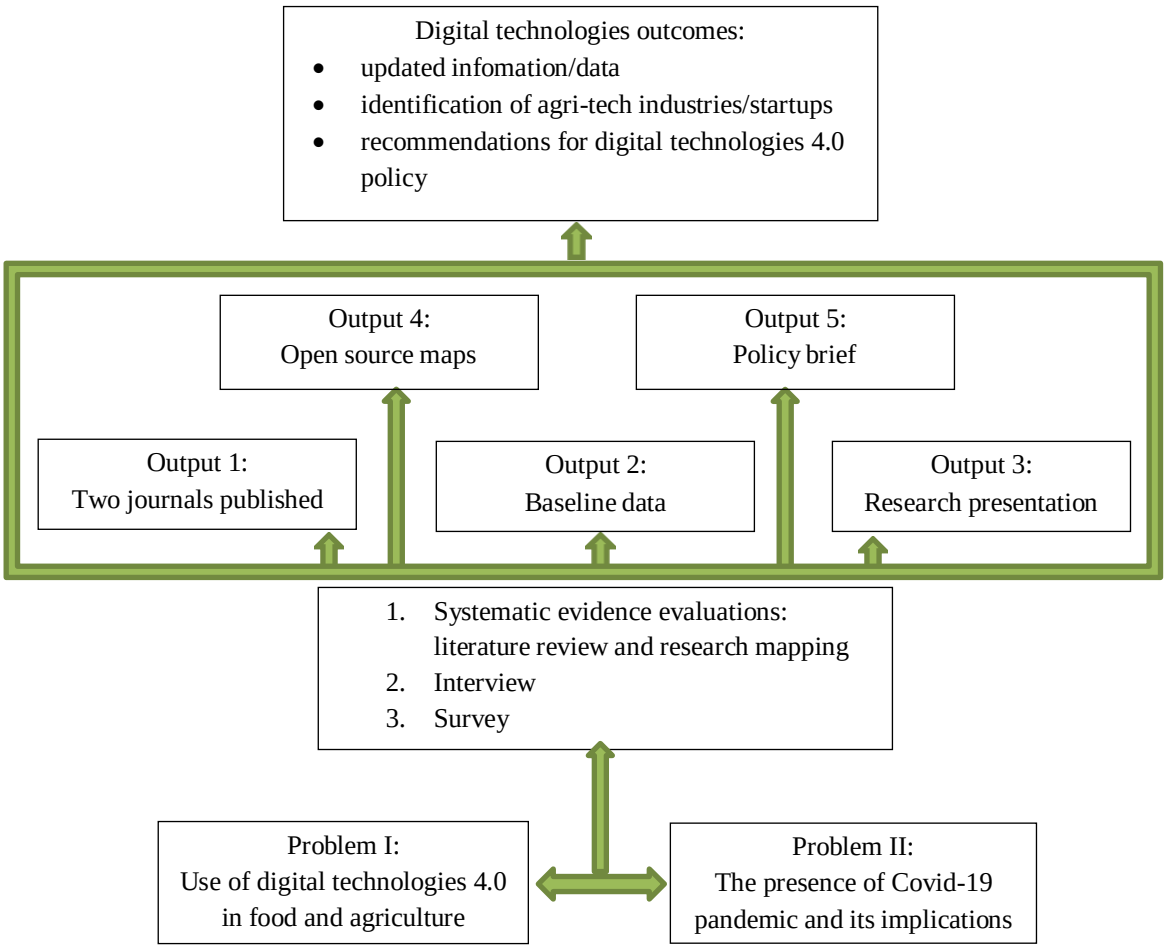


Figure 1. Framework of this study

1.4 Expected Output

In this study, expected outputs that will be proposed include:

1. two international journals published: The research results will be submitted to Q2-Q3 scientific publishing journals, namely: Journal of Science Education and Technology (Springer Nature Q2 with a five year impact factor of 2.218) and NJAS - Wageningen Journal of Life Sciences (Elsevier Q3 with cite score of 5.5).
2. a policy brief: This output will be compulsory for us because the principal investigator is a PhD candidate. This policy brief, which consists of concise research findings, will be very useful for the GOI's (Government of Indonesia) recommendations, especially for the Ministry of Agriculture. The recommendations will help enhance the new directories and

knowledge as well as product knowledge of the Ministry on the use of digital technologies 4.0 in the sector of food and agriculture.

3. baseline data that will be used for national respository: Baseline data of this study will be interlinked with IPB e-Journal repository so that one of the research team members at IPB University will be responsible to update.
4. national/international presentation of the results of this study: A national or international conference on agriculture or digital technologies will be attended by one of the team members to present the study results.
5. accessible/open source research mapping: A QGIS website will be developed by an expert to provide the reseach results, and each year and each five year period the data will be updated following the procedure of systematic evidence evaluation.

On the other hand, the outcomes of this study will be:

1) Updated infomation/data on food and agriculture digital technologies use,
2) Identification of agri-tech industries/startups that have been developed in Indonesia pre-, during, and post-Covid-19 pandemic, and
3) Recommendations for GoI related to the best practices to expedite the acceleration of digital technologies.

To achieve the outputs and outcomes, measurable activities proposed of this researh project will be monitored and evaluated. Obtained data on the status of the project activities are recorded its completions, including completed, on-going, and or uncompleted.

2. REVIEW OF RELATED LITERATURE

2.1 Current Uses of Digital Technologies in Indonesia

The Government of Indonesia released its digitalization roadmap, "Making Indonesia 4.0" with aim to create Indonesia as one of the global top ten economy countries by 2030, and food and beverage are one of the top five sectors that became a target for the digitalization (Ministry of Industry 2018). Figure 2 shows food and beverages have the highest impact and feasibility for the developement of industrial digital technology 4.0. In the Roadmap, GoI has set 10 national priorities, including: 1) reform material flow, 2) redesign industrial zones, 3) embrace sustainability, 4) empower SMEs, 5) build nationwide digital infrastructure, 6) attract foreign investments, 7) upgrade human capital, 8) establish innovation ecosystem, 9) incentivize technology investment, and 10) reoptimize regulations & policies.

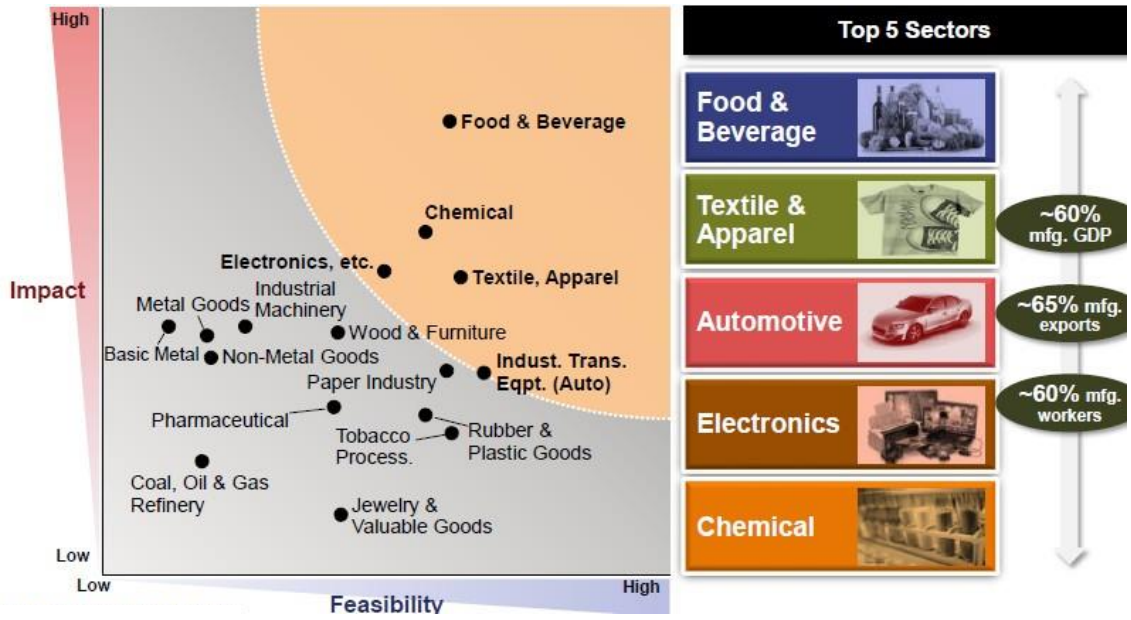


Figure 2. Sector potential for digital technologies 4.0 (Source: Ministry of Industry 2018)

It is well-know that digital technologies in food and agriculture sector in Indonesia have been used as electronic tools, systems, devices and resources that generate, store or process data. These tools can be in form of social media, online games, multimedia and mobile phones. Sahara et al. (2018) reported that , Indonesia farmers/agriculture consumers have utilized the digital technology for boosting the agricultural system information. In addition, a certain digital apps is also used for improving the market system and product quality, maximizing the farmer's profit and boosting the local product demand. That is also in line with the study of Loukos et al. (2019) stating that digital tools in Indonesia have been used for monitoring last-mile operations, market access, and centralised data collection.

With the presence of the fourth industrial revolution (4IR), digital technologies 4.0 is now more well-recognized, belonging to IoT, AI, big data ana analytics, cloud computing, advanced robotics, additive manufacturing, digital twins, and augmented reality. There are some examples of digital technologies 4.0 that have been used for food and agriculture in the world and Indonesia. For instance, farm machinery automation allows fine-tuning of inputs and reduces demand for manual labour; remote satellite data and in-situ sensors improve the accuracy and reduce the cost

of monitoring crop growth and quality of land or water; and traceability technologies and digital logistics services offer the potential to streamline agri-food supply chains, while also providing trusted information for consumers (OECD 2019). Rokhmana (2015) reported also that in Indonesia Unmanned Aerial Vehicle-(UAV) based platform for remote sensing in supporting precision agriculture mapping was used, and this tool is equipped with R/C aeromodeling plane for carrying digital pocket camera as sensor imagery. Wulandari et al. (2020) also reported that smart farming or digital farming that has been applied by farmers in Nudira Farm, Bandung.

These technologies have been integrated with the business development and management of food and agri-tech startups/industries. According to the study of Angel Investment Network Indonesia (2020), some of the GoI's projects on digitalization have been run, such as: FoodTechIndonesia22 (public-private partnership aims to strengthen poultry sector in Indonesia), VegIMPACT (program on improving vegetable production in Indonesia), and Dairy Village (modern and sustainable dairy farm to improve productivity and quality of milk), and MAIA - Millennial Agripreneurs in Action (providing students with knowledge on development of agriculture work, development, and agripreneurship).

2.2 Type of Digitalization in Indonesia Food and Agriculture

There are several types of digital tools that have been studied and applied in food and agriculture sector in Indonesia. In term of studies, some researchers identified common digital technologies that have been used in Indonesia, such as mobile phone, SMS, website and social media (Akhmadi 2018, Lestari et al. 2019a, Lestari et al. 2019b, Tanti et al. 2019). From his review, these tools play an important role in agricultural marketing by increasing market share and obtaining faster information on price, product and networks. In addition, these technologies help increase business motivation, non-formal education, length of business, and agritourism products. In addition, a study of Subejo et al. (2019) revealed that conventional and new elctronic media have been used by farmers, such as television, radio,and mobile phone to get new information. In Coastal Yogyakarta, conventional electronic media are still dominant in use by farmers and the use of new electronic media are still in increase trend.

According to Soegoto et al. (2019), there are two digital precision agriculture technologies, such as soft and hard precision agriculture. Soft precision agriculture depends mainly on visual observations of and management decisions plants and soil based on experience and intuition, not on statistical and scientific analysis whereas hard precision agriculture uses all modern technology such as global positioning system (GPS), remote sensing (RS), and variable rate technology (VRT). Juswadi et al. (2019) studied the importance of digital marketing strategy for Indonesia agriculture products, and there are some digital marketing tools that can be used, including the belt and road portal, companies-participants' web sites, online stores, social media accounts and social media marketing (SMM) activities, search engine optimization (SEO) activities, media and context advertisement, email marketing, integrated customer relationship management (CRM) and e-CRM system (Juswadi et al. 2019). In field of fertilizing, a precision farming system can harnesses geographic information system (GIS), GPS, RS, and VRT. Manulu et al. (2013) simulated a

nitrogen fertilizer tool that is controlled with VRT to provide information related to the appropriate location that has high productivity so that the location can be well-controlled for fertilization.

