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THAILAND'S SMART AGRICULTURE AND ITS IMPACTS ON THAI FARMERS: A CASE STUDY OF SMART AGRICULTURE IN AYUTTHAYA, THAILAND

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Abstract

Smart agriculture driven by technologies is one of the agriculture strategies under the 20-year Thailand's national strategy, laid out in 2018, on competitive enhancement strategy which has been developed to achieve value-added agriculture and improve Thai agriculture to meet the global demand and to achieve the Sustainable Development Goals of the United Nations. This study examines Thai agricultural sector's problems by using agriculture sector in Ayutthaya Province as a case study. The study also examines the implementation of the smart agriculture in Ayutthaya Province by focusing on its advantages and disadvantages and offers appropriate solutions for greater development. The data were collected using semi-structure interviews with 18 key informants who have relevant experience in the area of agriculture and smart agriculture technologies. The results of the interviews illustrated the current situation of the agricultural sector such as the problems of irrigation system management, high production cost, and a decline in the agricultural commodity prices. The results also indicated advantages and disadvantages of the smart agriculture used to develop Thai agricultural sector. The smart agriculture can help reduce the production costs, increase productivity in terms of quantity and quality, and help reduce the use of labor. However, some groups of farmers, especially the elderly, deny using the smart agriculture as it is costly, and they do not have sufficient background knowledge about technologies

Keywords: Smart Agriculture, Agriculture, Thai Farmer

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Introduction

Agriculture has long been regarded as the important backbone of the Thai economy. Ministry of Agriculture and Cooperatives (2022) reported that there are around 8 million households covering around 9.2 million people officially registered with the government to work in the agricultural sector (farming, livestock, agro-forestry as well as aquaculture) and around 48.60 percent of them (4.4 million people) are mainly earning their living by only farming (planting seeds or crops and growing edible plants). Thus, crop production is the most significant sub-sector among the agricultural sub-sectors (Singhapreecha, 2014)

The agricultural sector, especially in terms of farming or growing edible plants plays an important role in improving food security and nutrition for people in the country. It also helps create employment and incomes for many Thai populations, especially during adverse circumstances, such as during COVID-19 pandemic. According to Qu Dongyu, Director-General of the Food and Agriculture Organization (FAO), investing in agriculture, especially the development for small-scale production, has a greater impact on firstly, ending extreme poverty and secondly, ensuring food security than investment in other sectors (Food and Agriculture Organization of the United Nations, 2021). Those mentioned goals are two main Sustainable Development Goals (SDGs) prioritized by the United Nations (UN) (Obaisi, 2017). Moreover, researchers and experts who studied the importance of the agricultural sector found that agriculture can play an important role in achieving the SDGs, particularly SDG 1 and SDG 2- which are no poverty and zero hunger respectively. In order to achieve these two UN ambitious goals requires an engine that can improve the agri-food sector. Several innovations and agricultural technologies, such as modern farming, have been used as a new approach to making the agricultural sector more sustainable (Juhari, 2021; Musa et al., 2022). On global level, Thailand is one of the world's top exporters of commodity crops. Agriculture contributes to 15-20 percent of the Country's total export. One of Thailand's export commodities is rice. In 2022, Thailand is the world's third-largest rice exporter after India and Vietnam (Reuters, 2022). Thus, the government places agriculture high priority in the year of 2019, approximately 6.5 billion USD was earmarked for the Ministry of Agriculture and Cooperatives (MOAC) in order to promote Thai agriculture (Thairath, 2018). Yet, the problems in the Thai agricultural sector still remain the same every year.

There are problems in Thai agricultural sectors and farming system mentioned by experts and researchers. These problems can be divided into three main problems which are: (1) The problem of Thai farmers as Thai agricultural sector is facing the problem of serious labor shortage in agricultural industry. Thailand including agricultural sector has a large elderly population. Thai farmers has been steadily on rise with the average of over 50 years old, while the young generations are uninterested in farming and go for working in service and manufacturing or industrial sector (2) The problem of Thai farms, which also consists of firstly, the decrease in the average size of a small-scale farmland due to industrialization and urbanization (Kwanmuang et al., 2020). And secondly, Thai farmers are facing with less land ownerships. (3) The problem of Thai farming as Thai farmers always strict to the traditional characteristic of Thai farming and most of them are working on small-scale or family-run farming. They are also facing with less access to natural resources, especially water resources (Attavanich et al., 2019).

Thus, to overcome all the problems, Thai government has been trying to reform its agriculture policies. By applying modern technologies and innovative instruments to agricultural sector, for example “smart agriculture” in order to increase the efficiency of Thai agricultural productivity and create sustainable agriculture. In 2018, the government released a long-term development framework called “the 20 Year National Strategy” framework (2018-2037) aiming that Thailand will turn into a developed country.

Smart agriculture is one of agriculture's strategy that is under Thailand 20-year National Strategy on "Competitiveness Enhancement" (National Strategy Committee, 2018). agriculture will be driven by modern technologies, innovations and knowledges, such as handy sense (control water according to temperature and humidity), drone (unmanned aerial vehicle) and laser land levelling for rice paddy field.

Since smart agriculture is a new approach for Thailand's agriculture and there are not many researchers studying about Smart Agriculture, therefore this research will examine the effectiveness and implementation of Smart Agriculture which is used in Thai agricultural sector by having Ayutthaya province as a case study, because Ayutthaya province is being consider as one of Thailand's important agricultural areas. Moreover, the farmers in Ayutthaya province can be an example group of farmers who can implement smart agriculture to produce agricultural products that meet the quality standards of many famous chains of supermarket. The research results will identify the current situation of Thailand's agriculture as well as existing advantages and disadvantages as well as problems of the smart agriculture implementation experienced by the Thai farmers. Moreover, proper recommendations suggested by the participants will also focused. Thus, the research results obtained from this study will benefit further development and better effectiveness of Thailand's Smart Agriculture strategy.

