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

BY

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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 (SDGs) of the United Nations (UN). 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. The research also gives proper recommendations for improving the agricultural sector such as promoting and providing knowledge and training skills about smart agriculture to both farmers and the officers, preparing better access to loans for farmers and group of service providers, and adjusting government's annual budget ceiling.

(Total 141 pages)

Keywords: Smart Agriculture, Agriculture, Thai Farmer

Student's Signature …..... Thesis Advisor's Signature .....

Table of Contents

Table of Contents (continued)

List of Tables

Page

Table

List of Figures

Page

Figure

Abbreviations

AI	Artificial Intelligence
AFOLU	Agriculture, Forestry and Other Land Use
DSS	Decision Support System
FAO	Food Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographic Information System
GPS	Global Positioning System
ICT	Information Communication Technology
IFAD	International Fund for Agricultural Development
IoT	Internet of things
IPCC	Intergovernmental Panel on Climate Change
MAP	Modern Agricultural Platform
MDGs	Millennium Development Goals
NESDP	National Economic Development Plan
NSTDA	National Science and Technology Development Agency
PA	Precision Agriculture
R&D	Research and Development
RS	Remote Sensing Technology
SDGs	Sustainable Development Goals
UAV	Unmanned Aerial Vehicle
UN	United Nations

Chapter 1

Introduction

1.1 Background and Significance of the Problem

For Thailand, agriculture has long been regarded as the important backbone for Thai economy. Minister 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 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).

Thailand has the area of 323 million rais (1rai is equal to 1,600 square meter). The areas over 149.20 million rais of the country accounting for 46 percent of the total area is used for agricultural activities in planting, livestock and fisheries (Office of the National Water Resources, 2021).

For national level, agricultural sector, especially in term of farming play an important role in improving food security and nutrition for people in the country. It also helps create employment and income for many Thai population, especially during adverse circumstance, such as during COVID-19 epidemic. Agriculture could be one of the best solutions for unemployed labours from all sectors who went back to their hometown for agricultural sectors (Suwannarat, 2011). On global level, Thai agriculture is very well-known as one of the major agricultural exporters. 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 in priority as evident in the annual budget plan.

Each year new agricultural-related projects and cooperatives created by the Ministry of Agriculture and Cooperatives (MOAC) are announced, and large sums of cash are injected into the rural economy in order to eliminate agricultural issues at its root. Recently, in fiscal year 2019, approximately 6.2 billion USD is earmarked for the MOAC in order to promote Thailand's agriculture and Thai farmers' wellbeing (Thairath, 2019). Yet, the problems in Thailand's agricultural sector that will be mentioned as follows still remain the same every year.

For international perspective, according to the World Bank Development indicators, Thai agriculture sector has similar patterns of changes in the percentage the utilization of agricultural land, the percentage of agricultural labour force to total labour, as well as the percentage of agricultural value add to Gross Domestic Product (GDP) relative to neighboring countries (i.e., Myanmar, Laos, Cambodia, Philippines, Vietnam) and compared to other leading countries (i.e., the United State, Australia, Netherland, China, India). However, Thai agricultural value added per worker has slower growth and is a lot of lower than the agricultural value added per worker of other leading countries, such as United States, Netherlands and Australia (Attavanith, Chantarat, Chenphuengpawn and Mahasuweerachai, 2019) as shown in Figure 1.1