Besides the above digital technologies, IoT integrated with telegram was studied in Indonesia by Astutik (2019), which is used for smart farming, can assist the monitoring of data from agriculture. Through the utilisation of these tools, it can expedite agriculture development toward industry 4.0. Through this industry digital technology 4.0, Puspitasari (2019) suggested that to achieve sustainable agriculture development in Indonesia, application of the technologies, such as AI, IoT, robotics, autonomous vehicles, biotechnology, nanotechnology, 3-D printing, and quantum computing, can be undertaked by on-farm and off-farm. Figure 3 also shows some of digital technologies 4.0 in field of agriculture's Information and Communication Technologies (ICTs). To date, the studies of digital technologies have become applications in food and agriculture sector in Indonesia. A study from the World Bank (2020) found that there are several agri-tech industries/startups benefiting digital technologies 4.0, such as eFishery, KARSA, NeuraFarm, Sentragro, AgroDrone, 8Villages, Habibi Garden, TaniHub, Chilibeli, Kedasayur, HARA, Koltiva, Crowde, iGrow, and Tanijoy. An apps that was developed has been widely used by agriculturists, researchers, and famers to search agricultural information dissemination, namely iTani. This apps is very valuable and gave quite satisfaction for readers surveyed by means of Customers Satisfaction Index (Mayangsari et al. 2020). This app was made by the Center for Agricultural Technology Library and Dissemination, Indonesia Ministry of Agriculture.

Figure 3. Agriculture ICTs (Source: FAO & ITU 2017)

2.3 Food and Agriculture Digitalizations during Covid-19 Pandemic

Implementation of industry 4.0 digital technologies is very cumbersome and challenging. The World Bank (2020) identified the challenges, including the lack of an enabling environment, generally low digital literacy rates, limited access to technology, unfavorable policies, limited information integration across value chains, and inability to build agriculture services that generate revenue due to lack of ecosystem and regulatory standards and in some cases cultural barriers. Another unexpected regard that become an opportunity and problem during the development of industry 4.0 digital technologies in food and agriculture sector is the Covid-19 pandemic. It is well-known that the Covid-19 pandemic generated the decrease in the growth rate of agricultural production sharply from 4.3% to 0% year on year, possibly reflecting a sharp fall in palm oil exports in the first months of 2020 (Subawa et al. 2020). Furhermore, according to the study of Wisnujati et al. (2020), the behavior of farmers in East Java showed relatively no difference before and after the Covid-19 because farmers still work as usual. However, the brothers of the farmers returned home because of the culture of going back or also because the factories, shops, restaurants where they work have been close, this is a burden for farmers.

In view of industry 4.0 digital technologies, there have been no studies in particular on the use of food and agriculture digitalizations during the Covid-19 pandemic in Indonesia. In some scientific journals, recommendations to discover appropriate and adaptable technologies are needed during and post-pandemic. For instance, Facebook, Instagram, Twitter and YouTube were used for digital zakat campaign and zakat collection during Ramadhan and the pandemic. The inclusiveness of digital contents is practically significant in campaigning zakat as a religious obligation that contributes to social and financial benefits (Hudaefi et al. 2021). A study of Rozaki (2020) revealed that information and mechanization regarding farm-level production are needed to support food-and-farming-system diversification, leading to enhance local food production. It is very diffifult and rare to find scientific articles on digital technologies 4.0 implications on Indonesia food and agriculture sector. However, a survey of McKinsey & Company reported that food retail in Indonesia during the Covid-19 pandemic, and the result showed that about 33% increase in the use of online market after the Covid-19, and prior and during the Covid-19 the use is only 16%.

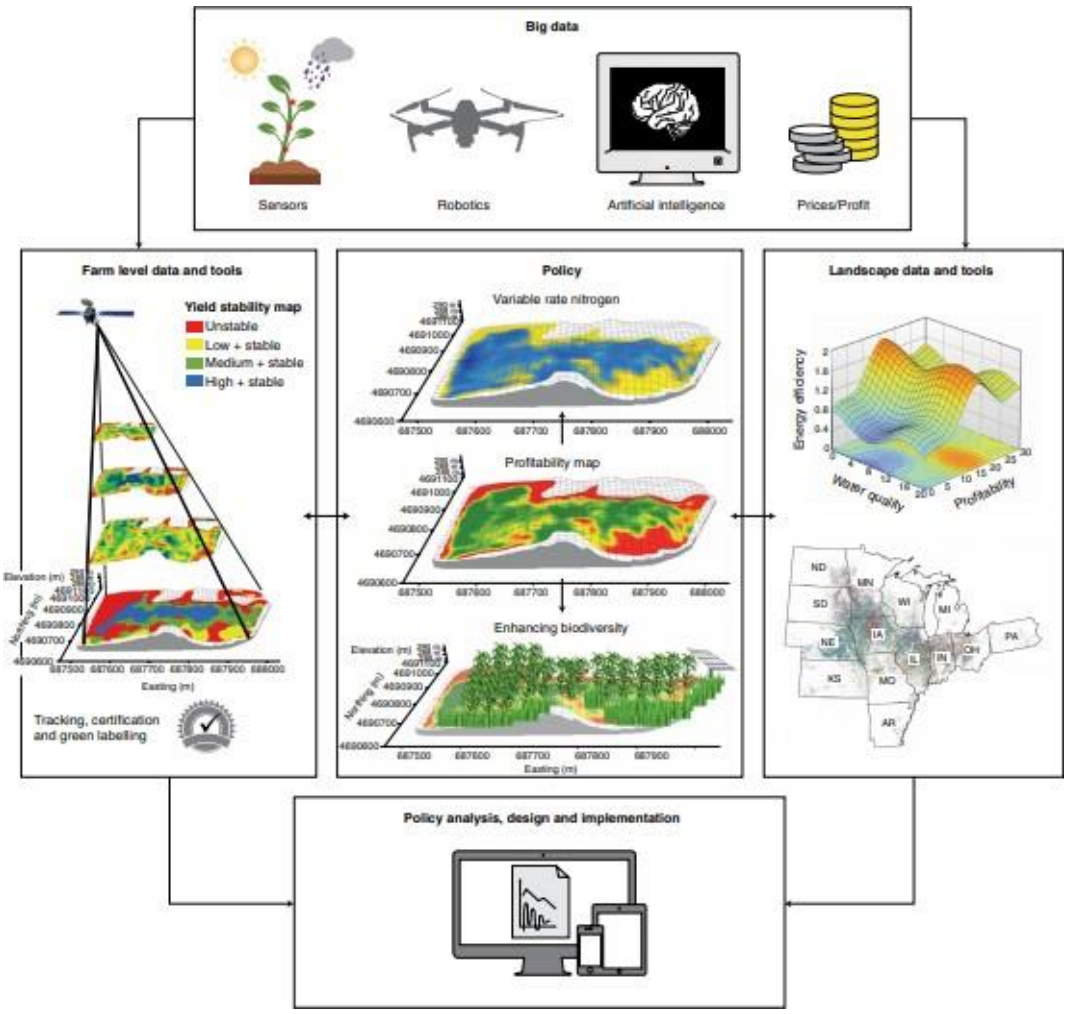


Figure 4. Digital agriculture use (Source: Basso et al. 2020).

Referring to global sources on the implications of the Covid-19 pandemic on food and agriculture digital technologies 4.0, there have been some scientific studies that were conducted. The impacts of this pandemic has triggered some countries to apply digitalization in food and agriculture field, such as big data, IoT, cloud computing, robotics, and automation. To accelerate the digitalization; digital skills, operational and training skills, supply chain skills, digital marketing skills, and Health Safety Environment (HSE) skills are necessarily required (Telukdarie et al. 2020). Hrustek (2020) also reported that the studies on food and agriculture digitalization have increased in the last two years, and it is noted that the benefits of applying digital technologies are not in question, and big data and analytics, IoT, AI and machine learning, blockchain, and cyber-F systems are mostly applied. Through digitalizing agriculture sector (Figure 4), it can help re-design fields or subareas within fields that are unprofitable or environmentally unsustainable, and sustainably intensify high-yield areas of the field knowing that these can respond to more inputs (Basso et al. 2020).

2.4 Industrial Application of Indonesia Food and Agriculture Digitalization

Industrial 4.0 digital techologies have forced the creation of digital economy in Indonesia. Through digital transfromation, Indonesia's digital economy potential is valued at US$133 billion, while in the ASEAN, it reached US$300 billion (Kurmala 2020). To date, it has been found many applications of digital technology 4.0 in Small and medium-sized enterprises (SMEs), fintech startups, and or industries. As of 17 April 2020, there are some agritech startups in Indonesia recorded by Tracxn (2020) (Table 1).

Table 1. Agritech startups in Indonesia

Name of startups	Short description	Link
TaniHub	App-based online marketplace to trade agriculture commodities: It delivers products through an in-house delivery team Tani-Express.	https://tanihub.com/
Chilibeli	Online community based platform for agricultural products: It connects farmers and manufacturers with agents through instant-messaging tools.	https://www.chilibeli.com/
eFishery	Provider of an IoT based automatic fish feeding solution: It comprises of a feeder that can sense the fish's appetite through motion sensors, and if the fishes feel agitated or hungry, the machine feeds them automatically.	https://www.efishery.com/
Crowde	Online platform for connecting farmers with retail investors: The farmers can get their project listed upon registration. Investors can choose among the listed projects for making their investments.	https://www.crowde.co/
8Villages	Marketing solution for companies in agribusiness: It connects the farmers directly with the companies engaged in agribusiness.	https://8villages.com/
iGrow	Crowdfunding platform for farming: The proceeds are utilized by farmers to carry out the entire farming operation and the farmers share the revenue generated by selling the harvest in proportion to the seed investment with the users.	https://igrow.asia/
InFishta	Online platform connecting investors with fish farmers: It allows investors to choose the cultivation method, determine the funds to be invested, and invest in fish farming projects.	https://www.infishta.com/
Jala	IoT enabled solution for monitoring water condition in the shrimp farm: The device can be submerged in the pond and is equipped with multiple sensors for monitoring parameters like dissolved oxygen, temperature, humidity, pH, salinity, and TDS (total dissolved solids).	https://jala.tech/id/
Habibi Garden	IoT-based precision farming platform: They deploy a central device which connects to a number of sensors to record data related to light intensity, humidity, moisture, nutrients and send it to the central cloud platform.	https://www.habibigarden.com/
Eragano	Mobile application for effective farming: The application's features include AI generated farm	http://www.eragano.com/

	schedule, integrated with e-commerce farm supply and crop protection program.	

Source: Tracxn (2020)

Besides these agritech startups, there are also other startups that develop agriculture digital technologies in Indonesia. For instance, Angon, Blumbangreksa, Etanee, Karsa, Kecipir, LimaKilo, Pantau Harga, and MyAgro (Eka 2016). These startups also benefits modern technologies, such as IoT and market place. During this pandemic, PT Petrokimia Gresik, PT Astra Agro Lestari and PT Rukan started to use technologies, such as machine learning and big data, to streamline business and overcome challenges (Rahman 2020). PT Pupuk Kalimantan Timur also received the INDI 4.0 award due to its commitment and consistency to implement digital technologies 4.0, starting from smart operation, smart maintenance, smart distribution, and digital performance management system (Ministry of Industry 2020).

3. METHODS

In this study, method used is based on systematic evidence evaluation, including sytemtic review and review mapping.

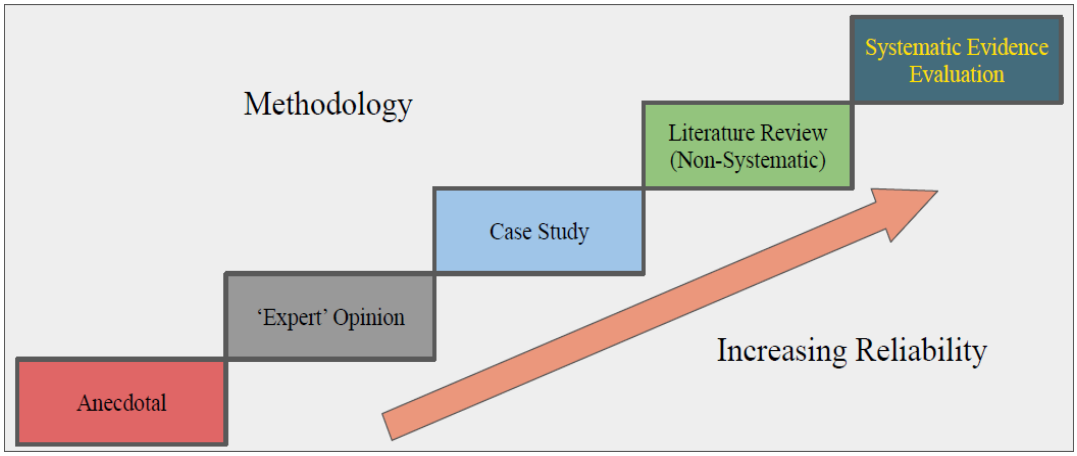


Figure 5. Systematic review evidence hierearchy

This method is very new in the field of environment, especially food, agriculture, and forestry. This method is not just a literature review but it is more realible than literature review, case study, expert opinion, and anecdotal (Figure 5); and this method will adopt the procedures developed by the Oxford Systematic Review LLP, the University of Oxford (2020) and Pullin et al. (2018). Besides that method, survey and interview will be conducted to acquire primary data that will support the evidences obtained from systematic evidence evaluation.