This research has three main objectives which are: (1) To examine the current situation of Thai agricultural sector and farmers working in agricultural sector. (2) To analyze the advantages and disadvantage of Smart Agriculture as it has been used by Thai farmers as the way to improve Thai agricultural sector. (3) To propose the solutions for Thai government in order to have the effective of Smart Agriculture strategy for Thai agricultural sector and farmer.

Literature Review

The Situation of Thai Agriculture

According to the 2020 World Population Data Sheet of the Population Reference Bureau, the current world population is 7.8 billion people which may reach 9.9 billion people in 2050 (Kaneda et al., 2020). The growth of population also comes along with demand for food. Thus, nowadays, many people around the world suffering from chronic undernourishment and malnutrition. Over the years, the world's agricultural sector has been the most significant sector of the economy in facing the food security challenges. Thailand's agricultural sector also has to increase its capability and productivity in order to meet the global populations' demands. However, Thai farmers are still facing many problems, especially in term of productivity that still do not reach the goal. Moreover, Thai farmers' incomes are still very low. According to the World Bank's report, there is an increasing number of poor people in the years 2016, 2018 and 2020. The majority of the poor (79 percent) live in rural areas, mainly in agricultural households (World Bank, 2022). Thai farmers normally still lack in-depth knowledge about both marketing planning and agricultural production management. In addition, Kraipinit et al. (2017) studied about smart agricultural management of Thailand and found that there are two main problems facing the farmers which are firstly, problems of agricultural production and secondly, problems outside agricultural sector.

Agricultural production must rely on agricultural production factors and inputs. However, at present, agricultural production factors and inputs have changes and affect agricultural productions and products. The main factors affecting Thai agricultural production are as follow: (1) Biodiversity: Thailand can be considered as a country that has a high level of biodiversity, but nowadays, biodiversity that is a critical resource for agricultural production and nation food security has been degraded due to the expansion of agricultural production in response to greater demands for food. Moreover, urban land expansion as well as possession and exploitation of natural resources incorrectly can also affect nation's biodiversity which will

lead to a negative impact on Thailand's food security. (2) The use of chemicals in agricultural production: chemicals substances, such as pesticides and fertilizers are necessary for increasing productivity, however, it directly affects Thai farmers' health and environment which includes soil quality, water as well as causing air pollution. Moreover, chemical contamination in agricultural products also affects consumers health (3) Labor in agricultural sector: the population and labors in agricultural sector tend to decrease, especially, young generation people and workers mainly due to income insecurity. The average age of farmers rose from 54 years in 2008 to 58 years in 2018 (Attavanich et al., 2019) while the agricultural sector is increasingly under pressure needing to feed a growing population. Thus, Thai agriculture has to rely on foreign labors in order to replace domestic workers. This situation tends to affect the sustainability of Thai agricultural production and food security.

For problems outside agricultural sector, Kraipinit et al. (2017) also mentioned that farmers should take into account a change of factors outside agricultural sector in order that they can predict trends that may affect agricultural production process by using collected past and real-time data as a production planning information which is very necessary for reducing agricultural production losses and increasing agricultural production efficiency to meet market demands. The important problems of factor outside agricultural sector are: (1) Climate change: agricultural sector is still facing the problems of climate change which is the result of global warming, causing climate variability and high global temperatures. Climate change can cause negative impacts on key factors in agricultural production, such as rainfall, biodiversity, plant disease outbreaks. Climate data is therefore important for agricultural production planning in order to reduce risks that may arise from the effects of fluctuating weather conditions. (2) Trade and legal change: the world economic crisis and competition has resulted a number of changes in the regulation of economic management in each country for example, regulations on trade and investment, tariff measure, consumer protection law.

Population growth nowadays is rapidly accelerating, intensifying a stain and pressure on the agricultural sector as high yields are expected. According to the United Nations (2013), food production must sustainably increase by 70 per cent to feed global population in 2015. However, as already mentioned, there are still the problems that is threatening the sustainability of agricultural system and impede the world's capacity of producing food to meet its needs. Hence, a transition to a smart and sustainable agricultural system for producing enough food without critically degrading resources and environment is needed (Musa et al., 2022). Juhari (2021) also emphasized the importance of smart agricultural technologies that technology can lead to more productive, profitable and sustainable food and agricultural system.

The Situation of Smart Agriculture in Thailand

Thai Government has realized the importance of smart agriculture. The smart agriculture has been inserted in 20-year National Strategy. The 20-year National Strategy consists of six main strategic areas, the second one that is related to agricultural sector is the competitiveness enhancement. With this national strategy on national competitiveness enhancement, Thailand hopes to become a developed country with stable, sustainable economic growth as well as increased national competitiveness. This second strategy consists of five key development guidelines. The first development guideline that focuses on exploring value-added agriculture in order to upgrade country's productivity is related to smart agriculture as it gives an importance on driving agriculture with technologies and innovations, for example safe farming, biological farming and smart farming in on order to increase efficiency and production in both quantity, quality as well as value and variety of agricultural products.