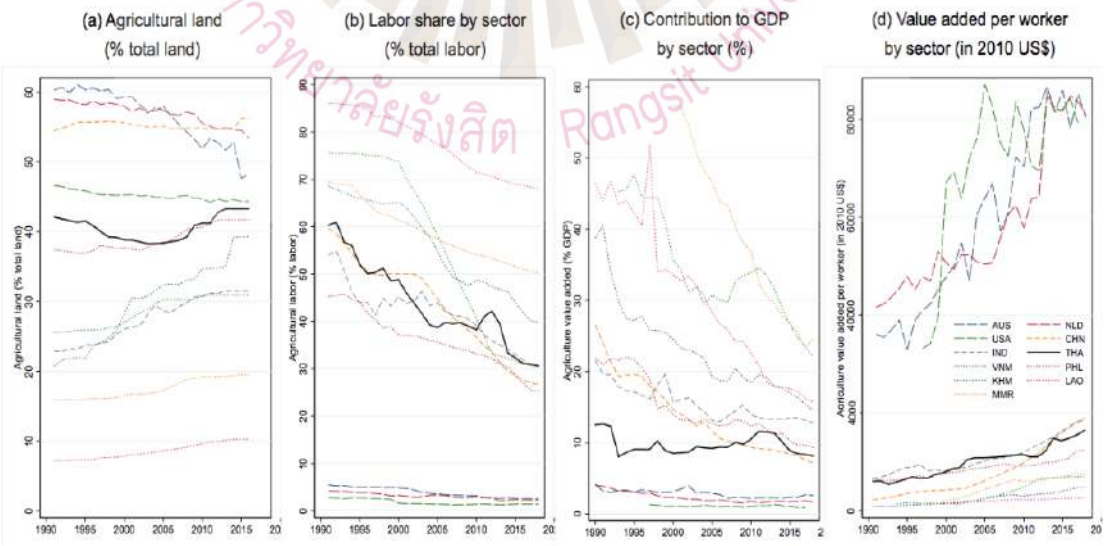

Figure 1.1 Thai Agriculture Relative to the Rest of the World

Source: Attavanith et al., 2019

For national perspective, Rieber (2013) mentioned that Thailand has experienced high GDP growth and development in the past several decades, changing from a low-income to middle-income country mainly because of an increase in agricultural output. Nowadays, agriculture has declined in importance. However, the rapid growth in industrial sector has restructured the Thai economic. Thailand has shifted its concentration to industrial and service sector leaving the agricultural sector a less important contributor (Suwannarat, 2011). In 2019, the agricultural sector has generated the lowest value added per worker with the slowest growth relative to other economic sectors and contributes only 8.0 percent of Thailand's GDP which becomes small compared to other sectors to GDP, while it employs approximately 31.62 percent of total labour force (Plecher, 2021). The industrial sector employs only around 22.63 percent of total labour force, but it accounts for 33.4 percent of total GDP, while the service sector employs around 45.75 percent of total labour force which accounts for 58.59 percent of total GDP (O'Neill, 2021) as shown in Figure 1.2 and 1.3