3.1 Materials

Materials used for this are: literatures obtained/searched from Google Scholar, Microsoft Academic, BASE, CORE, Science.gov, Semantic Scholar, and or Baidu Scholar. The literatures

are obtained in period of 2001 to 2021 or within the last ten years. Other apps used are Colandr, Publish and Perish, and Mendeley for data extraction, screening, and documentation. Ms. Excel version 2021 is used for data inputs and analysis with including some parameters for data extraction. QGIS 3.16 Hannover (GNU General Public License, USA) is used for mapping the evidences. For interview and survey, Zoom Meetings (Zoom Video Communications, USA) and Survey Monkey (SVMK Inc, USA) will be harnessed respectively. If the internet connection is unstable, phone call will be conducted for interview.

3.2 Time and Place

This study will be carried out between March to November 2021. The place of this study will be conducted by desk review and field studies with "a principle of no harm" for the researchers during the Covid-19 pandemic. If it is mandatory to be carried out in the field, Covid-19 health protocol recommended by WHO (WHO 2020) and GoI (Ministry of Health 2020) will be undertaken. Interview and survey are possibly conducted by virtual means to contain the transmission of SARS-CoV2.

3.3 Procedures

As mentioned in the introduction of method part, this study will follow a method of systematic evidence evaluation, consisting of literature review and evidence review mapping. Procedures developed by the Oxford Systematic Review LLP, the University of Oxford (2020) and Pullin et al. (2018) will be harnessed. In addition, survey and interview will be also used for obtaining primary data.

Systematic evidence evaluation is a novel method used to review a wide range of sources/information with aim to inform debates and decisions on specific issues. This method is very useful to provide changes by means of the existence of robust evidences extracted from a wide range of sources. As the general information, Figure 6 shows the flow of systematic evidence evaluation. In this study, there will be two sources of data, including 1) primary data, and 2) secondary data. The procedures to obtain these data can be seen in Figure 7. As a general description, a good question that will be proposed for this study is:

"How significant implications of the implementation of the industry 4.0 digital food and agriculture technologies to respond the pre-, during, and post-Covid-19 pandemic?"

P (Population)	: food and agriculture sector in Indonesia
I (Intervention)	: implementation of digital technologies 4.0
C (Counterpart/Control)	: unimplemented digital technologies 4.0, conventional technologies, non-digitalization
O (Outcomes)	: food and agriculture changes in pre-, during, and pre-post

pandemic, types of digitalizations used, increased number of digital tools used, studies and industrial applications (agritech startups/companies) of digital technologies in food and agriculture sector

From the above question, it can be concluded that PICO framework will be used for the protocol of this study. The framework will be used for guiding the literatures downloaded. By using academic search engines, such as Google Scholar, Microsoft Academic, BASE, CORE, Science.gov, Semantic Scholar, and or Baidu Scholar. A complex query will be used for the search of literatures with the following keywords: "food and agriculture in Indonesia" AND "digital technologies 4.0" OR "digital tools 4.0" AND "Covid-19 pandemics" OR "digitalization" AND "food and agriculture studies and agritech startups and companies" OR "implications of food and agriculture digitalization" AND "pre- and post-pandemic".

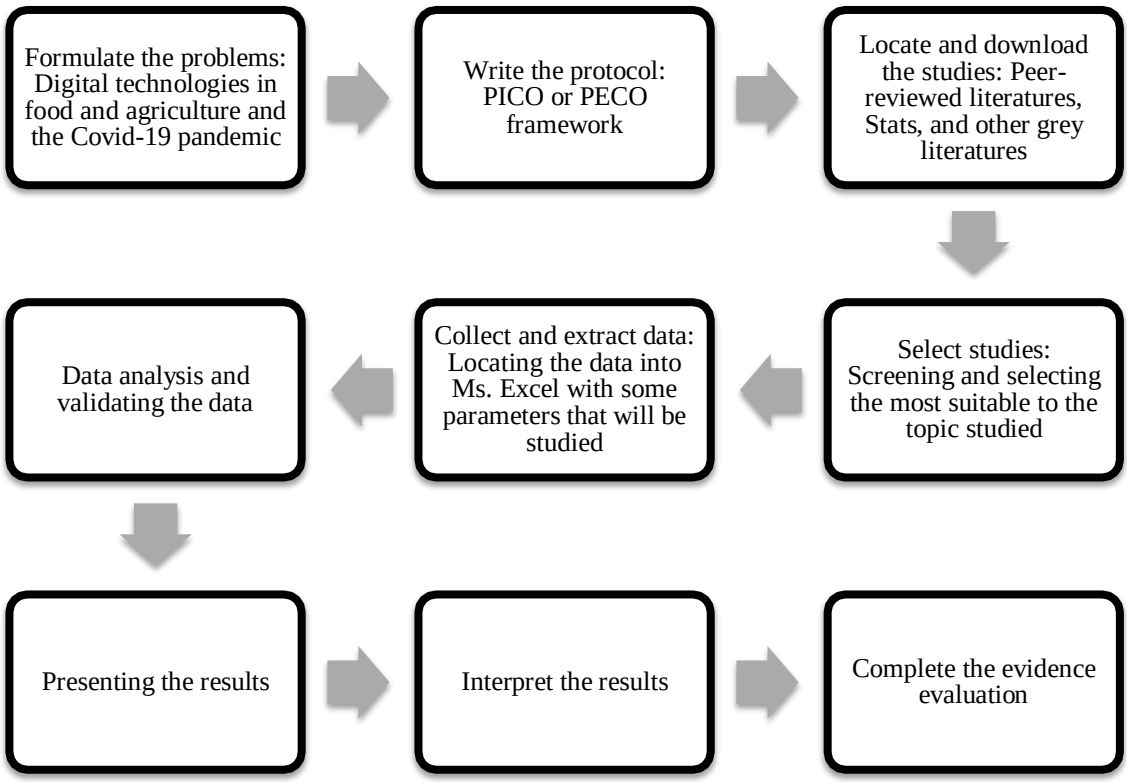


Figure 6. Systematic evidence evaluation flows

In the search, these key words can be translated into Bahasa Indonesia. Thus, the literatures obtained can be in form of Bahasa Indonesia and English within the last ten years (2001-2021). Other sources and documents used for this method include per-reviewed scientific articles, grey literatures, policy briefs, meetings report, relevent governmental/companies documents, FAO Stats, World Bank Stats, websites, and scientific articles. From these sources, most of the data belong to secondary data whereas primary data can be collected from survey or questionnaire, and

interview. Acquired primary and secondary data were verified, and most notably, primary data obtained from survey and questionnaire were also signed by the respective interviewees or relevant stakeholders (Figure 7). Parameters that will be extracted are: publication year; publication site; industries/companies/institutions name; digital technology types (big data and analytics, internet of things, artificial intelligence, machine learning, robotics, blockchain, and cyber-F systems); digitalization use; challenges and benefits; purposes; digitalization data; digital technologies 4.0 in food, agriculture, crops, livestock, fishery, and forestry; pre- and post-Covid-19 implications; and relevant policies.

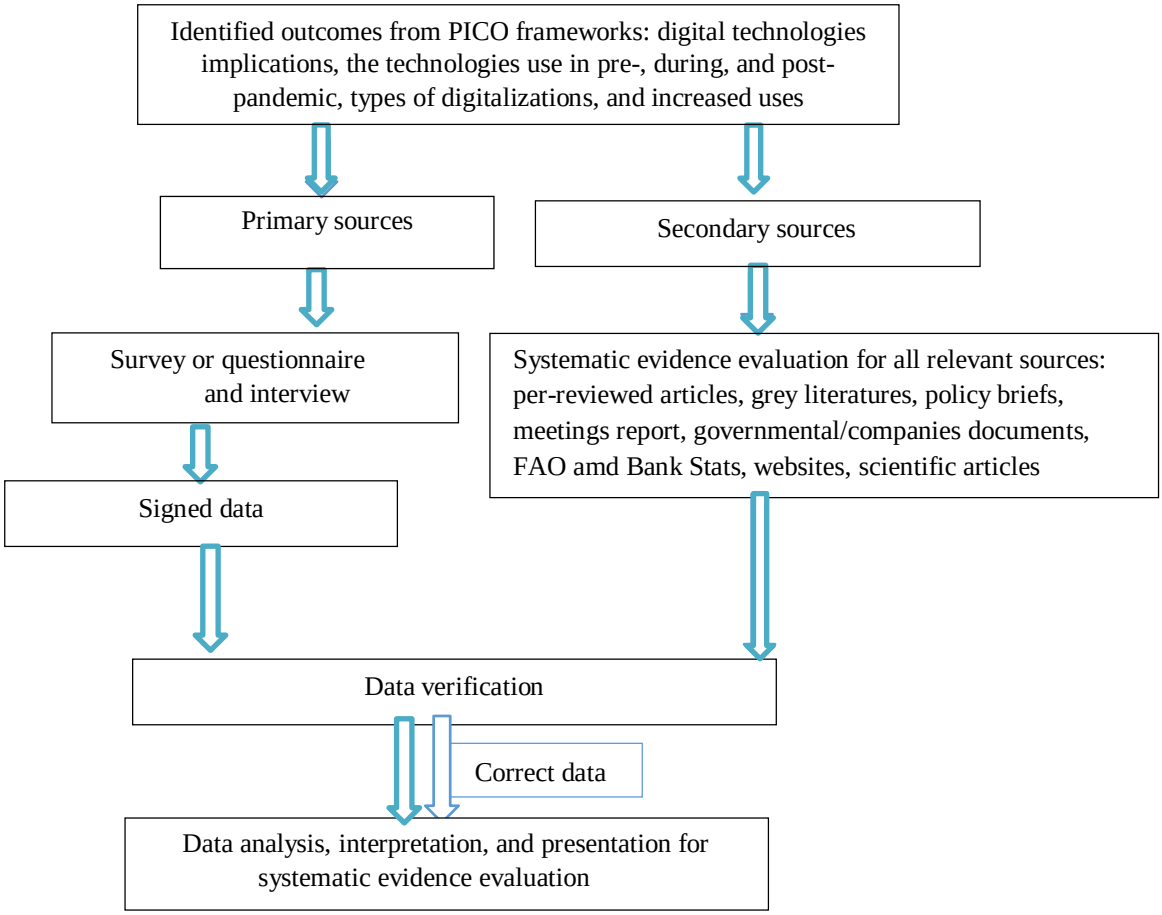


Figure 7. Data obtainment from primary and secondary sources

4. RESULT AND DISCUSSION

4.1 Implementation and Outputs Achievement Status

This research project was completed since 26 November 2021 in which the outcomes were achieved. The accomplished outcomes of the Project are such as:

1. Two drafted manuscripts that will be published internationally to scientific publishers. The manuscripts are entitled: 1) Mapping of Digital Technology Studies in Indonesia

Food and Agriculture Sectors and Their Relation to Covid-19 Pandemic submitted in the Digital Society Journal; and 2) Overview of Digital Agriculture Technologies in Indonesia: Policies, Implementation, and Covid-19 Relation submitted in the Smart Agriculture Technology Journal.

2. One drafted policy brief that will be published to the ASEAN CRN Policy Brief website. The draft is entitled: Progressing Indonesia's Agriculture 4.0 Through Research and Application Towards ASEAN Digitalization Initiatives in the Covid-19 Pandemic.
3. Two types of map, which are a) interactive maps and 2) thematic maps. These maps can be accessed through the following links:
   - Fiften thematic maps were produced
   - Three interactive maps were produced, and these online links can be seen at
     a. https://agriculture40studies.gis.co.id/ (link for digital research distribution)
     b. https://agriculture40companies.gis.co.id/ (link for digital companies distribution)
     c. http://agriculture40research-companies.gis.co.id/ (link for digital studies and companies distrbution)
4. A requested module from SEAMEO BIOTROP is still under preparation to finish.