In addition, the smart agriculture concept has also been inserted in the 12th national economic and social development plan (2017-2021) and the 20-agricultural and cooperative strategy (2017-2036). These two plans are not only in consonance with 20-year national strategy, but also with the UN's SDGs. These two development plans were launched with the goals aiming

that Thai agriculture will be prospered as well as Thai farmers will be secured and escape from the middle-income trap by having the average national income per head of more than 390,000 baht in the year 2036 (Chu-onsakul, 2020).

Definition of Smart Agriculture in Thailand

Smart agriculture is also called smart farming. There is no single definition of smart agriculture as smart agriculture is a very recent concept, its term and concept have not reached a consensus in the scientific literature yet.

Some define smart agriculture by emphasizing the integration of data and communication technologies into agricultural production system as well as the use of information transfer and concentration in remote storage systems or server, to allow different farm data to be combined and evaluated for decision-making process. For example, Lehmann et al. (2012) who also emphasized that smart agriculture relies on two important factor which are data collection as well as data storage and analysis. Data collection is guaranteed by using sensors in agricultural sector. This sensor is an electrotechnical system that detects environmental and physical quantities, for example humidity, temperature, pressure and light, then transforms them into a signal that can be interpreted and collected as data. This process will be used with farm management in every step and in all conditions.

Moreover, besides the use of information and communication technology in the cyber-physical farm management cycle, Wolfert et al. (2017) also emphasized that there is the use of other new technologies such as the Internet of Things (IoTs) and Cloud Computing robots and artificial intelligence in farming.

Some defined smart agriculture by emphasizing its advantages, such as National Science and Technology Development Agency (2020) stated that smart agriculture or smart farming is an effort to develop agriculture in four areas which are reducing cost of production, increasing the quality of agricultural production standards and product standard, reducing the risk in agricultural sector caused by the outbreak of pests and natural disasters, and managing the transmission of knowledge about technology and innovation which can lead to the well-being. Moreover, it can be defined as the smart agriculture as a green technology approach that can increase agricultural and food production to meet the increasing world population's demands, while it helps reduce the use of inputs and reduces the impacts in the environment as well as climate changes since it does not cause the ecological footprint.

Relevant Research

Musa et al. (2022) wrote the research called "The Role of Smart Farming in Sustainable Development" aiming to examine the development of agriculture into smart farming and how smart farming can contribute to the Sustainable Development Goals (SDGs) in Southeast Asia, especially the SDG indicator 2.4.1 of SDG goal 2, defined as the "Proportion of agricultural area under productive and sustainable agriculture". The research focus on how smart farming can be imparted in sustainable agriculture by analyzing the economic, environmental and social impact which means economic dimension includes land productivity, profits and resilience, environmental dimension includes soil profile, water usage, chemical substance usage and biodiversity. The social dimension includes employment opportunities, food security and land tenure (Food and Agriculture Organization of the United Nations, 2023).

The world has been facing challenges in feeding the world's population due to the growing population, environmental condition, risks of climate change, rapid urbanization as well as the unprecedented COVID-19 crisis. All these factors have resulted in a new dimension of food insecurity and disruption of supply and demand. According to this research results, smart farming in Southeast Asia, even though it is in its early stages, it can be considered as one of the approaches to tackle this issue. Smart farming can be imparted as part of sustainable agriculture. The researchers can find this research result by analyzing the economic, environmental and social impact of smart farming in Southeast Asia.

For economic impact, smart farming has the potential in making agriculture more profitable and sustainable by reducing resource inputs and cost which ensure that farmers can save immensely labor and input costs. For environment impact, smart farming comes with many opportunities that can reduce ecological footprint. It helps manage crop production in an environmentally friendly way. For social impact, smart farming has the potential to boost youth involvement in agriculture which can help address the ageing farmers.

The research result finally shows that the transformation of agriculture into smart farming in Southeast Asia will take some time as there are still some important challenges that need to be tackled such as smallholders or small-scale farmers who dominate agricultural sector in Southeast Asia still lack capital to finance smart farming. Moreover, communicating with older farmers could also be a challenge as they could not understand the technicalities of new technologies (Musa et al., 2022).

The research of Juhari (2021) called “How the Agrifood Sector can be more Sustainable in Meeting SDG1 and SDG2?” reaffirms that there are three main strategies that would help sustain agri-food and agricultural sector which are: implementing smart farming, supporting farmers in terms of finance, and encouraging youth involvement in agriculture.

For Thailand, Kwanmuang et al. (2020) studied about “Small-Scale Farmers under Thailand’s Smart Farming System” and found that Thailand’s agricultural sector is challenged in many aspects and still does not reach its goals as there are a declining of farm size, an increasing number of labor shortage in the agricultural sector while the demand for global food is increasing, small-scale farmers who dominate Thailand’s agricultural sector need to use smart agriculture aiming that this new approach will help to solve problems and limitations in agricultural sector. After the implementation of smart farming in Thailand, the researchers found that smart farming does not only have various advantages to farmers, but also have constraints when implementing to the large number of Thai small-scale farmers who are facing aging and lack of capital and knowledge. Thus, raising the awareness of technologies acceptance of Thai farmers is needed. The transferring and training for famers should be major concern.

Smart agriculture or smart farming become important approach for many countries in the world, especially countries that has agriculture-related career as a main source of incomes for people in the country. As the result shows that smart farming or smart agriculture technologies can create sustainable food system or resilient food production for the increasing demands of the world populations and also create sustainable incomes for people working in agricultural sector. Moreover, according to Thailand’s 20-year National Strategy, smart agriculture can be considered as an important approach that help increase the country’s productivity and competitiveness. Thus, smart agriculture implementation should be studied. However, there are still only few researches studying about this new approach. All researches mentioned in this section still also have its limitations as all three researches are a purely theoretical paper exploring the latest trend of agriculture and the adaptation of smart farming technologies in Southeast Asia. The source of information and data in those papers are mostly secondary source. Hence, this research is the study that considers the use of primary resource data and observation for in-depth results and focuses on smart agriculture implementation only in Thailand which is the main study case which will allow researcher to have more focused results.