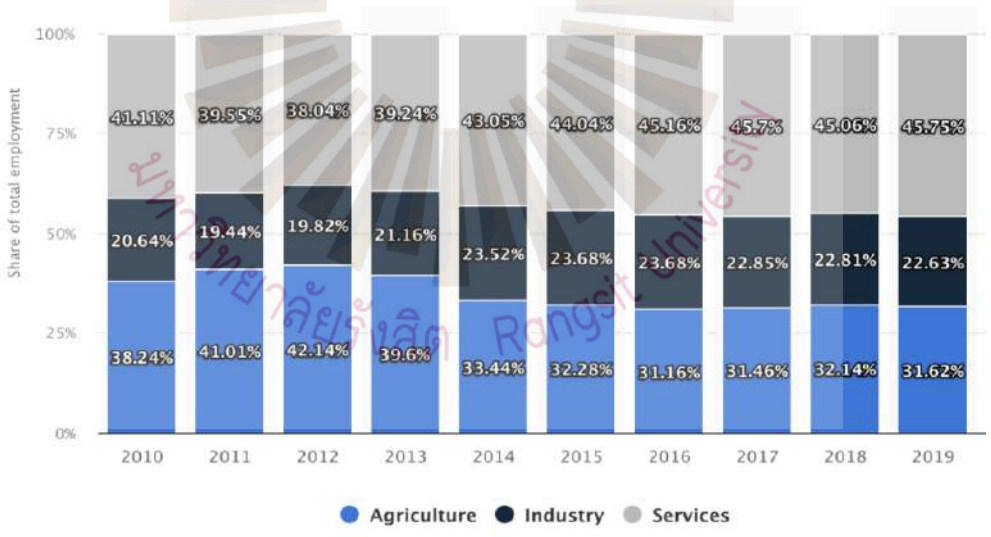

Figure 1.2 Thailand: Distribution of Employment by Economic Sector

From 2010 to 2019

Source: Plecher, 2021

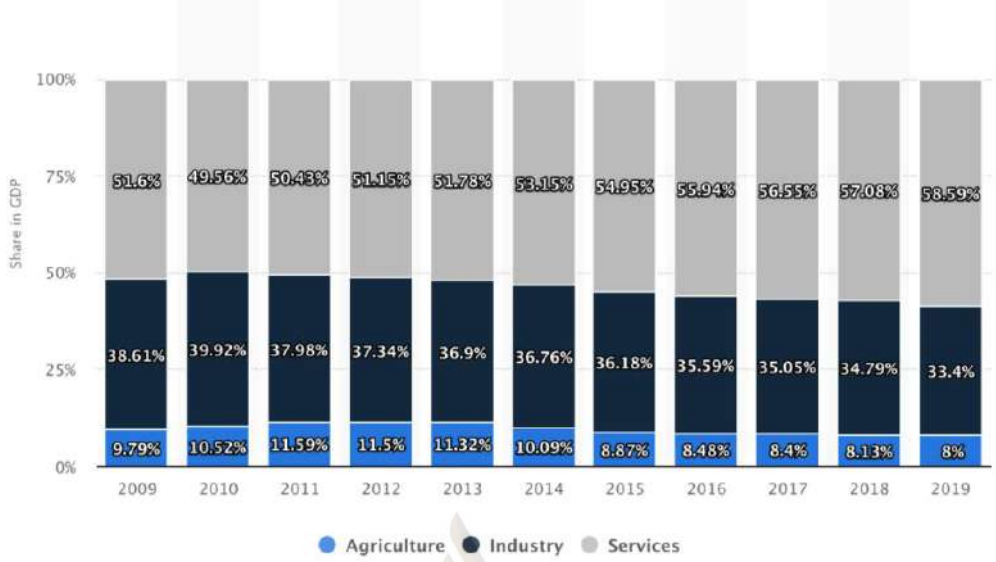

Figure 1.3 Thailand: Share of Economic Sectors in the Gross Domestic Product (GDP) From 2009 to 2019

Source: O'Neill, 2021

Moreover, the statistic record also showed that since 2014, GDP of Thailand's agricultural sector started decreasing significantly. An average of GDP of agricultural sector was about 1.46 billion baht in 2013. Since then, it has continued to decrease down to 1.22 billion baht in 2015 (Post Today, 2019). Although there was an improvement of GDP on agricultural sector, especially in 2018, after that the GDP has been declining significantly. The growth rate of Thai agricultural sector's GDP was unstable as shown in Figure 1.4 (Office of Agricultural Economic, 2020).

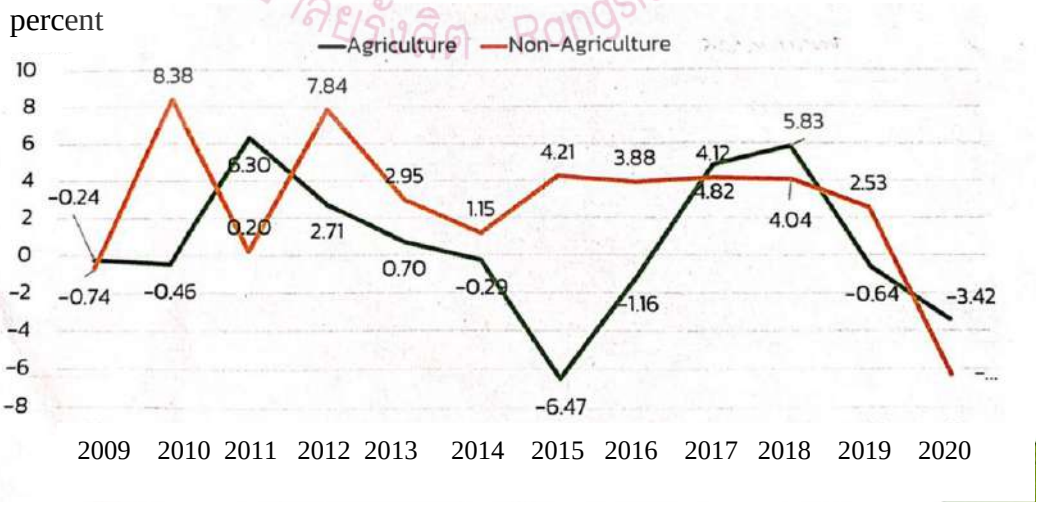

Figure 1.4 Thailand: the agricultural gross domestic product (GDP) growth rates

Source: Office of Agricultural Economics, 2020

Besides the fact that agricultural sector can be considered as an important driver of national GDP growth, it can also help reduce poverty, especially rural poverty which is still a problem in Thailand (Rieber, 2013) and provide food in order to meet a demand of population in the country.

According to Sustainable Development Goals (SDGs) applied by the United Nations' (UN) member states in order to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030 (United Nations Development Programme, 2021a), reducing poverty reduction and food insecurity, especially among the poor and vulnerable persons are what SDGs prioritized (Obaisi, 2017). Thus, the SDG 1 which is trying to end poverty in all its forms everywhere and SDG 2 which is ending all forms of hunger and malnutrition, making sure that people have sufficient and nutritious all years as well as promoting sustainable agriculture and supporting small-scale farmers (United Nations Development Programme, 2021b, 2021c) are very significant for SDGs.