From the above, we can conclude that about 100% outputs were achieved. For the submitted publication, we also attached the submitted manuscripts for your references.

4.2 Results and Discussion

4.2.1 Digital technology-related higher educations

Figure 8 shows a map of agriculture-based higher education (HE) institutions in Indonesia. There are about 4593 higher education institutions, comprising 122 public HE institutions (PTN), 3,044 private HE institutions (PTS), 187 government HE institutions (PTK/L), and 1,240 religious HE institutions. These HE institutions, which have studied agriculture, engineering, and information, communication, and technology (ICT), are interlinked with and pivotal to producing well-rounded millennials (Gen Y) who have good academic digital literacy and digital media practices. These skills are versatile to help digitalize the agriculture sector into Agriculture 4.0. However, in a study of Katadata Insight Center (2020), during the Covid-19 pandemic, Indonesia's digital literacy score was 3.47 out of 5.00 (average to good), in which the score was generated from several sub-indexes. In addition, from the study, Indonesia has the lowest score in the information and literacy data sub-index (3.17 out of 5.00) over other sub-indexes (communication and collaboration (3.38), safety (3.66), and technology capabilities (3.66)) throughout Indonesia provinces. That study also informed that millennials had the highest digital literacy index of about 25%. As a result, HEs have been progressed to develop strategic digital thrusts that support the implementation of Agriculture 4.0. According to PwC (2018), many HEs are now are developing specific digital strategies in reaction to the massive shift towards using new technology, yet lack the vision, capability, or commitment to implement them effectively (PwC 2018).

According to the Ministry of Education and Culture (2020), from Indonesia's HEs, Indonesia only has an engineering-based study program of 18%, an agriculture-based study program of 7%, and mathematics and natural sciences-based study program of 4%. These study programs provide courses pertinent to digital technologies that can be applied in the food and agriculture sector. Through digital education that supports intensive research, innovations on digital practices in the food and agriculture sector can be produced by Millenials. Entrepreneurship education also provides millennials an excellent chance to integrate their acquired digital skills into practices, such as digital start-ups development, fintech, and e-commerce. Pogorelskaia et al. (2020) revealed that digital education and learning infused in the higher education curricula is key to addressing the digital divide. Besides courses, it is also noted that HEs dimensions have been permeated with digital technologies, including teaching, infrastructure, curriculum, administration, research, business process, human resource, extension, digital transformation governance, information, and marketing (Benavides et al. 2020).

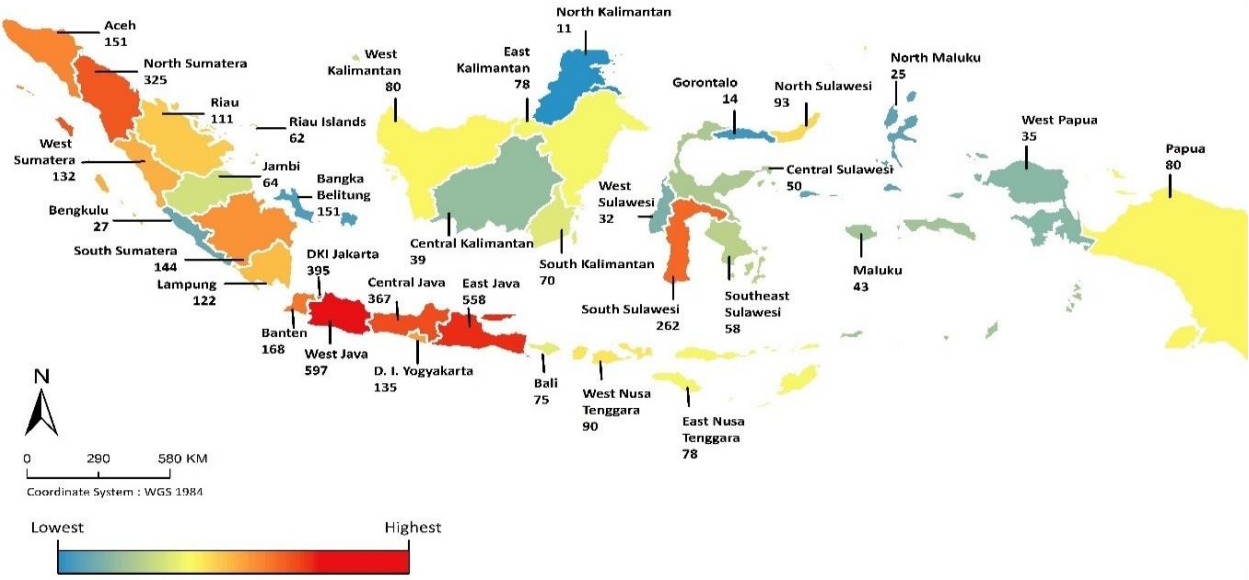


Figure 8. Number of higher education institutions in Indonesia

4.2.2 Types of digital technologies for the agriculture sector

From the kinds of literature reviewed systematically, there are types of digital technologies that have been considered to disrupt the global agricultural sector. They are such as artificial intelligence (AI), the internet of things (IoT), blockchain, big data, smartphone, uncrewed aerial vehicles, digital employees or workspace, virtual reality, augmented reality, robotics, automation, and 3D printing (Table 2). These technologies also increase the yield productivity of agriculture produced by managing and controlling certain parts or whole parts of the food supply chain. For instance, AI that is sometimes integrated with IoT, remote sensors, and or drones can be used for

agriculture plantation management, pesticides control use, fertilizer intake, and crops irrigation. From this study, limited studies are identified for digital employees or workspace and 3D printing for the agriculture sector. In Indonesia, digital technologies mainly studied for their application for the sector include smartphones, drones, robotic and automation, AI, IoT, blockchain, and big data. This detail is explicated further in the next part of the result and discussion.

Table 2. Types of agriculture digitalization-based disruptive technologies

Type of digital technologies	History	Description	Uses in agriculture
Artificial intelligence (AI)	He was coined by John McCarthy, Alan Turing, Marvin Minsky, Allen Newell, and Herbert A. Simon in a conference at Dartmouth College, Hanover, New Hampshire, in 1956.	One of the computer sciences designed to simulate human intelligence and programmed in machines to mimic human actions.	Integrated with remote sensors for soil moisture content detection and automated irrigation; integrated with a drone for pesticides and herbicides spraying and plants monitoring (Talaviya et al. 2020); and integrated with AI for crops selection, fertilizers selection, field management, and crop harvesting (Jha et al. 2019).
Internet of things (IoT)	Kevin Ashton firstly introduced the IoT in 1999 as presenting it for Procter & Gamble.	Devices (machines, equipment, software, and other things) are interconnected with the internet for gathering information, analyzing information, and creating actions.	Integrated with agriculture in the form of intelligent agriculture applications, services, and sensors (Ayaz et al. 2019); and used specifically for agriculture planting and management monitoring, irrigation, fertilizer and yield management services, and plants and agriculture environmental monitoring (Doshi et al. 2019).
Blockchain	They were used as the public ledger for transactions, first invented by Satoshi Nakamoto's pseudonym in 2008.	They are referred to as distributed ledger technology, storing distributed databases across the whole computer system or among participating parties.	Used in agriculture insurance, food supply chain, smart farming, and E-commerce of agricultural products (Xiong et al. 2020); and used in the agribusiness sector, helping to promote more excellent reliability and agility in information with a reduced cost (Rocha et al. 2021).
Big data	Coined by Roger Mougalas from O'Reilly Media in 2005, it referred to as a large set of data with impossibility to harness traditional business intelligence tools.	Large amounts of digital datasets are generated from digital sources requiring advanced computer storage and analysis technologies.	Provides predictive insights in farming operations, drives real-time operational decisions, redesigns business processes for game-changing business models (Wolfert et al. 2017), recasts conventional process-driven agriculture, and plots the course for more innovative and data-driven farming (Lioutas et al. 2019).
Smartphone	They were discovered in 1994 as IBMs Simon (the first smartphone) featured with apps and touch-screening.	Highly advanced features that are combined with mobile phone and connected with internet.	Integrated with camera and GPS as a sensor for farming management, extension services, and information systems (Pongnumkul et al. 2019); and specifically used to inform decision making for sustainable fertilizer management (Golicz et al. 2021).
Uncrewed aerial vehicle (UAV)	Invented in 1917 by Elmer Sperry, Peter Cooper Hewitt, Josephus Daniels, and Glenn Curtiss to provide the Navy with its first uncrewed aircraft, the aerial torpedo. Founded later in the 1970s by Abraham Karem (known as the Drone Father) in the form of UAV (drone) technology.	An aircraft without human onboard operators run remotely by a human operator or autonomously by an onboard computer.	Used in precision agriculture to spray the pesticides to avoid the health problems of humans (Mogili et al. 2019); and used to count the plants, nutrient applicator sprayer, mapping, and normalized difference vegetation index plant health indexing (Norasma et al. 2019).
Digital employees or workspace	He was introduced by Paul Miller in his book “Digital Workplace: How Technology is Liberating Work” in 2012; and promoted in 2009 by John Mcconnell as a “web office,"	A team of automated employees or workers with digital skills who are in the form of robots trained to perform tasks equivalent to physical employees/workers	Provide quick, reliable, and secure access to agriculture data from customers via multiple devices to reduce the times used for searching information and improving the agriculture system.

	"online office," and "web workplace" via his intranet session.		
Virtual reality	Invented in 1957 by Morton Heilig with the name of Sensorama, a multimedia device made from virtual reality technology, and in 1987, the term 'virtual reality' was coined by Jaron Lanier.	The computer-based simulation enables a person to interact with an artificial three-dimensional environment synthetically or virtually.	Used for virtual agriculture research to reduce experiment costs, shorten the research time, get visualized process and experiment (Li 2008); and applied for agriculture scientific research and teaching, goods circulation, and agricultural machinery design and manufacturing (Yu et al. 2010).
Augmented reality	Coined by Tom Caudell and David Mizell in 1990 for its terminology; and in 1957, Sensorama, which could deliver visuals, sounds, vibration, and smell to the viewer, was created by Morton Heilig in 1957.	Real-world objects, which are enhanced by superimposing computer-generated information.	Contributes to the optimum management of agriculture farms, including water quality management, remote collaboration, and boardroom discussion (Xi et al. 2018); and is used to improve rural emergency response by providing an up-to-date view of on-farm hazard information (Weichelt et al. 2018).
Robotics	Built by Al-Jazari in 1206 for a programmable humanoid robot and coined by Isaac Asimov in 1941 for a word of "robotics." In 1956, Joseph Endgelberger and George D. Devol were responsible for the birth of the robotics industry.	A technology acquired from a multidisciplinary field of science and engineering with the primary producers of robots that can substitute for or assist human actions.	Used for land preparation before planting, sowing/planting, plant treatment, harvesting and yield estimation, and phenotyping (Oliveira et al. 2021); and has the potential to take off a load of labor shortage and increase productivity (Kushwaha et al. 2016).
Automation	They are coined its terminology at the Ford Motor Company by D.S. More complex in 1946 to describe the increased use of automatic devices and controls.	Technologies that are produced to operate automatically with minimizing human interventions.	They are utilized in the agriculture maintenance, control of insecticides and pesticides, water management, and crop monitoring (Puranik et al. 2019); and used in field machinery, irrigation systems, greenhouse automation, animal automation systems, and automation of fruit production systems (Edan et al. 2009).
3D printing	It was introduced in 1984 within a patent filed by Charles Hull on stereolithography.	A process to create or manufacture three-dimensional objects from materials being added together with the assistance of a computer.	Provides an engineering solution for customized food design and personalized nutrition control, a prototyping tool to facilitate new food product development, and a potential machine to reconfigure a customized food supply chain (Sun et al. 2019); and used as a soilless cultivation substrate for hydrogels 3D printed with incorporating microorganisms (Kalossaka et al. 2021).

4.2.3 Studies progress on digital technologies use in Indonesia

4.2.3.1 Map distribution of digital agriculture technologies

Figure 9 shows a map of digital technologies studies that were conducted in Indonesia. All the studies extracted from publications are documented in Supplementary Data 1. In this study, some parameters were identified, including digital technology distribution and studies language used. An online interactive map of this study is also available at https://agriculture40studies.gis.co.id/. The map details some parameters that can become a reference for the users or readers. Figure 9 shows that most of the digital agriculture studies concentrated in Java island, and Sumatera island, Sulawesi island, and Kalimantan island were evenly scattered. However, Papua island had a minimal number of studies. Most of the studies published in journals, scientific articles, working papers, and other grey literature were produced by universities and research-based institutions. This study noted that these institutions were very active in researching the use and progress of digital technologies for Indonesia's food and agriculture sector. The activeness of these institutions are presumably due to 1) one of the leading research topics, 2) availability of support (government policy/mandate, finance, technical, and other assistance) from internal and external institutions, 3) up-to-date and novel research concern, 4) the tremendous benefits of digital technologies for agriculture, and 4) unpredictable and urgent situations especially during the Covid-19 pandemic (this part will be discussed in sub-chapter 3.3.3).