Research Methodology

This research was conducted in the pattern of qualitative method. Semi-structure interview with open-end questions was used to collect information from participants as it is direct communication so that it allows to obtain personal opinions and in-depth information.

Approximately 18 participants were selected by purposive sampling technique. These 18 participants consist of 8 farmers, 5 government field officers from MOAC and 5 policy makers

from MOAC. They were divided into 3 groups. Then, these 3 groups were interviewed by using semi-structured, open-ended questions.

The first group includes 8 Thai farmers who apply smart agriculture to their farms. These 8 farmers were divided into two group.

The first group of farmers has 4 farmers. All 4 farmers in the first group have criteria as follows: (1) Owning or managing farms or growing crops or plants as a business. (2) Having farms or doing farming in areas of Ayutthaya province. (3) Working at least 5 years as a farmer in Thai agricultural sector. (4) Being less successful at applying smart agriculture to their farms as the farmers use or apply smart agriculture technologies for their farm production and management and being able to increase yield per unit of smart farm more than 10 percent according to Thailand's Master Plan under the National Strategy on Agricultural Issues.

The second group of farmers also has 4 farmers. All 4 farmers in the second group have criteria as follows: (1) Owning or managing farms or growing crops or plants as a business. (2) Having farms or doing farming in areas of Ayutthaya province. 3) Working at least 5 years as a farmer in Thai agricultural sector. (4) Being less successful at applying smart agriculture to their farms as the farmers use or apply smart agriculture technologies for their farm production and management, but they cannot meet the requirement of Thailand's Master Plan under the National Strategy on Agricultural Issues which means they can only increase yield per unit of smart farm less than 10 percent.

Beside the group of farmers, the second group is the group of 5 government field officers from MOAC. They regularly work in field and work closely with farmers in Ayutthaya province. They have criteria as follows: (1) Having work experience in MOAC or in the area of Thai agriculture. (2) Having work experience or working alongside with the farmers in Ayutthaya at least 5 years. (3) Being an officer of MOAC.

The third group includes 5 policy makers from MOAC. These policy makers have criteria as follows: (1) Having a work experience in MOAC or having a work experience in an area of Thai agriculture or in the field of smart agriculture. (2) Working in the position of executive or policy maker at least 5 years. (3) Being an officer of MOAC.

In order to protect the anonymity of all groups of participants, this research will identify the participant as Participant A, B, C. The details of all participants are as follow:

Table 1 List of Interviewed Participants

Number	Name	Work Place / Position
1	Participant A	Farmer at Nakhon Luang district
2	Participant B	Farmer at Muang Ayutthaya district
3	Participant C	Farmer at Maita district
4	Participant D	Farmer at Muang Ayutthaya district
5	Participant E	Farmer at Tha Ruea District
6	Participant F	Farmer at Bangpahun District
7	Participant G	Farmer at Bang Sai District
8	Participant H	Farmer at Pang Pa In District
9	Participant I	A district agriculture officer in Maita district
10	Participant J	A chairman of agricultural cooperatives in Changyai district
11	Participant K	A district agricultural officer in Pailom district
12	Participant L	A district agricultural officer in Changyai district
13	Participant M	An inspector of MOAC in Muang Ayutthaya district.
14	Participant N	The honorary adviser attached to the committee on Agricultural and Cooperatives Division
15	Participant O	The senior adviser attached to the chairman of the Sub-committee on Factor of Agricultural Product

Number	Name	Work Place / Position
16	Participant P	The senior officer of the Rice Department, MOAC
17	Participant Q	Senior officer of Department of Agricultural Extension, MOAC
18	Participant R	The Deputy Chairman of the Agriculture and Cooperatives Committee, Senate

The data analyzed in this research was conducted in the pattern of qualitative method. Grounded theory was used for analyzing the research findings.

Research Findings

The research results were collected by semi-structured interviews with the group of farmers in Ayutthaya provinces, the group of government field officers from MOAC who work with farmers in Ayutthaya province and the group of policy maker from MOAC.

Situation and Problems of Agricultural Sector

There are five main problems that were mentioned by interviewed farmers and MOAC field officer. These problems could indicate current situation and problems of Ayutthaya province's agricultural sector. These main five problems are (1) the problem of irrigation system management: all eight interviewed farmers and one out of five interviewed government field reported that inadequate water management is still the main problem in Thai agricultural sector and this water management problem can be considered as water shortage and floods as Participant K (2021) reported that: "Thai agricultural sector also faces problems with inadequate water management, causing farmers to experience frequent droughts and frequent floods. Moreover, climate change makes the situation even worse."

(2) the problem of high production cost, especially the cost of production inputs such as fertilizer and pest control substances. This problem was also mentioned by all eight farmers and three interviewed government field workers. (3) the problem of dropping or low prices of agricultural commodities which was reported by three farmers and four government field officers. Participant D (2021) reported that: "The cost of production inputs become higher every year which does not correspond to agricultural products' prices nowadays. This should be tackled."

(4) The fourth problem is the problem of land ownership as many Thai farmers including farmers in Ayutthaya are not a landowner and they have to lease land with a high price. This problem was reported by Participant B (2021) that: "Many Thai farmers are still unable to be a landowner. They have to rent land at high price for farming and cannot to any land development."