These two goals are directly influenced by the performance of agriculture as QU Dongyu, the Director-General of the Food and Agriculture Organization of the United Nations (FAO) stressed that investing in agriculture, especially the development for small-scale production is very important for food security and poverty reduction than investment in other sectors (Food and Agriculture Organization of the United Nations, 2020). Achieving these UN ambitious goals will require the engine that improve the agri-food sector. Agricultural technologies hence are rapidly evolving in the world's society as a new approach that modifies society in general including agricultural sector. Several innovations, agricultural technologies, such as modern farming has been used as a new adaptable approach to make agricultural sector more sustainable, prospective and productive (Juhari, 2021; Musa, Basir and Luah, 2022).

Thailand is also the country that is still facing the problems of poverty. According to the World Bank Report, between 2015 and 2018, the poverty rate in Thailand increased from 7.2 percent to 9.8 percent–the absolute number of people living under the poverty line rose from 4.85 million to more than 6.7 million (World Bank, 2020b).

Most of the poor are living in rural area and mainly come from agricultural households, particularly in Northeastern regions of Thailand (World Bank, 2022a). According to the Bank of Thailand's Puey Ungphakorn Institute for Economic Research, in 2018, 40 percent of Thai farming households are living under the poverty line, set at 32,000 baht a year. Thus, the quality of life among Thai farmers is declining with increasing debts. About 30 percent of farming households have debt levels above the average annual farming income per person and 10 percent have more than three times higher debt (Banchongduang, 2018).

In term of food security and food supply, according to Population Reference Bureau's report in 2020, the world's population is expected to reach 9.8 billion in 2050 (25 percent from the current population) (Kaneda, Greenbaum and Kline, 2020). Thus, food demand is also expected to increase between 59 percent to 98 percent by 2050 (Elferink and Schierhorn, 2016). This has raised concerns on the challenge of sustainable agriculture and food security.

It has been indicated that there are large numbers of people who are undernourished and poor amid rise in population worldwide and most of them depend on agriculture for their livelihoods (Obaisi, 2017). For Thailand, the problems of malnutrition, according to Biodiversity, Sustainable Agriculture, and Food Sovereignty Action Thailand Foundation (BioThai)'s annual report, about 6.5 million Thais still suffer from malnutrition and hunger and more than 600,000 Thai children suffered from malnutrition (Rujivanarom, 2018). Moreover, more frequent disasters happening nowadays also impact agricultural products. This can lead to a more serious food insecurity when the farmers cannot respond to the increase of food demand in the country (Aon Benfield, 2012). These represents that Thailand still has challenges to reach the goal of no poverty and zero hunger.

As already mentioned at the beginning, most of agriculturalists are earning their living by only farming (planting seeds or crops and growing edible plants). Thus, crop production, especially rice can be considered as a significant agricultural sub-sector that affects the Thai economy, national GDP and labor force (Singhapreecha, 2014).

This sub-sector can also play a significant role in ending poverty and hunger problems as well as improving life of people in farming sector who are typically the poorest and still vulnerable. In order to improve agricultural sector and eliminate its problems, the problems of growing plants or crops should be hence prioritized and focused.

The problems in Thai farming system can be divided into three main problems which are:

1) The problems of Thai farmer which consists of two important aspects:

Firstly, Thai agricultural sector is facing an ageing problem of the farmers. The average age of Thai farmer has been steadily on the rise. Thai farmers become ageing. They are now, on average, over 50 years old. Between 1993 and 2013, the proportion of farmers aged 45 years old or more double from 23 percent to 52 percent, and 12.5 percent of farmers are now more than 65 years old. Moreover, according to the report from Nation Thailand, there are only 1,700 farmers aged under 20 years (Nation Thailand, 2018).

This imbalance in the numbers across ages in Thai farmer demographics is due to a massive career shift and Thai social norms. Nowadays, young people are uninterested in farming. Thai baby-boomer farmers worked very hard to raise their children with a better education hoping that they could escape poverty by increasing their off-farm income particularly in services and manufacturing. (Kamsow, 2018). Furthermore, some of the farmers believe that agriculture should be only their secondary means of income which will guarantee their livelihood (Tonsri, 2012).

The ageing problem will become more serious and pose a serious threat to food security as well as productivity of farm in the near future because most of ageing farmers neither know how to access to any technical knowledge nor new technologies. Thus, they can rarely take an advantage of technology, digital innovation and information for farming (Longindarat, 2011).

Secondly, a farm labour shortage as the number of agricultural labours has gradually decline across the region, while the demand of global food is increasing. This trend happens because farmers always faces the same problems in agricultural sector.