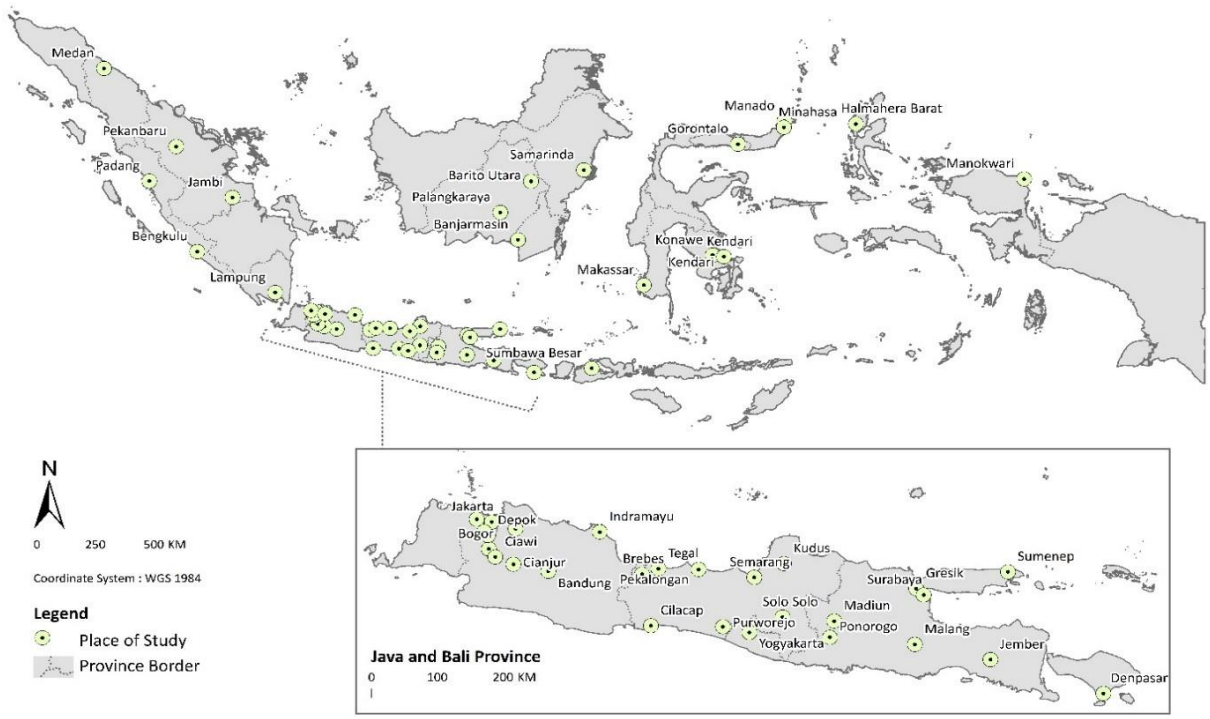
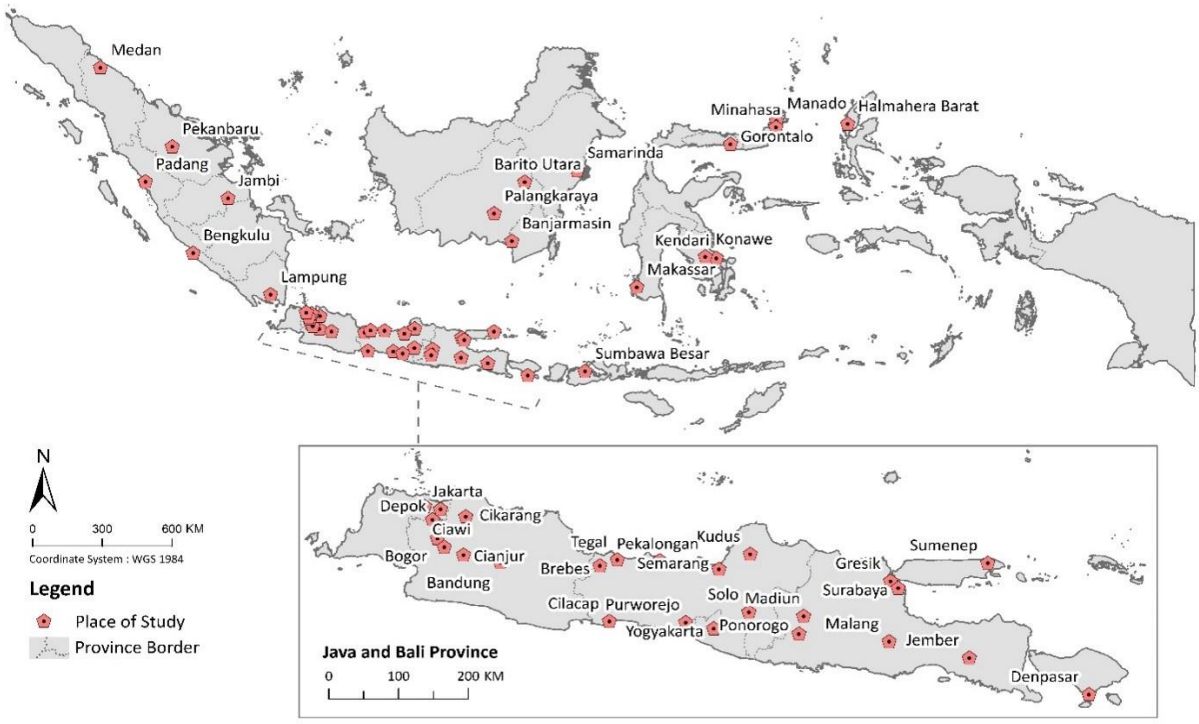
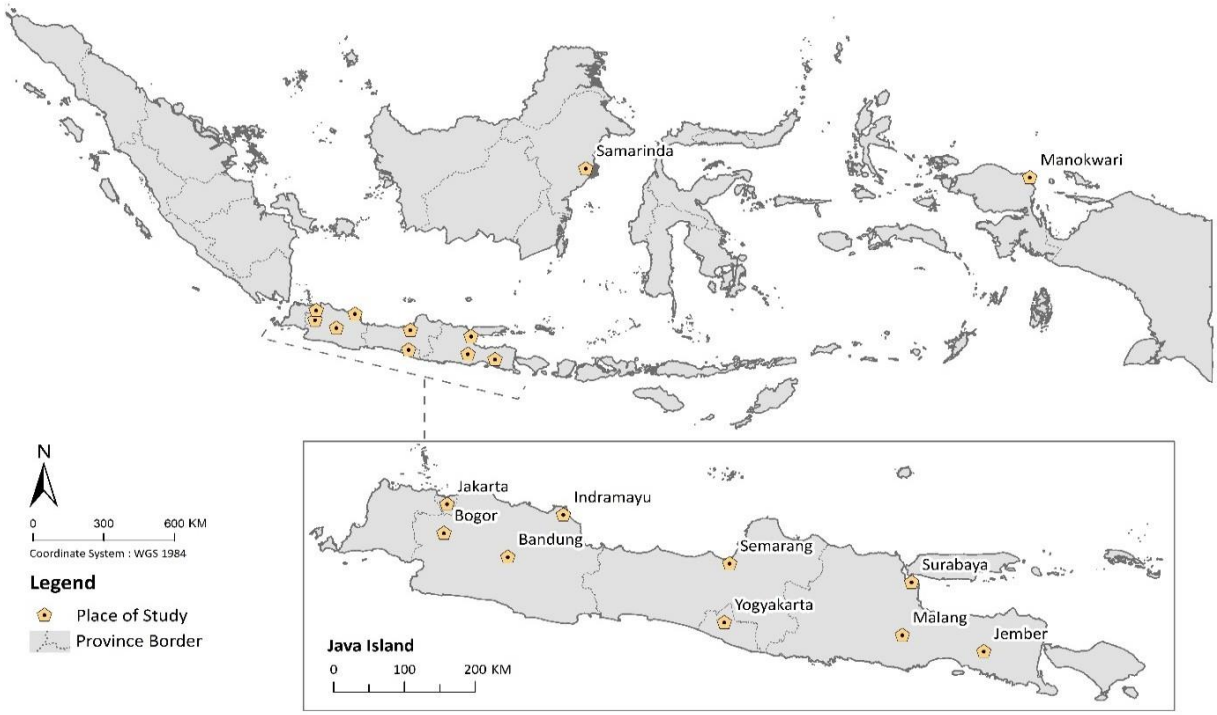


Figure 9. Distribution of digital agriculture technology studies

In this study, the research can be primarily a baseline or a starting point for applying digital technologies in sub-agriculture sectors, such as crops, fishery, forestry, and livestock. In addition, the research can be room for improvement of digital technologies that have been already utilized. For instance, Go-Tani apps-based Android was developed as an agriculture extension platform in Blanco.



(a)



(b)

Figure 10. Map of languages used for digital agriculture technology studies: a) Bahasa Indonesia and b) English

Timur district and these apps were used to provide credible and factual information to address farmers' problems (Yasin et al., 2019). Purwakarta government has also applied an automated teller machine rice (E-perelek) to provide effective and efficient access to perelek rice by the public (Fitriah et al. 2020). A study reported by Hasdar et al. (2019) targeted beneficiaries from Agrofood Technopreneur Programme succeeded in providing online training for smallholder farmers to promote their agriculture products in Bukalapak, Shopee, Tokopedia, and Google My Business.

Languages that were dominantly used for publications are Bahasa Indonesia, and it is minimal to find publications in English. Maps of language types used for digital agriculture technology studies are presented in Figure 10. Similar to the studies distribution, based on the languages, most of the studies were carried out in Java island than other Indonesia islands. Digital agriculture studies, which were preferably published in Bahasa Indonesia, are presumably because of 1) ease of communications among Indonesia researchers in different geographical conditions, 2) limited access and proficiency lack of researchers in harnessing English, and 3) many available national journal publishers accomodating digital agriculture technology studies publication.

4.2.3.2 Types and uses of studied digital agriculture technologies

From this study, major digital technology types are studied, such as websites, IoT, AI, big data, Global Positioning System (GPS), Geographical Information System (GIS), and robotics. Maps of these digital technology distributions are presented in Supplementary Data 2. Referring to Supplementary 2, this study shows that these technologies were primarily studied in Java island for specific purposes. Of these technologies, IoT is the most studied application for the food and agriculture sector, and it is followed by GPS and GIS, website, AI, big data, and robotics. IoT, AI, and big data belonging to new and advanced technologies are considered dominantly studied in Indonesia because of their excellent potentials that can be applied for intelligent farming, precision farming, and digital farming. In addition, these technologies can be integrated with other digital technologies, such as sensors, smartphones, and other machine controllers, to manage the agriculture sector skillfully.

Besides these technologies, this study also identifies some digital technologies that were limitedly studied, such as drones, cloud computing, blockchain, 3D printing, augmented reality, nanotechnology-based electronics, and advanced analytics. These technologies are considered very novel and need specific expertise to understand how these technologies work. Table 3 shows the uses of studied digital agriculture technologies in Indonesia.