(5) Thai agricultural sector is facing serious labor shortage issues as the country is entering an aging society. Most of the farmers nowadays are elderly people, while young generation living in farmer families are more interested in working in other sectors. This problem was reported by three interviewed government field officers. Participant L (2021) reported that: "Most farmers are ageing people and do not have inheritance who will continue to do farming. Young generations whose parents are a farmer are not interested in farming activities because the income from agricultural sector is not as much as the income from other sectors."

Advantages and Disadvantages of the Implementation of Smart Agriculture

Advantages of Smart Agriculture Implementation: After using smart agriculture technologies, all Participant Found that implementing smart agriculture technologies in farms has advantages. There are four main advantages of using smart agriculture that were reported by them. These four advantages are: (1) smart agriculture can help farmers to work with fewer mistakes which help reduce production costs and all expenses that farmers have to pay unnecessarily. This advantage was reported by all eight interview farmers, three out of five interviewed government field officers. (2) smart agriculture can helps increase productivity as

well as quantity and quality of agricultural products which can bring better economic returns and living standards to farmers. This was reported by five farmers and two government field officers. (3) Implementation of smart agriculture could help reduce the number of labors used in agricultural sector and the cost of labor. This advantage was reported by four farmers and three government field officers. For example, Participant G (2021) mentioned that: "When using smart agricultural technologies, I know quite for sure how many rice grains I sow per rai. Nowadays, I use only eight to ten kilograms of rice grains per rai, while before I used around 25 kilograms of rice, this shows that smart agriculture can help reduce the cost of production and input. I use smart agriculture, which is drones. After deducting costs, I found that it is more profitable than hiring labor."

For the question about the advantages of smart agriculture, all five policy makers were also asked about an achievement of smart agriculture in Thailand and how it can help improve agricultural sector. They all reported that smart agriculture in Thailand was just getting started. Its implementation is still in an early stage as smart agriculture concept was inserted in 20-year National Strategy launched in 2018. All five policy makers have a positive perspective towards smart agriculture implementation as they have experienced that modern technologies show a positive trend for farmers, both in terms of cost, time, labor and resource reduction, especially in the cases of large-scale farms.

Moreover, Thailand is trying to achieve the UN's SDGs in every dimension by 2037 as its 20-year National Strategy Plan is in consonance the UN's SDGs. Participant N, O, P, Q and R were also asked about the development of agricultural sector and its role in helping and support Thailand to achieve the SDGs. Participant N, O, P, Q and R gave their opinions highlighting that smart agriculture can improve agricultural sector and has potentials to help Thailand SDG6 which is ensuring availability and sustainable management of water and sanitation for all. Participant N, O, P, Q and R also believed that smart agriculture could help farmers to use water effectively, SDG12 which is ensuring sustainable consumption and production patterns, SDG13 which is taking urgent action to combat climate change and its impacts. Moreover, Participant O, P, Q and R stated that smart agriculture related to SDG1 which is ending poverty problems and SDG 2 which is ending hunger and malnutrition problems. For example, Participant P (2021) mentioned that: "In terms of poverty eradication, Smart agriculture can increase agricultural products which can also increase income for farmers. Moreover, in term of ending hunger, the famine situation in Thailand is better than many countries in South Asia and Africa. Smart agriculture is an important tool to increase agricultural products to meet all demands."

However, Participant N (2021) has a different perspective and mentioned that: "In Thailand, smart agriculture is It is still far from the tool used in order to eliminate poverty and hunger. We consider that smart agriculture can help farmer, but still cannot help end poverty or hunger problems. Smart agriculture in Thailand still needs more support from the government in order to help Thailand reach this SDGs."

Disadvantages of Smart Agriculture Implementation: After using smart agriculture technologies, Participant Found that implementing smart agriculture technologies in their farms still has its disadvantages that should be concerned. There are four main disadvantages of using smart agriculture that were mentioned by all groups of participants which are: (1) Smart agriculture can be expensive to implement and it has a high maintenance cost. This disadvantage was reported by five out of eight interviewed farmers and all five interviewed field government officers. (2) Smart agriculture makes use of high technologies that require technical skills, precision and specific experiences to make it success. However, many farmers do not have the skills. This disadvantage was reported by five farmers and four government field officers. (3) Applying smart agriculture is very new approach that, in some famers' opinions, are complicated to use. Thus, farmers, especially aging farmers who farm in

traditional methods still do not accept using of agricultural technology as they do not fully understand the benefit and risk of using technology in agriculture. This advantage was reported by two farmers and four government field officer and (4) smart agriculture is an emerging concept for Thai agricultural sector that is dominated by small-scale farmers and family-runs farms. As it was a new concept, smart agriculture implementation in Thailand needs full ongoing supports from the government, for example smart agriculture service centers covering all areas, loan or funding, technologies and machineries, service providers, developing skills of officers and farmers, especially young smart farmers as well as promoting and supporting research and development. This disadvantage was reported by all government field officers. For example, Participant M (2021) mentioned that: "Smart agriculture technologies require a very high investment. Moreover, for an agricultural loan, farmers still have to pay high interest rates. Thai farmers also still have very little knowledge about technologies, which may make the use of smart farming technologies not as effective as they should be. Moreover, there are still only few smart agriculture service centers in Thailand which do not cover all areas. This should be continuously tackled and supported."