Both the increasing number of ageing famers and the labour shortage in agricultural sector can become a serious threat to food safety, agricultural production process, and stable livelihood of people Thus, it is urgent to improve agricultural sector and encourage Thai farmers to do their farms (Kwanmuang, Pongputhinan and Jabri, 2020).

2) The problems of Thai farm which consist of two aspects:

Firstly, Thai farm is facing a decrease in the average size of small-scale farm. The majority of Thai farmer are smallholders who are holding a small size of farm. Moreover, the size of farmland has also continued to decrease over the past number of years in every region of Thailand due to, for example industrialization, urbanization, land policy, property rights as well as land and labour market (Kwanmuang et al., 2020). A small plantation area can affect productivity of the agricultural sector. Thus, half of farming households are still having productivity levels below the mean (Nations Thailand, 2018).

Secondly, the farmers are facing a large inequality in land ownership. The report revealed that around 40 percent of farm households do not have land ownership (Attavanith et al., 2019). If the farmers still do not have land ownership, it will be difficult for them to do efficient farming because the farmers will have only few alternatives to improve their productivity.

3) The problems of Thai farming which consists of two important aspects:

Firstly, the traditional characteristics of Thai farming need to be improved. Thai farmers normally work on small-scale or family-run farming and they still grow only monoculture.

With small-scale farmers, the famers have to pay for high cost of all materials. Raw materials, fertilizer, tools and other accessories for farming become more expensive when they buy in small quantities. They also have to face the problem of less scope production. Farmers cannot take advantages of the use of the machinery (farm solution,2016). While growing monoculture crops, farmers always obtain small yield. Furthermore, farmer may take the risk of low market price (Attavanith et al., 2019).

Secondly, Thai farming is also facing a large inequality in the access to natural resources, especially water resources which is one of the most important assets for agricultural sector. Thailand has an agricultural area around 149.2 million rais, but only 33.8 million rais come under fully irrigation system. Others still depend on the rainy season to produce water for agriculture (Ministry of Agriculture and Cooperative, 2021). Moreover, natural disasters and changing of climate change nowadays make resource problems such as floods, droughts and soil degradation become more severe (Udomkerdmongko and Chalermpao, 2020).

For many years, the Thai government has tried very hard to eliminate the problems of farming sector. However, existing agricultural policies tend to put an importance on short-term assistance that did not solve the problems at its root, for example the policy of supporting certain amount of money to farmer for the preparation of growing rice, also to subsidize the price of crops such as rice, tapioca, palm and rubber. Moreover, much of the government's expenditure on agriculture focused more on activities, such as dam construction as well as road and railway building, which were designed to promote commercialization and greater production for export, rather than on activities that would directly uplift farmers' life and rural incomes, such as land reform, and support for smallholder technological innovation (Thaiprasert, 2006).

Now, Thai government is realizing the importance of agricultural sector and trying to overcome all the problems faced in this sector. The government is thus trying to reform its agricultural policies by applying modern technologies and innovative instrument to agricultural sector for example smart agriculture and smart farmer in order to improve agricultural productivity and create sustainable agriculture. Furthermore, the

government has also tried to invest in research and development (R&D) and knowledge. These new approaches will help strengthen incentives for Thai farmers, especially young farmers to achieve sustainable productivity growth in the future.

In 2018, the Thailand government released a clear long-term development framework called 'The 20-Year National Strategy Framework (2018-2037).' Thai 20-year National Strategy is the master plan that runs in line with Thailand 4.0 policy started by the government in 2017 which are aimed at bringing Thailand into the digital world and achieving more advanced living standards (Garnjanakarn, 2019). This National Strategy is also crucial as it will provide Thailand a long-term direction for SDGs (East-West Management Institute, 2018). Through its vision –'Thailand becomes developed nation with security, prosperity and sustainability in accordance with the principle of Sufficiency-Economy Philosophy (SEP)'–,Thailand will turn into a developed country with the high-income rate and can bring a good quality of life to Thai people by 2037.

All sectors have to work in accordance with the 20-year National Strategy including agricultural sector led by MOAC. The six strategies comprising this national strategy are: Strategy on Security, Strategy on Competitiveness Enhancement, Strategy on Developing and Strengthening Human Capital, Strategy on Broadening Opportunity and Equality in Society, Strategy on Eco-Friendly Development and Growth and Strategy on Public Sector Rebalancing and Development. Agriculture is mainly responsible for enhancing national strategy on competitiveness by using the concept of 'Value-Added Agriculture'. This concept has tried to upgrade productivity in term of quantity, value of product and product diversity.