Table 3. Uses of studied digital technologies in Indonesia

Name of digital technology	Features	Utilizations
IoT	Integrated with smartphone/android, other digital technologies for innovative and precision farming	To increase the level of accuracy in predicting total harvest and production capacity; to monitor and control agriculture activities, such as water, humidity, temperature; to improve agriculture quality and quantity; and to provide benefits on the attainment of smart and precision farming.
GPS/GIS	Integrated with android, smartphone, and or a mobile phone; and these technologies are compromised.	To support precision farming within monitoring agriculture land, plants healths, agricultural land area, rice plants growth; and predicting harvests, soils, and drought; and to provide data mapping, location analysis, and proximity analysis for the agriculture sector.
Website	Web e-commerce, GIS digital web (web map), and web-based apps	To provide a platform for promoting/marketing food and agriculture products; to provide a digital map of agricultural lands and crops area; to monitor and evaluate agriculture activities, and to provide data and information for farmers and customers
AI	Supply-demand analysis; intelligent decision support; and integrated with a smartphone, android, IoT, mobile phone, and sensor	To support the development of precision/smart farming through e-commerce, e-trading, e-logistics, and fintech; to improve accuracy and quality in supply chain and data management, market access, digital financial services, digital information, and precision agriculture.
Big data	Integrated with social media, sensors, smartphones, mobile	To extract data from generating agriculture activities, provide information or data beneficial for agriculture

	phones, apps, and other digital technologies	decision-making, and support innovative and precision agriculture systems.
Robotics	Integrated with an automated system, agriculture machines, apps, mobile or smartphone, and other digital devices	To support farmers in the agriculture management systems, such as planting, weeding, irrigation, fertilizing, and harvesting.
Social media	Whatsapp, Twitter, Facebook, YouTube, and Instagram	To provide an online platform for products promotion, marketing, and customer reaching; and to provide information, data, and capacity building activities for farmers (training, education, entrepreneurship hubs)
Drone	Integrated with WiFi, smartphone, mobile phone, camera, digital map, and tablets	To assist farmers in pesticide spraying control, plant health surveillance, plant growth monitoring, and pest and diseases identification; and provide agriculture-based mappings, such as land mapping, crop area, and harvested lands.
Cloud computing	Integrated with other digital technologies (big data, IoT, AI), smartphone or mobile phone, sensors, and satellite	To support the development of intelligent farming by collecting data from other agriculture sources/devices and providing data and information for farmers that will guide decision-making.
Blockchain	Integrated with IoT, big data, AI, cloud, smartphone or mobile phone, and mobile apps	To enhance traceability and transparency in food and agriculture supply chain used for off-farm modern agriculture and smart farming
3D printing	It is integrated with the computer, internet, and molding machine, and smartphone.	To replace perishable machines or devices that support farmers or fishers in carrying out agriculture activities and help conserve agriculture products such as earthenware and pot.
Augmented reality	Integrated with a smartphone, android, apps, e-learning, GPS, Google Maps, and other digital technologies (big data, AI)	To provide visualization of agriculture products (crops, vegetables, fruit); to provide assistance in e-learning and e-library for agriculturists; and monitor plant media for hydroponics.

From this study, most advanced digital technologies are studied to explore their potential for supporting the development of smart farming, precision farming, and or digital farming. These concepts are sometimes referred to as decision agriculture and agriculture 4.0. According to Pivoto et al. (2018), smart farming incorporates information and communication technologies into machinery, equipment, and sensors in agricultural production systems, ultimately used for decision making. Smart farming relies on intelligent means to extract and gather data from various farm operations for agricultural decision-making. Technologies used for smart farming are such as big data, cloud computing, AI, and IoT. In a study by Rains et al. (2009), precision farming is defined as a management practice that can increase profits by utilizing more precise information about agricultural resources. This term tends to focus on optimizing agriculture inputs (fertilizer, pesticides, water) precisely to gain more profits. Technologies sometimes used for precision farming are GIS, GPS, sensors, variable rate technology (VRT), and yield monitoring (Y.M.). The terminology of digital farming is much broader because it is a practice of modern technologies, which combines smart farming and precision farming.

4.2.3.3 Relation of digital agriculture technologies and Covid-19 pandemic

Figure 11 shows the study's map on digital agriculture technologies that are related to the Covid-19. That figure highlights that digital agriculture technology studies relevant to the Covid-19 pandemic are distributed in Java, Sumatra, Sulawesi, and Kalimantan island. Most of the studies are concentrated in Java island, but the studies are not found on Papua island.

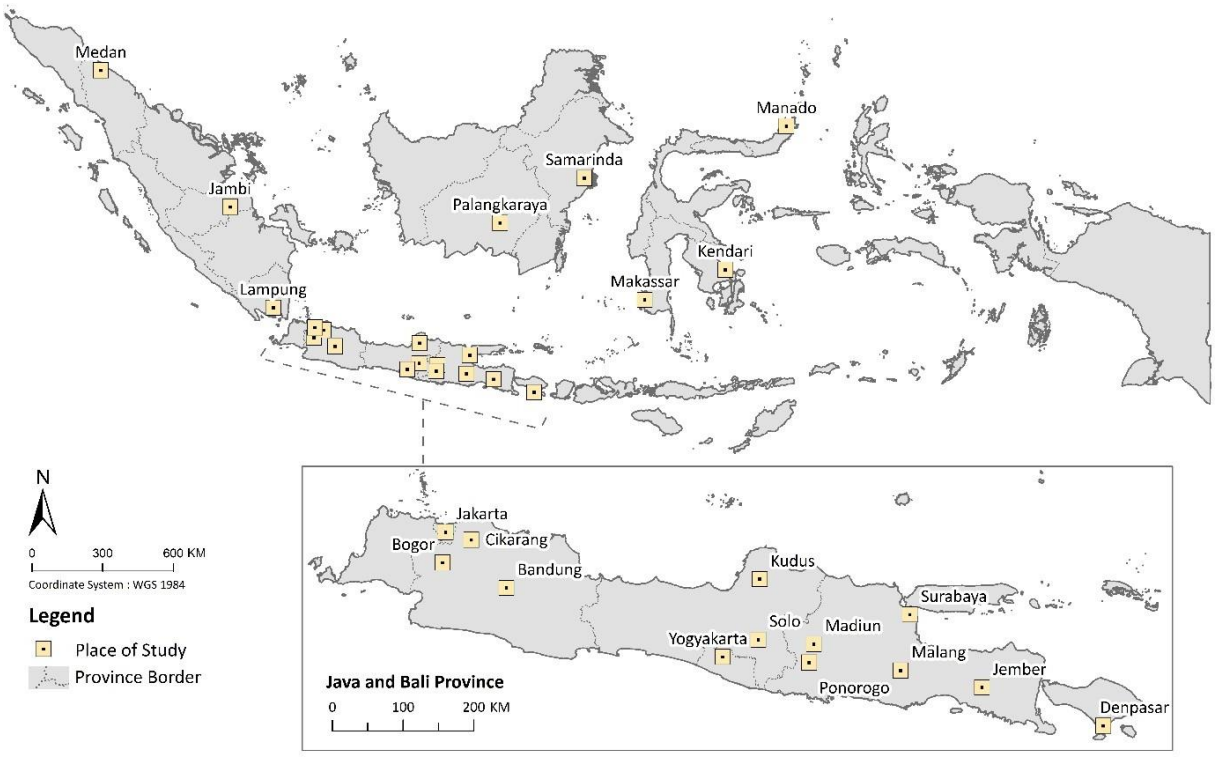


Figure 11. Studies distribution on Covid-19 pandemic - related digital agriculture technologies

From this study, it is well-noted that the Covid-19 pandemic has disrupted Indonesia's food and agriculture value chain, and the disruption has generated both positive and negative impacts for the practices of digital agriculture technologies. Regarding adverse effects, the pandemic has challenged the implementation of digital agriculture technology activities, such as digital monitoring and auditing system for administrative regards in the Indonesia Ministry of Agriculture (Latifah 2020). In terms of positive effects, the pandemic has accelerated the implementation of Agriculture 4.0 and has urged small-sized medium enterprises (SMEs), millennials, and university students to discover innovations and research related to digital agriculture technology practices (Gandasari 2020, Sondakh et al. 2020, Rapitasari 2021). Digital apps were also recently discovered, such as Amouras (Latifah et al. 2020) and Takesi (Gandasari 2020). During the pandemic, agriculture producers and consumers of agriculture products have shifted their mindset to benefit social media (Chaerani et al. 2020) and to harness online platforms for marketings and e-marketplaces, such as Shopee, Tokopedia, Lazada, Bukalapak, Blibli, Sayurbox, TaniHub, and Kecipir (Vinolina 2020, Ibrahim et al. 2021). With the presence of the pandemic, new regulations to support the application of digital agriculture technologies were issued. For instance, STRANDS

KA: National Strategy for Artificial Intelligence 2020-2045 has envisaged food security as a significant area for A. I development.

4.2.4 Digital agriculture strategies

Mainstreaming digital agriculture in a national food and agriculture policies agenda and plan is one of the best strategies to create opportunities for sustainable development and inclusive growth during the pandemic. Table 4 shows agro-food strategies in Indonesia that mainstream the Covid-19 in agri-food 4.0. The GoI has arranged strategies for digital transformation with and without mainstreaming the food and agriculture sector. These strategies can be a national initiative, policy, vision, and plan to place the fourth industrial revolution (4IR) in specific economic development sectors, especially food and agriculture. All these strategies have included the food and agriculture sector in their strategic activities or policies agenda but only one digital strategy that did not include the sector: Presidential Regulation No. 95 the Year 2018 on Electronic-Based Government System (SPBE). In addition, not all these strategies have integrated and directly interlinked digital technologies with the food and agriculture sector, such as National Industrial Development Master Plan 2015–2035; National Research Master Plan 2017-2045; Indonesia 2045: Berdaulat, Maju, Adil, dan Makmur (Sovereign, Progressive, Fair, and Prosperous); National Medium-Term Development Plan (RPJMN IV) 2020-2024; and Law of the Republic of Indonesia No. 11 of 2020 on Job Creation (Omnibus Law on Job Creation).

Some strategies that have embodied digital agriculture technologies are such as 1) National Movement of 1000 Digital Startups: The Digital Energy of Asia; 2) Presidential Regulation No. 74 the Year 2017 on Road Map of the National Electronic-Based Trading System (e-Commerce Road Map) 2017-2019; 3) Making Indonesia 4.0 (Toward 2030); 4) President Regulation No. 39 the Year 2019 on One Data Initiative (Satu Data Indonesia); 5) STRANDS KA: National Strategy for Artificial Intelligence 2020-2045; 6) Ministry of Agriculture Regulation No. 4 the Year 2019 on Guidelines for Agricultural Human Resources Development Movement Towards World Food Barns 2045; 7) Ministry of Agriculture Regulation No. 16 the Year.

Table 4. Indonesia digital agriculture policies and initiatives

Name of Strategies	Type of strategies	Content	Responsible stakeholders	Food and agriculture issues	Information related to Covid-19		
					Pre-Covid	Covid-19	Past-Covid
National Industrial Development Master Plan 2015 - 2035	National plan (The Indonesian government has issued Government Regulation No. 14 the Year 2015 concerning Master Plan of National Industry Development (Rencana Induk Pembangunan Industri Nasional/RIPIN) Year 2015-2035. RIP is drafted to fulfill the mandate of Law No. 3 the Year 2014 concerning Industry, in line with RPJMN 2015-2019)	This master plan is assigned with the Governmental Regulation No. 14 the Year 2015 and is arranged as the mandate implementation of Law No. 3 the Year 2014 about Industry. This master plan guides government and industrial actors in planning and developing industries in Indonesia for the next twenty years.	Leading actor: Ministry of Industry. Supporting actors: Indonesian Chamber of Commerce and Industry, relevant institutions, industry actors, and universities.	The food and upstream agriculture industry became the mainstay industry prioritized under the national plan. However, in the plan, the industry has not yet been connected with digital technologies. Digital technologies are connected directly with manufacturers of electronic and ICT; and manufacturers of capital goods, components, supplementary materials, and services.	This master plan was adopted in June 2015 and has not yet considered the covid-19 pandemic.	N/A	N/A
National Movement of 1000 Digital Startups: The Digital Energy of Asia	National initiative	This program is an early-stage digital start-up development program, facilitating participants to network and form a team and get assistance. As of 05 July 2021, this initiative has engaged more than 1,160 startups in 20 cities, and the info can be seen at https://1000startupdigital.id/beranda/#penggerak.	Leading actor: Ministry of Communication and Information Technology. Other actors: Indonesia startups	The agriculture and fishery sector is included in this initiative with streamlining digital technologies used for their start-up development. Some startups under the sector have been supported at the list of the startups can be seen at this link: https://1000startupdigital.id/beranda/#penggerak.	This initiative was established in 2016, and it is continued to progress. Issue of the covid-19 pandemic has become one of the accelerating factors and challenges of the start-up implementation.	During the covid-19 pandemic, the planned programs are primarily conducted online, such as online YouTube incubation and workshop.	N/A
National Research Master Plan 2017-2045	National plan	This master plan is composed to align long-term research needs with national development related to science and technology from 2017 to 2045.	Leading actor: Ministry of Research, Technology, and Higher Education. Supporting actors: research-based governmental institutions and other ministries	This includes the food or agriculture sector, but the sector is not directly connected with digitalization or digital technology.	This master plan was composed by the Covid-19 pandemic. Food derived from the agriculture sector was included as the primary research focus.	N/A	N/A
Presidential Regulation No. 74 the Year 2017 on Road Map of the National Electronic-Based Trading System (e-Commerce Road Map) 2017-2019	National policy	This regulation rules the acceleration and development of a national electronic-based commerce system (e-commerce). The Roadmap direction and steps of preparing and implementing commercial transactions, based on a range of electronic devices and procedures.	Main actors: Coordinating Ministry for Economy, Ministry of Home Affairs, Ministry of Commerce, Ministry of Cooperatives and Small and Medium Enterprises, Ministry of Transportation, Governor of Bank Indonesia, and Chairman of Board of Commissioners of the Financial Services Agency (OJK). Supporting actors: Financial services authority, venture capital association /angel capital, e-commerce and digital economy association	In the E-commerce Roadmap, logistics system development for rural to urban communities such as farmers and fishers is included.	This regulation and roadmap were effective as of 3 August 2017. However, these did not include the Covid-19 pandemic issue.	N/A	N/A
Making Indonesia 4.0 (Toward 2030)	National initiative	This national initiative provides guidances to implement strategy and road map for 4RI in Indonesia with concern on five industrial sectors and ten national priorities.	Leading actor: Ministry of Industry. Supporting actors: ministries, national and local government, industry associations, research and education institutions, and technology providers.	This includes the food and beverage industry sector, which will be attained its competitiveness at the regional level.	This national initiative was composed before the Covid-19 pandemic and was designed towards 2030. Food and beverage are one of the leading industrial sectors, which will be attained its regional competitiveness.	N/A	N/A