The Recommendations from Participants

There are four main recommendations highlighted by the research participants. The first recommendation is that the government should support the development and training skills about smart agriculture for both farmers and officers. Secondly, all groups of participants also recommended that the government should support suitable smart farming tools or machineries for farmers to do their smart farms. Moreover, the support from the government in form of smart farming equipment service providers were also recommended. Thirdly, they emphasized the importance of funding supports and loans. The government should prepare better access to loans for farmers and evaluate further the agri-finance area in order to give famers the opportunity to afford smart technologies to be implemented in the food production. Besides these three recommendations, the results show that the group of farmers gave the importance on the fourth recommendation which is that the government should focus on water resource and irrigation problem which is an important factor for agricultural activities. For example, Participant I and Participant Q mentioned that: "Preparing better access to loans and make smart agriculture pilot project that cover all areas of farming might encourage farmers to apply and invest in smart agriculture and other new technology in their farms." (Participant I, 2021) "Skills are important. Taking farmers to learn from farmers who are successful in using smart agriculture is a good way to give farmers information and skills. They can see with their eyes that using smart agriculture. This way of training will make farmers more comfortable to learn." (Participant Q, 2021)

Discussion & Conclusion

Discussion

From the conducted interviews data collection, the following step is the discussion part in order to identify the current situation of agricultural sector in Ayutthaya province, the advantages and disadvantages of smart agriculture after its implementation in Ayutthaya province and the solutions recommended by participants for a better smart agriculture development.

Current Situation

The five essential problems mentioned by interviewed farmers and government officers can describe the situation of agricultural sector in Ayutthaya province. Firstly, there is the problem of water shortage and flood. According to Participant A and C, new technologies are needed to predict amount of rain fall or reduce the use of water. Kwanmuang et al. (2020) mentioned in their research that smart agriculture farmers will use high technologies such as handy sense and green the reduce the use of water for growing plants as it can control water distribution to the growing crop at the minimum requirement of the crop, while in case of flood and other

natural disaster smart agriculture technologies allows smart farmers to reduce the dependency of uncontrolled external factors such as natural disaster, climate change and disease outbreaks as farmers can connect to reliable forecast application in order to minimize risks and prepare for any damage to their product that could be occurred.

For the problem of dropping or low prices of agricultural commodities, while farmers are still facing higher production costs. Smart agriculture cannot directly solve low prices of agricultural products, but it has the potential to improve the profitability of agricultural sector for farmers (Juhari, 2021) as smart agriculture can generate higher yields, while reducing the resources inputs and cost to minimum level. Farmers, hence, can earn more income.

Moreover, farmers are facing the problem of agricultural labor shortage as it can be seen that in Thailand, including Ayutthaya province, most of the agricultural activities are being done by ageing farmers, while young generation tends to move away to urban area and find employment in other sectors. Therefore, smart agriculture approach has been engaged in Thai agricultural sector in order to attract young generation back to farming. Participant B and G decided to use smart agriculture because smart agriculture consists of various high technology tools such as drone to sow rice seed and spray fertilizer and pesticide. Such tool can replace labor and reduce working time, while farmers will have a stable yield and can increase productivity, for example Participant G mentioned that drone can minimize the use of human labor almost 100 percent and also give better results. Moreover, Musa et al. (2022) also emphasized that smart agriculture can solve the problem of agricultural labor because smart agriculture can contribute to positive social impact, where having more potential of youth will be involved in the agricultural sector. The implementation of new technologies and innovation can show to youth that there can be a feasible and profitable business opportunity in agricultural sector. Moreover, young generation farmers have more concern on their effort spent on the farm work, so they try to find the way to assist them in term of reducing their effort on-farm work (Chu-ongsakul, 2020). Hence, smart agriculture and innovation and technology can address this issue and can encourage youth into agricultural sector and expand the desire of youth to apply in any agriculture-related career.

The last problem is that some farmers in Ayutthaya province are still not be a landowner and they have to lease land with a high price in order to grow crops. Smart agriculture is not directly as Participant R also mentioned that smart agriculture cannot be the best solution for all agricultural problem. However, this problem should be taken into consideration as full land ownership of farmer has impact on country economic performance and agricultural productivity. It can enhance the agricultural product yield of small-scale and midsize farm and allow farmers to access enough natural resources resulting in the informal debt reduction. Smart agriculture can make the situation of this problem better because it helps farmers to be able to pursue as sustainable agriculture career by reducing the cost of production inputs such as seed, fertilizer and pesticides, while it can increase productivity. So, farmers can sell agricultural products in volatile markets. When farmers can have a stable status of career, they will have stable income and be able to pay by installment to buy their own land.

Advantages and Disadvantages of Smart Agriculture

Advantages of Smart Agriculture: Smart agriculture can firstly help farmers to work with fewer mistakes which help reduce resource inputs and cost. Secondly, it also helps increase productivity as well as quality and quality of agricultural products. These two advantages were reported by most of interviewees. The case study of Chinese agriculture is a good evidence. China can feed 20 percent of the world's population with only about 7 percent of its arable land by investing in agricultural technology under its agricultural modernization plan. (Daxue Consulting, 2022)

For Thailand, the 20-year national strategy on competitiveness states that smart agriculture is one of the key factors in building competitiveness of the country and farmers as it can be to

develop agriculture for the benefit of increasing the value of agricultural product (an increased value derive from cost reduction and increasing of agricultural productivity) and increasing yield per unit area of farming. (Office of the National Economic and Social development Council, 2021)

In term of increasing the value of agricultural product and increasing productivity quantitively, the goals and indicators for smart agriculture mentioned in Master Plan under the National Strategy on Agriculture Issues have aimed at two main points. The first indicator is that the increasing values of products that derive from smart technologies increase up to 3 percent by 2022. The second indicator is that the increasing productivity per unit of farmlands that are managed by smart technology increase up to 10 percent by 2022.