'Smart Agriculture' is one of agriculture's strategy that is under Thailand's 20-Year National Strategy on Competitiveness Enhancement that was created in order to achieve Value-Added agriculture and improve agricultural sector. With Smart Agriculture strategy, the government will drive agriculture sector through modern technologies, innovations and knowledges (National Strategy Committee, 2018), while helping develop Thailand's agriculture and in long term, can help Thailand to achieve the goals of the

20-year national strategy as well as SDGs, especially the goals of eradication poverty and hunger by 2030.

Moreover, since there are many problems occurred in agriculture sector which are mainly a declining of average farm size as well as an increasing number of ageing farmers and labour shortage, while the demand of global food is rising, Thai farmers will inevitably have to apply Smart Agriculture strategy in the future. Although, Smart Agriculture can be considered as one of important tools used by the government in order to bring prosperity to Thai agricultural sector, Smart Agriculture is facing many constrains that could arise, for example a large number of Thai farmers are lack of technology knowledge and capital, a technological unemployment as well as knock-on impacts on rural people (Kwanmuang et al., 2020). Thus, the government needs to focus more on researches, invention and development of smart agriculture technologies that are suitable for Thai farmers in order to prepare the long-term plans for any problems in the future.

Since there are not many researches studying about Smart Agriculture, therefore this research will examine the effectiveness and implementation of Smart Agriculture used in Thailand's agricultural sector in order to identify its existing benefits and problems experienced by Thai farmers. These benefits and problems will offer appropriate further development plans and solutions for better effectiveness of Thailand's Smart Agriculture strategy. The more effective of Smart Agriculture will help to reduce the problems faced by Thai famers at the root in various areas, hence reducing poverty and hunger or food insecurity problems. Without the clearly identify benefits and problems of Smart Agriculture and taking steps to create long-term development plans as well as solve the problems, Smart Agriculture strategy would not effectively create any developments or changes for Thailand's agricultural sector and Thai farmers.

1.2 Research Objectives

1.2.1 To examine the current situation of Thai farmers working in agricultural sector.

1.2.2 To analyze the benefits and problems of Smart Agriculture used by Thai farmers.

1.2.3 To propose the solutions for Thai government in order to have the effective of Smart Agriculture strategy for Thai agricultural sector and farmer.

1.3 Research Questions

1.3.1 What is the current situation of Thai farmers working in agricultural sector?

1.3.2 What are the benefits and problems of Smart Agriculture used by Thai farmers?

1.3.3 What would be the appropriate solutions for Thai government in order to have the effective Smart Agriculture strategy for Thai agricultural sector and farmers?

1.4 Definition of Terms

Farmers in this research means people who own or manage a farm as well as grow any kinds of plant as a business in Ayutthaya province, Thailand.

Agriculture in this research means the art or science or practice of faming which includes only cultivating the soil, growing crops or raising plants as farming which includes only cultivating the soil the soil, growing crops or raising plants as well as the preparation of plant products for people to use and their distribution to markets. It does not include forestry, hunting, fishing and livestock production.

Smart Agriculture in this research is the concept that used in order to create effective agricultural production management. It emphasizes the use of modern technologies and innovations as well as new knowledges in farm management, for example precision agriculture, geo-informatics technology and Internet of Things or IoTs in order to enhance productivity and farmers' profits, while the farmers can reduce losses and cost as well as labour requirement. Smart Agriculture also enables and encourage more people to join agricultural sector and to help facilitate market in the future.

Chapter 2

Literature Review

It is necessary to study about the situation in the world agricultural sector and Thai agricultural sector and the use of modern technology in this sector because Thailand's agriculture is facing many challenges, while the rural people and developments still depends on agriculture. All problems thus, affect farmers' life and the success of Thai agricultural sector in the future.

Smart agriculture is one of the solutions that can help enhance Thai agricultural sector's potential and help Thai farmers overcome the problems or limitations. However, as smart agriculture is a new approach, it does not only have many advantages, but also have constrains when implementing to farmers. The government still needs cooperation on the researches and invention in order to develop technologies that are suitable for Thai farmers and prepare any impacts happening in the future.

This chapter will present the overview of Thai agriculture and farmers, the case studies of smart agriculture as well as other issues related agriculture, the contents will be as follows:

1) The importance of agricultural sector

2) Overall situation of smart agriculture implementation both in the world and Thailand

3) Concepts of smart agriculture

4) Successful countries in smart agriculture management

5) Laws and plans related to smart agriculture

6) Agricultural management model related to smart agriculture

2.1 The Importance of Agricultural Sector

This section examines and studies about the potential role of agricultural sector in long- term countries' economic growth and development. There are many scholars who study about a linkage between agricultural sector and overall countries' development. The improvement of agricultural sector has been seen as opportunities for countries' development. It can make impact in countries which can be divided into three areas which are economic impact, social impact and environmental impact as (Food and Agriculture Organization of the United Nations (2018) stated that a sustainable food system (SFS) is profitable (economic sustainability), has broad benefits to the society (social sustainability) and a positive impact on the natural environment (environmental sustainability). Moreover, Juhari (2021) and Musa et al. (2021) also stated that having a sustainable agri-food sector can give positive impacts in aspects of the economic, social, and environment. And Juhari also emphasized in the research that implementing smart agriculture is one of important strategies that can help create sustaining the agri-food and agriculture.