Presidential Regulation No 95 the Year 2018 on Electronic-Based Government System (SPBE)	National policy	This policy regulates the implementation of information security, certification, and audit management system in implementing the Electronic-Based Government System. Digital technologies, which are observed to have the potential to develop in Indonesia, have been included in the Master Plan of the National Electronic-Based Government System.	Main actors: National SPBE Coordination Team. Supporting actors: central agencies, local governments, employees of the State Civil Apparatus, individuals, communities, business actors, and other parties who utilize SPBE services.	Food and agriculture were not mentioned in the regulation and Master Plan. Digital technologies are integrated with the Master Plan, such as mobile internet, internet of things, cloud computing, extensive data analysis, and artificial intelligence.	This regulation was issued and legislated in October 2018, and these happened before the Covid-19 pandemic. The food and agriculture sector was not mentioned in the regulation and master plan of SPBE, but digital technologies were planned to develop in Indonesia.	N/A	N/A
Indonesia 2045: Berdaulat, Maju, Adil, dan Makmur (Sovereign, Progressive, Fair, and Prosperous)	National vision	This vision is a picture and roadmap of Indonesia, which will be achieved by 2045. This vision consists of four pillars, including (1) Human Development and Mastery of Science Knowledge and Technology, (2) Sustainable Economic Development, (3) Equitable Development, and (4) Consolidating National Resilience and Governance.	Leading Actor: Ministry of National Development Planning. Supporting actors: all policymakers in the executive, judicial, and legislative circles; higher education; young generation; as well as various professional institutions	This includes food security and farmers' welfare, and the sector is under pillar 2: Sustainable Economic Development. However, the sector is not directly interlinked with digital technology. In this vision, digital technology is interconnected with industry and creative economy (Pillar 2) and infrastructure development and equity (Pillar 3).	N/A	This master plan was signed by the Indonesian president in May 2019, and it was identified during the Covid-19 pandemic occurring in Indonesia. However, the pandemic issue was not integrated with the plan.	N/A
National Medium-Term Development Plan (RPJMN IV) 2020-2024	National plan (It is also set with President Regulation No. 18 the Year 2020 on 27 January 2020 about National Medium-Term Development Plan (RPJMN IV) 2020-2024)	This planning document is made for a 5-year program from 2020 to 2024, which describes the Indonesian President's vision, mission, and programs after the general election of 2019. This document is the last step of the National Long-Term Development Plan 2005-2025, consisting of 4 pillars and seven agendas.	Leading actor: Ministry of National Development Planning. Supporting actors: ministries/governmental bodies at the national and local level, other institutions, public-private sectors, and Indonesian citizens.	Food and agriculture are incorporated into development agenda No. 1 of RPJMN IV Year 2020 - 2024 (Strengthening Economic Resilience for Quality Growth). This sector is not directly interlinked with digital technology.	Digital transformation for 4IR was subjected to this national strategy in the Macro-Economic Framework 2020-2024 and Mainstreaming RPJMN IV 2020-2024. Digitalisation also has been integrated into the development agenda of the RPJMN IV 2020-2024. However, this strategy was adopted on 14 August 2019 without mentioning the Covid-19 pandemic.	N/A	N/A
President Regulation No. 39 the Year 2019 on One Data Initiative (Satu Data Indonesia)	National policy	This regulation controls the implementation of One Data Initiative with several regulated principles: meeting data standards, having metadata, complying with data interoperability rules, and using reference codes and master data. This regulation did not mention digital technologies use, but the Initiative has an essential role in digital transformation development, especially during a pandemic.	Main actors: Executive Office of the President and Ministry of National Development Planning. Supporting actors: designated national and local government.	The One Data Initiative is designed to provide an online sharing knowledge platform for communication and coordination. This platform is still in development and can be accessed at https://data.go.id/. Food and agriculture data have been integrated with the portal.	This regulation was issued on 12 June 2019, and the regulation did not mention the Covid-19 pandemic and food and agriculture sector. However, in the progressed portal of the initiative, Covid-19 information, food, and agriculture data have been provided the portal.	Data on food and agriculture have been updated on the website of One Data Initiative. The government also still progresses the development of the initiative.	Data on food and agriculture have been updated on the website of One Data Initiative. The government also still progresses the development of the initiative.

STRANDS KA: National Strategy for Artificial Intelligence 2020-2045	National plan	This national policy direction consists of focus areas and priority areas of artificial intelligence (AI) technology, and this direction contains food security as one of the AI main areas.	Leading actor: Agency for the Assessment and Application of Technology (BPPT); Supporting actors: ministries, research institutions, universities, national to local government, and other stakeholders	This includes food security as one of the AI main areas	N/A	This strategy has included health, research, and education activities and bureaucracy reformation to address the Covid-19 pandemic.	This strategy has adapted the New Normal for the Covid-19 pandemic.
Law of the Republic of Indonesia No. 11 of 2020 on Job Creation (Omnibus Law on Job Creation)	National policy	This law regulates labor regulations, simplification of permits, investment requirements, and government administration. Digitalization is also incorporated in some articles of the law.	Leading actor: People's Representative Council. Supporting actors: ministries, industries, and investors.	This law has mentioned digital technology and industry revolution 4.0 for SMEs development, broadcasting, and land use. The food and agriculture sector is not directly connected with digital technologies.	N/A	This law was issued on 03 November 2020. However, the Covid-19 did not become a global issue for the development of this law. Food and agriculture became the primary sector of discussion of this law but did not connect directly with digitalization.	N/A
Ministry of Agriculture Regulation No. 4 the Year 2019 on Guidelines for Agricultural Human Resources Development Movement Towards World Food Barns 2045	National policy	This regulation rules the Development Movement of Agriculture Human Resources Towards World Food Barns 2045, which aims to improve the capacities and competencies of human resources. Digital technologies are one of the characters needed by millennial farmers who support the implementation of the Movement.	Leading actor: Ministry of Agriculture. Supporting actors: young people, farmers, agro-based institutions, and agriculture industries.	This regulation placed young people with an age range between 19 to 39 as leading human resource / millennial farmers for the implementation of the Movement, and they are required to be adaptive with digital technology use.	This regulation was issued on 10 January 2019, and this integrated millennial farmers who have digital technologies knowledge and skills as pivotal actors for the Movement.	N/A	N/A
Ministry of Agriculture Regulation No. 16 the Year 2013 on Guidelines for Agricultural Extension Information Management System in Ministry of Agriculture	National policy	This regulation provides a reference and guidelines for the Management Information Systems and Agricultural Extension operational standards in the Ministry of Agriculture.	Leading actor: Ministry of Agriculture. Supporting actors: cyber extension actors at the national to a local level	The Guidelines provide online platforms, such as cyber extension, agricultural extension workforce information system program (Simluh), and farmer and farmer group information system (Simpoktan).	This regulation was stipulated on 25 February 2013, and a digital technology example, cyber extension, was introduced in the Guidelines. The cyber extension is an agricultural extension information system through internet media to support the provision of agricultural extension materials and information for extension workers. This system might still be applied during and after the pandemic.	N/A	N/A
Decree of Ministry of Agriculture No. 259 the Year 2020 on Ministry of Agriculture Strategic Plan 2020-2024.	National policy	This strategic plan delights a medium-term strategic planning document of the Ministry of Agriculture for 5 (five) years starting from 2020 to 2024.	Leading actor: Ministry of Agriculture. Supporting actors: ministries and other agriculture agencies under the Ministry of Agriculture.	This strategic plan promotes digital transformation in the era of industry 4.0 in the agriculture sector, especially in information systems. Technologies used are such as Big Data, IoT, AI, and so forth.	N/A	This plan was adopted on 04 Mei 2020 during the Covid-19 pandemic. However, the pandemic has not yet been highlighted in the Guidelines and has not yet interlinked with digital technologies use and acceleration.	N/A

Two thousand thirteen on Guidelines for Agricultural Extension Information Management System in Ministry of Agriculture; and 8) Decree of Ministry of Agriculture No. 259 the Year 2020 on Ministry of Agriculture Strategic Plan 2020-2024.

In these strategies, digital agriculture transformation identified is digital agriculture startups, industry, and e-commerce development; online data platform for agriculture information; digital technologies (AI, IoT, big data) integration; cyber extension and agriculture exchange platform; and millennials empowerment for agriculture development. For operating these activities, prominent actors who are involved include the Ministry of Agriculture and Ministry of Industry but inter-ministerial and multi-stakeholders coordination is necessarily needed, such as Ministry of National Development Planning, Coordinating Minister for Economy, Minister of Home Affairs, Minister of Commerce, Minister of Cooperatives and Small and Medium Enterprises, and Minister of Transportation. In the agriculture sector, it is noted that Regulation No. 16 the Year 2013 on Guidelines for Agricultural Extension Information Management System in the Ministry of Agriculture was issued by the Indonesian Ministry of Agriculture to provide guidelines on the use of online platforms, such as cyber extension, Simluh, and Simpoktan. Afterward, two national policies and a national plan were adopted to apply digital agriculture technologies in the ground.

The GoI has also opened opportunities to develop agriculture 4.0 into practices through the National Movement of 1000 Digital Startups, Making Indonesia 4.0, and One Data Initiatives with support from these policies and plans. The opportunities also provide millennials, for instance, to develop their own business, entrepreneur, or startups. This is also supported with data from the World Economic Forum (2019), reporting that In Indonesia, 35.5% of the share of youths in Indonesia aspire to be an entrepreneur. However, within implementing digital agriculture into practices, the GoI is suggested to consider the existing challenges, such as labor alteration, data protection, and cybersecurity, digital divide issues, digital education and capacity building development, integration of digital technologies research and practices, sustainable mechanism for digital actualization, and public and private partnership. These challenges are also identified by Soeparna et al.'s (2018) study, stating some hurdles in implementing IoT for e-agribusiness, namely, security issues, data privacy, devices complexity, costly devices, and skilled human resources. The digital divide is also considered a significant issue as using digital technologies in Indonesia, mainly because of the Indonesian demographic, having more than 18,000 islands with different equality to access and use the technologies. About 50% of forest farmers in Gunungkidul Yogyakarta, for example, had a high level of the digital divide, and only farmers with high educational levels and income could utilize digital devices optimally to meet their lifestyle needs (Dewinta et al. 2019).

4.2.5 Digital agriculture practices

Research and innovation in digital agriculture need to be applied into practices with support from the GoI strategies (initiatives, national plans, and policies), as highlighted in Table 3. In Indonesia, there are digital agriculture-based companies (startups, businesses, industries, and SMEs) established to support the development of agriculture 4.0. An

interactive map was successfully developed from this study and can be accessed at this link: https://agriculture40companies.gis.co.id/. That map consists of the distribution of digital agriculture companies, name of companies, location of companies, brief information, types of digital technologies used, year of establishment, and references. That map is handy for providing information on how far digital technologies (types and utilization) have been developed and applied in Indonesia's food and agriculture sector.