The case study of farmers in Ayutthaya Province who have joined as members of an agricultural cooperative in Ayutthaya province show that most farmers have joined together on smart agriculture farming system and in 2021, they could reduce production costs by 21.95% and increased productivity per unit area by 3.14%. Altogether, the total production value increased by 51.58% (from the original profit of 2,901 baht per rai, increased to 4,509 baht per rai). (Phra Nakhon Si Ayutthaya Provincial Agriculture and Cooperatives Office, 2022)

In addition, there is also another evidence. The 20-year national strategy report in 2021 shows the result indicating that a group of farmers participating in the large-scale smart agriculture project could increase the value of agricultural products as a result of reducing production costs and improving productivity, the total increasing by 31.61 percent. In term of increasing the yield per unit of farm, the value of large-scale smart agriculture farming 2021 increase by 38.4 percent (Office of the National Economic and Social development Council, 2021), but the government should continue to encourage more farmers to participate in the large-scale smart agriculture farming program.

In term of increasing quality of agricultural products, by adopting smart agriculture technologies, for example, precision agriculture, smart irrigation, early warning system farmers can access to precise data and information collection. Moreover, they can precisely measure variation within a field. Thus, they can increase the effectiveness of agricultural inputs and resources, such as water, pesticides and fertilizers as they can use the inputs more accurately and selectively (Kwanmuang et al., 2020). In addition, using smart agriculture technologies can help farmers monitor better the needs of individual plants and adjust their nutrition correspondingly or can let farmers know about the current situation or forecast the situation in advance so farmers can react before any harms happen to plants.

The last advantage is that smart agriculture can help reduce the use of labor during labor shortage trends. It also helps unnecessary expense for labor cost as Participant B decided to use drone to sow the seed and spray pesticide in his farm because it is cheaper than hiring labor. While Participant G also reported that drone can minimize the use of human labor almost 100 percent and it gives better result than hiring human labor. This is also aligned with Kendall et al. (2017) who studied about the implementation of smart technologies in China and found that for Chinese farmers, one of the main reasons that famers decide to use smart farming technologies, such as precision agriculture (PA) technologies is that it can address the labor shortage problem which is associated with rural-urban migration and reduction in family-run farms as Chinese government will promote the consolidation of Chinese farms into larger management zone.

Besides the three advantages, the interviewed policy makers realize the relations between smart agriculture implementation and UN's SDGs although Participant N believes that smart agriculture implementation is at the beginning state and it is still not be the solution of eradicating poverty (SDG 1) and alleviating hunger (SDG 2). The researches of Musa et al. (2022) and Juhari (2021) reaffirmed that smart agriculture contributes to sustainable

development, especially realizing the zero hunger and eradicating poverty as it creates positive impacts to the country's environment, social and economic.

Disadvantages of Smart Agriculture: There are four disadvantages mentioned by participants which are firstly, smart agriculture requires an expensive investment so that not every farmer who are willing to use smart technologies and can afford it. Secondly, smart agriculture requires technical skills, precision and specific experiences to make it success. These two disadvantages were most mentioned by interviewed participants. The research finding of Fleming et al. (2018) also points out that smart agriculture is very expensive to invest in and non-affordable for some groups of farmers. Thus, this disadvantage can cause inequality development between different groups of farmers classified by for example, capital investment, education, farm size or territories. Ageing farmers or small farm holders would lack motivation and would be excluded from agriculture development. However, Thai government have been trying to promote smart agriculture by launching a program called "Large-scale Farming" model aiming that farmers can work together and have more opportunity to access technologies.

The third disadvantage is that smart agriculture is still a very new approach that, in some farmers' opinions, it is complicated to use. Thus, farmers, especially aging farmers who farm in traditional methods still do not accept using agricultural technology. This became evident in the research of Srivetbodee & Igel (2021) who stated in their research about the adoption of digital technology in agriculture that farmers who are older than 45 years old are less likely to be willing to adopt new farming practices because they do not want to invest in smart technologies. However, if they are willing to accept the use of technologies, they will not try to perceive the usefulness of technologies but are leaving the responsibility to their children. Moreover, Chu-ongsakul (2020) also find out from his research that the main problem is that farmers are still not confident on the outcome of smart agriculture and deny applying it because if the actual problem is the capital investment concern the farmer can ask for loan from the bank but in fact, they deny going to the bank and reject the innovation adoption with the reason lack of capital investment.

The last disadvantage of smart agriculture implementation mentioned by interviewees is that smart agriculture is a new concept, it requires full ongoing supports from the government. Participant N and O emphasize that the government should support smart farmers all the way through. Moreover, the budget system of Thailand still remains the big concern as there are many agricultural management projects under Thailand's 20-year national strategy. However, the budget support from the government is not sufficient for running all the project continuously and efficiently. Moreover, Kwanmuang et al. (2020) also found that in order to drive smart agriculture strategy, the government should support not only the budget, but also should support the cooperation among all related agencies, such as private sector and educational institutions.