The next section will discuss about how agricultural sector can contribute positively to national or global effects in aspects of the economic, social, and environment.

Firstly, agriculture play significant role in economic growth. Musa et al. (2021) mentioned that smart agriculture has the potential in making agriculture more sustainable and profitable by reducing costs of production and resource inputs. Developing agricultural sector by, for example promoting innovation such as smart agriculture is important for country's competitiveness and productivity developing agricultural sector, such as by promoting innovation such as smart agriculture is needed. Not only that, using technologies in agricultural sector can also help farmers to get connected with potential consumer directly, thus, shortening the supply chain.

Moreover, Lin (2018) dean of Institute of New Structural Economics (INSE) at Peking University stated in his article "Agriculture is Key for Economic Transformation, Food Security, and Nutrition" that agriculture plays an important role in transforming economies in developing countries and helps those countries to reach high-income status, along with achieving other essential development goals, such as ensuring food security and improving nutrition. Thus, in order to end hunger and undernutrition while accelerating economic growth, Thus, agricultural transformation must become a reality. According to Lin, one country that can be a good example is China. China improved its agriculture and went through an economic transformation that can accelerate growth and reduced hunger and undernutrition. China's rapid growth in GDP per capita in current US dollars from $155 to $8,123 between 1978 and 2016 was due to agricultural transformation.

Traditionally, the importance of agriculture in economic development is normally reflected by its contributions to its share in Total Value Added (TVA) (Chikwama, 2014) and Gross Domestic Product (GDP) (Meijerink and Roza, 2017). Jatuporn Jatuporn, Chien, Sukprasert, and Thaipakdee (2011) examined whether agricultural growth led to overall economic growth, or vice versa. They found that there is a virtuous cycle between agriculture and GDP, with each contributing to the other.

Johnston and Mellor (1961) identify five types of inter-sectoral linkages that emphasize agriculture's role in economic growth. These linkages were operating though both production and consumption which include:

1) Providing food for domestic consumption
2) Releasing labour for industrial employment
3) Enlarging the market for domestic industrial output
4) Increasing the supply of domestic savings
5) Earning foreign exchange

Meijerink and Roza (2007) and Chikwama (2014) also mentioned about the linkages between agricultural sector and a growth in the national economic that agriculture is likely to contribute to growth in the national economic through its linkages

with the non-agricultural sectors. Agriculture's growth can be viewed from the perspective of its linkage to other sectors that are supplied by the farming industry which is called "forward linkage" or "agricultural growth linkage". This backward linkage implies that growth of the agricultural sector will increase demand of goods and services in non-agricultural sector (the local rural economy). Rural income growth and growth in consumption from farm households can increase due to increased outputs or crop productivity. Thus, that increasing income of each household is re-spent on other local goods and services that would not have had a market. The growth in non-agricultural sectors can further raise demand in the economy and fuel growth further. This process is referred to in economic literature as the "multiplier effect".

For the forward linkage, besides the fact that agriculture can improve national economic growth by through growth in consumption and rising incomes, Chikwama (2014) claimed that increasing agricultural outputs will help overcome supply constraints to downstream industries and thus supports their growth and development.

In order to talk about the role of agriculture in developing national economy, while other scholars emphasized the linkage or relation between agricultural sector and other sectors, Hazell and Diao (2005) mentioned that the engine of economic growth consists of tradable goods that can be sold, usually into deep markets (a market in which a large number of products can be transacted without affecting the price) abroad. These tradable consists of agriculture, services, manufacturing and oversea migration (in form of remittances). While, Dollar and Kraay (2004) stated that the openness to trade has been a central element of successful growth and it can help accelerates development. For agricultural trade, it normally affects two groups of developing countries. First, major exports will get a profit from increased access to market in other development countries. Second, major importers can get profit from cheap subsidized food imported from developed countries. Moreover, if importers import non-subsidized agricultural products, consumers in developing countries will have to pay higher prices for products. Thus, domestic agricultural producers can be able to compete with the imported products (Chikwama, 2014).