Besides that map, a thematic map was also made, as seen in Figure 12. This study shows that most of the digital agriculture companies are concentrated in Java island and followed in Sumatera island. Other islands (Kalimantan, Sulawesi, and Papua) are not found to find the companies, although they can reach these islands through the internet for their services and products marketing. For instance, food delivery services from Gojek (GoFood) and Grab (GrabFood) have been widely used in Kalimantan, Sulawesi, and Papua. Even during the pandemic, these unicorns' apps have benefited as an online food delivery for MSMEs players and consumers. The apps can be used to enhance MSMEs' performance and can be an alternative media for transactions to maintain and improve continuity during the pandemic (Nurlinda et al., 2021). Furthermore, it can be seen that the food delivery demand of these start-up unicorns increased about 10% for their services (Candra et al., 2021). During the implementation of social restriction, TaniHub and Sayurbox also recorded a three-fold increase in transactions. To maintain the availability of food products marketed during the pandemic, these startups developed several methods, such as planting program, 1000 farmers cooperation, farmers support (funding, technical assistance, and profit and loss calculation).

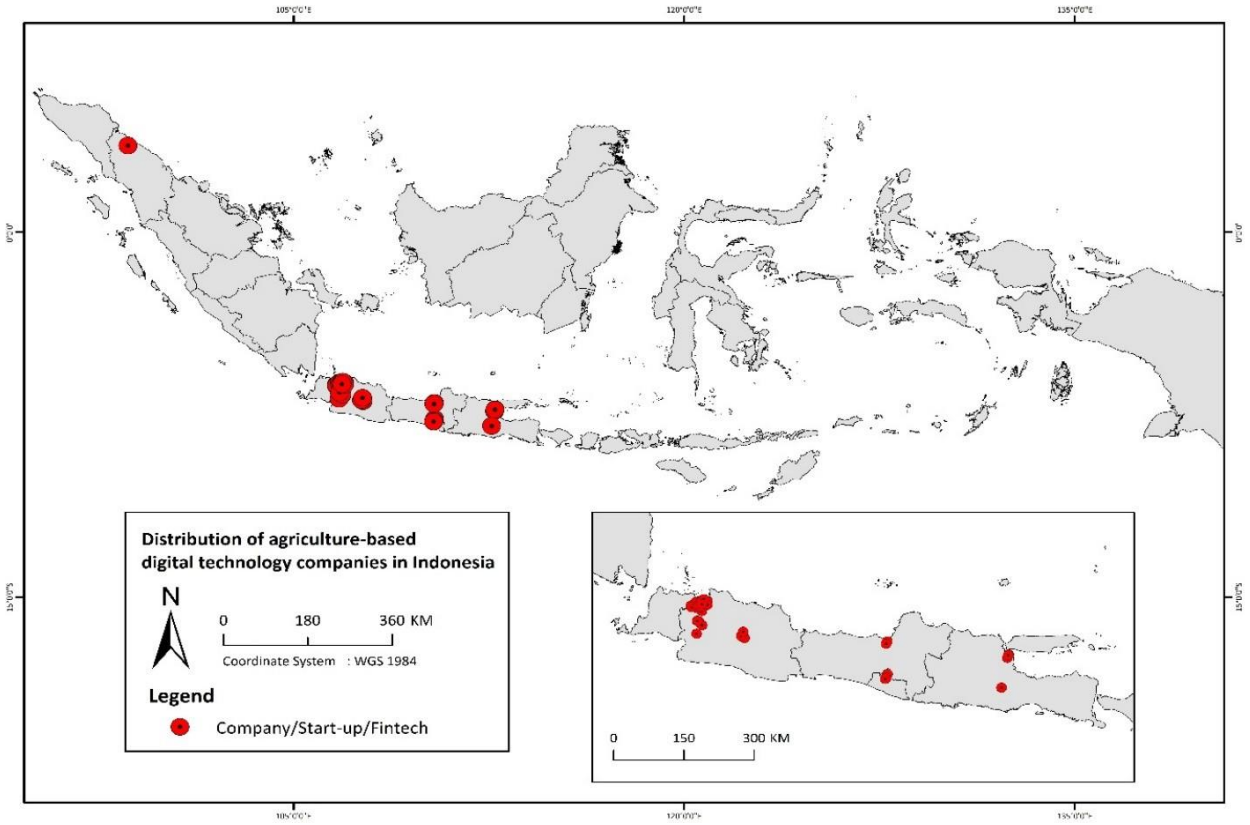


Figure 12. Distribution of digital agriculture companies

The identified companies harness digital technologies for e-commerce, farmers advisory, mechanization platforms, digital marketplace, traceability, food delivery, and peer-to-peer lending (Table 5 and Supporting Data 2). Examples of digital technology use in certain companies are summarized in Table 5. These companies are primarily headquartered in Java Island, although some digital technology features, such as mobile apps, iOS platforms, and smartphones, can be accessed in other Indonesia's islands.

Table 5. Examples of digital agro-food companies in Indonesia

Name of company	Digital technology used	Types of company	Brief information of the company
Gojek (GoFood), Grab (GrabFood), Traveloka (Traveloka Eats) and Shopee (ShopeeFood)	Artificial intelligence, and IoT-enabled GPS, smartphone (apps)	Food delivery services	These companies are a food delivery online platform allowing consumers to order, choose, and deliver food from specific restaurants/shops/markets through a smartphone without the direct presence of the consumers.
Warung Pangan and Shopify (Food and Beverages E-commerce)	Mobile apps, website, and cloud	E-commerce	These e-commerces facilitate suppliers, farmers, millennial farmers, entrepreneurs, and individuals who work for the food and agriculture sector to market their agriculture commodities and produces through the website or other electronic platforms.
TaniHub, Chilibeli, Agromaret, Rarali.com, and Eden Farm	Artificial intelligence, cloud computing, mobile apps and android, iOS platform, and website	Digital marketplace / e-marketplace	These online marketplaces provide an easy transaction process through digital technology features for trading agriculture commodities (fruit, vegetables, machines/infrastructures, and services) with connecting farmers and producers to retailers, wholesalers, and individual customers.
eFishery, KARSA, NeuraFarm, and Biopsy Agrotekno (Encomotion)	IoT, smartphone, mobile apps, artificial intelligence, drone, and satellite	Farmer advisory	These startups provide solutions and services for farmers and farming companies based on innovative and precision agriculture intended to increase agriculture productivity and efficiency and provide recommendations for policy decision-makers (at the governmental level).
TaniFund, Crowde, iGrow, Tanijoy, Mekar, iTernak,and Eragano	Website, smartphone, mobile apps, IoT, and blockchain	Peer-to-peer lending	This lending platform provides financial support for Indonesia's farmers by connecting them with investors.
HARA, Koltiva, and MSMB Indonesia	Big data, artificial intelligence, blockchain, GIS, IoT, mobile software apps,	Traceability	These startups provide valuable data and services for farmers or related stakeholders in making

	and cloud-based website		decisions and guidances for agriculture development.
PanenID, AgroDrone, and Agrito	GIS, drone, and IoT	Mechanization and automation services	These start-up companies provide products and or services for agriculture mechanization and automation.

Table 5 also shows that these start-up companies have utilized one or more digital technologies integrated each, such as big data, artificial intelligence, GIS, GPS, drone, IoT, cloud computing, blockchain, mobile apps, smartphone, and satellite. In addition, the digital marketplace is the most dominated field for start-up companies in Indonesia, followed by peer-to-peer lending and farm advisory. In this particular issue, the Financial Services Authority (OJK) issued Regulation No. 77/POJK.01/2016 about information-technology-based money lending services and the enactment is purposed to boost the lending services' growth and create a new financing alternative for the public. As of 10 June 2021, 125 peer-to-peer lending companies are registered under OJK; and in the agro-food sector, TaniFund, Crowded, iGrow, Mekar, and iTernak were registered.

4.2.6 Covid-19 pandemic implications on Indonesia digital agriculture

The Covid-19 pandemic has altered the development of the food and agriculture sector in Indonesia. This study showed that political strategies had been taken to address the pandemic, as highlighted in Table 3. Limited agro-food-based strategies are identified to address the pandemic, namely: 1) implementation of National Movement of 1000 Digital Startups: The Digital Energy of Asia, 2) Satu Data Indonesia regulated under the President Regulation No. 39 the Year 2019 on One Data Initiative, and 3) STRANDS KA: National Strategy for Artificial Intelligence 2020-2045. The last two strategies have also been confirmed with the presence of the post-pandemic. Most activities of these strategies are changed online rather than face-to-face strategies. In addition, national activities proposed under these strategies are presumably suspended.

Under the National Movement of 1000 Digital Startups, a website was created and accessed at https://1000startupdigital.id/tentang/. As of 16 November 2021, there are more than 1,160 startups, including agro-food start-up companies, in 20 cities; online activities (seminars, workshops, and other capacity-building) are still performed online during the pandemic. According to the Ministry of Communication and Information (2021), the pandemic can create significant momentum in accelerating and developing digital startups. Purbasari et al. (2021) also stated that the GoI encourages SMEs to proactively connect with digital platforms, especially to survive the Covid-19 pandemic. Their study also revealed that the Digital User Citizenship element is still in a relatively weak position during the pandemic. Still, Digital Technology Entrepreneurship and Digital Multisided Platform are in an auspicious position to continuously grow along with the increased digital SMEs and the widened online market base. However, Indonesia's startups have decreased from about 2,400 companies in 2019 to 2,311 companies in 2021 but have still ranked among the world’s five biggest startup centers.

Some of Indonesia's start-up companies have applied strategic measures to address the Covid-19 pandemic, including business model changes, work performance, and behavior management, new digital features addition, brand awareness campaign, organizational changes, and financial arrangements. For instance, according to Google, Tamasek, and Bain&Company (2021), 72% of consumers are more preferable to use digital food delivery service during the pandemic because it is more convenient and easier to use. Gross Merchandise Value (GMV) in the transportation and food sector has experienced double-digit growth since 2020, and it is projected to increase about 25% from 2021 to 2025. Contactless food delivery platforms (GoFood, GrabFood, ShopeFood) are still highly benefited during the pandemic to prevent the transmission of the Covid-19 diseases and avoid human-to-human interactions. Muttaqin et al. (2020) also reported a change in the pattern of work performed by startup companies in running their business so that a group is needed for employees. Pramono et al. (2021) also studied that during the pandemic, start-up behaviors (agility, entrepreneurship capability, business transformation, partially affected start-up performance during the pandemic organizational structure characteristics and had a partial effect on start-up performance. However, leadership technology did not have a significant effect on start-up performance.

Similar to the 1000 Digital Startups Program, The Secretariat of One Data Indonesia also always updates their datasets, particularly on food and agriculture, to the One Data Indonesia portal (https://data.go.id/) during the pandemic and post-pandemic. In STRANAS KA 2020-2045, food security is one of the main targeted areas for AI implementation. The strategy has also adjusted the pandemic and the New Normal era by planning health, research, education, and bureaucracy activities to address the Covid-19 implications.

5. CONCLUSION

Studies of digital agriculture technologies have been developed in Indonesia with focusing on their potential uses and applications. The information and literacy data sub-index in Indonesia is still considered moderate but the lowest than other sub-indexes under the digital literacy index, leading to the importance of digital literacy education. Agriculture universities and Millenials in Indonesia are considered to play an essential role in developing agriculture digital technologies. Studies on digital technologies mainly concentrate on IoT, GPS and GIS, website, AI, big data, and robotics, where IoT is the most studied digital technology for Indonesia's agriculture sector. Java island is still considered the highest producer of digital agriculture studies in Indonesia before and during the Covid-19 pandemic. The pandemic has provided two effects, namely negative and positive impacts. The pandemic has negatively challenged the implementation of digital agriculture technology activities but has benefited farmers, government Millenials, industries, and SMEs in accelerating the implementation of Agriculture 4.0. This study also observed that social media and e-commerces had shifted farmers to market their agriculture produces. The practices have been accelerated to develop, most notably, during the Covid pandemic and the New Normal era. Integrated into companies (MSMEs, industries, and startups), these digital technologies have been used for e-commerce, farmers advisory, mechanization platforms, digital marketplace, traceability, food delivery, and peer-to-peer lending.

However, these companies are primarily headquartered in Java island, and they need to scale up and upscale in other Indonesia's islands to expedite the implementation of agriculture 4.0. The development of startups needs governmental support, which is mainstreamed in the national strategies, including national action plans, policies, initiatives, and vision. However, minimal agro-food-based strategies could accommodate the importance of food and agriculture digitalization during pandemic and post-pandemic. It was also found that most of the strategies contain the issues only pre-pandemic.

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