The Appropriate Solution

There are four appropriate solution for improving smart agriculture implementation in Thailand. The first recommendation is that the government should support the development and training skills about smart agriculture for both farmers and officer, for example creating learning space and field workshops to persuade Thai farmers to use smart technologies as one of the best ways to encourage farmers to implement technologies is through training workshops. The model of sharing knowledge and experience to each other has high potential to motivate larger group. (Srivetbodee & Igel, 2021) According to Participant N and Participant M, farmers will believe in the use of technology when they can see the advantages with their own eyes. Moreover, the training for young generation farmers should be the main focus as they tend to be the most important group who is enthusiastic about learning new skills. They

also have potential to be the divers to motivate other farmers and bring ageing farmers to involve in smart farming. (Chu-ongsakul, 2020)

Secondly, the government should support suitable smart farming tools or machineries for farmers to do their smart farms. Moreover, Participant N and E also recommended the government to support the groups of smart agriculture service provider, which normally consist of young generation and smart farmers by giving them low interest rate loans and advises, as it is more productive to directly support groups of young generation who are interested in smart technologies and has a knowledge background about technology or has a strong inspiration to be a smart farmer as Chu-ongsakul stated that offering the special loan for young generation farmers who are interested in smart farming and has potential will solve the barrier on lack of investment. Thirdly, the government should prepare better access to loans for farmers and evaluate further the agri-finance area in order to give famers the opportunity to afford smart technologies as the concern on capital investment is the obstacles that most of the interviewees mention. Participant M and Srivetbodee & Igel (2021) found that better access to loans might encourage farmers to use new technologies and innovations.

Lastly, the government should focus on proper water resource or irrigation management. Chu-ongsakul (2020) stated that water resource is the main factor for agricultural activities and before implementing smart agriculture sufficient water resource is a basic factor that farmers need to have.

Conclusion

Thai agriculture is still challenged in many aspects as the demands of global food increasing, while there are the problems in agricultural sector such as problem of irrigation system management, high cost of production and inputs, declining of agricultural commodities prices, increasing number of aging farmers and labor shortage in the sector tends to rise.

Smart agriculture is the new approach to Thai agricultural sector which helps solve problems. It can mainly help reduce unnecessary costs of production and inputs and the use of resources, while it can increase both quantity and quality of agricultural products leading to an increase of the value of Thai agricultural product. Moreover, it also helps farm labor shortage problems. Although smart agriculture has many advantages and has positive impact on country's development, according to some Thai policy makers smart agriculture is still far from being a proper approach for ending poverty and hunger which are the two main SDGs as it still has some main disadvantages that should be developed for better results. However, the implementation of smart agriculture in Thailand can positively contribute to some other SDGs such as SDG 6 which focuses on water, SDG 13 which focuses on climate change adaptation and mitigation, SDG 12 which focuses on sustainable consumption and production, and SDG 15 which focuses on land use and ecosystems.

The disadvantages of smart agriculture applied in Thailand are that it requires a lot of money in order to invest in, thus it is still difficult for some groups of farmers to afford it. In addition, some groups of farmer, especially ageing farmers still deny using smart agriculture technologies because they do not have background knowledges about new technology and innovation and still do not realize its advantages.

In order to take smart agriculture into practice, the government should support knowledge and skills about smart agriculture for both farmers and officers, especially young farmers as they have potential to be the divers for the sector and motivate ageing farmers. Farmers should also be major concern as they are normally small-scale farmers who have different characteristics in term of skill of farm management and resource endowment. The government should also prepare better access to loans with low interest rates for farmers who are interested in smart agriculture technologies and groups of service provider, also adjusting government's annual budget ceiling to support all smart agriculture programmes in long term.

Recommendation

From the interviewed with intended participants, the recommendations could be divided into three relevant parts which are (1) farmers (2) government officers and policy maker (3) government and minister of agricultural and cooperative.

For Farmers: To make good progress for smart agriculture system, the farmers should prepare for the following actions: (1) Attending the training program about smart agriculture project which organized by the government through the Local Agriculture office. (2) Working as a group of farmers or join up with a large-scale farm group or cooperative farm group to be able to buy some expensive tools to use together. Record and collect some important agricultural data as statistics in order to improve the future farming. (3) Following information from MOAC continuously in order to be able to receive assistance from the government in case, such as receiving grants in case of damaged from disaster on agricultural products according to the rules set by the government, also the farmers can prepare or preventing their farms in case of outbreaks of diseases and insects. (4) For difficulty in accessing loan to improve smart agriculture farms, the farmers should follow the government policy, such as special low interest rate loan for large-scale farming. Furthermore, the farmer can contact the Bank of agriculture and agriculture cooperatives for other loan to improv their smart agriculture farms. (5) Recording and collecting some important agricultural data as statistics in order to improve the future farming.

For Government Officers and Policy Makers: (1) Keep looking for more information on smart agriculture theoretically and practically including the use of tools, machines and equipment that use high technology such as intelligent water control systems for farming (handy sense) in order to be able to give a good advice for the farmers. (2) Organizing smart agriculture programs and setup some visiting program on successful smart agriculture farm for farmers to study. (3) Informing all information and news about agriculture matters to farmers in terms of protection and prevention against natural disasters and outbreaks of diseases and pests, as well as disbursement of money in case of farmers requesting compensation for damaged agricultural products. according to the framework set by the government. (4) Becoming a good coordinator to contact relevant agencies such as Department of Water Resource, Department of Local Administration on the matter of water management and to assist the development of small water sources for the farmer, National Land Policy Committee for land ownership issue.

For Government and Ministry of Agricultural and Cooperatives: (1) Implementing the Twenty-Year National Strategy, especially the issue of increasing the area of irrigation system in rain agricultural areas to meet the target by supporting adequate budget. (2) Expanding and increasing the efficiency of Wi-Fi system throughout the country so that the farmers can use their high technology equipment which use Wi-Fi system everywhere in the farm.

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