For the potential of agricultural sector to contribute social impact is that firstly, better agricultural sector can contribute to a positive social impact, for example 4.0 agriculture has the potential to boost youth involvement in agriculture. A good agriculture has to take into account all groups categorized by gender, age, race and so on. This is because farmers in agricultural sector are the aging farmers, as youths do not want to participate in this kind of field. However, agriculture 4.0 make it possible for the youth to participate in agriculture as it is more efficient. The use of new technologies in agricultural sector can show to youth that agri-business is profitable business (Musa et al., 2021).

Secondly, good agriculture needs to contribute to the advancement of important socio-cultural outcomes, such as nutrition and health. Agriculture can be considered as an important mechanism for feeding the world's population. Good agricultural activities could have positive impacts on people health and nutrition in various ways, for example:

1) As The demand for the future global food and agricultural products is increasing because of population changes not only in population in absolute numbers but also population dynamics such as structure by age groups, and location (rural and urban) (Food and Agriculture Organization of the United Nation, 2017). The world's population may reach 9.9 billion people in 2050 (Kaneda et al., 2020). The growth of population also comes along with demand for food. Nowadays, roughly 795 million people, or one in nine, of people in the world are suffering from chronic undernourishment. Most of them are low-income labour who live in rural areas. In order to address the problems, short term solutions to food insecurity include social protection programs such as food aid, while for long-term solutions developments in local agriculture such as investment in sustainable technologies, such as smart agriculture in order to increase agricultural productivity that will be crucial for both meeting the demands of a growing population and adapting to environments increasingly affected by climate change (Ebeid, 2017).

2) According to Fan (2015), cops are produced not only for the market but also for people's consumption. As already mentioned, if households' ability to produce increase, people then can purchase or consume more better and cheaper food. Agricultural

advances, such as applying machineries and technologies in farms, led to the doubling of production and yields, improving the well-being of many people.

3) Fan also mentioned that agriculture can contribute to nutrition and health through an increased rural income that allow people to improve their diets, especially the poor that mostly locate in rural areas. Since an agriculture has potential to greatly reduce poverty, the poor have more opportunities to improve their health and undernutrition. Moreover, agricultural activities can also generate economy-wide effects such as increasing government revenues to fund health, infrastructure and nutrition intervention programmes.

Thirdly, sustainable agriculture can generate benefits or economic value-added for all stakeholders, such as wages for workers and profits for enterprises. Thus, good agricultural system will generate wealth that contributes to poverty reduction (Food and Agricultural Organization of the United Nations, 2018).

According to the World Bank (2021) and Christiaensen and Martin (2018), agriculture is one of the most important tools to end extreme poverty. A growth in agriculture is in general two to four times more effective at reducing poverty than an equivalent amount of growth generated in other sectors. Therefore, the focus should be mainly on the agricultural sector. There are a lot of evidences that agricultural growth contributes to reducing the poverty which are:

1) Improving agricultural growth in rural areas would give rural people a better access to land, water, health assistance and education which could help increase productivity. Thus, agriculture is essential to alleviate poverty as agriculture improve people's life and create higher income for farmers which include smallholders who constitute a large share of the rural poor (Food and Agriculture Organization of the United Nations, 2005).

2) Improving the agricultural sector has implications for poverty reduction if migrant workers returned to rural areas from the cities, it could help alleviate urban unemployment as it rises rural employment both for upstream from the farm in demand for inputs and services for agriculture and for downstream from the farm in the demand for processing, storage, and transport. Coxhead and Plangpraphan (1998) mentioned

that if agriculture were more important in the economy, it could provide a “safety net” for economic slowdowns.

3) An increase in agricultural output tends to decrease food prices and benefit consumers or purchaser of food which may include farmers themselves. The poor, both in rural and urban areas that have to spend their incomes on food also benefit relatively more. In term of farmers and food producers, however, the lower price of agricultural product may affect farmers’ business (Chikwama, 2014), thus technologies in agricultural sector play an important part to reduce the production cost in agriculture and hence benefit both farmers and buyers.

Lastly, on the environmental dimension, sustainable agriculture is determined by ensuring that the impacts of agricultural activities on the surrounding natural environment are neutral or positive. Sustainable agriculture aims to improve the better quantity and quality of agricultural product, while taking into consideration biodiversity, animal and plant health as well as reducing the carbon footprint, the water footprint, food loss and waste, and toxicity (Food and Agriculture Organization of the United Nations, 2018).

2.2 Overall situation of smart agriculture implementation both in the world and Thailand

2.2.1 World’s Smart Agriculture Implementation

Agriculture occupies nearly 40 percent of the earth’s surface, far more than any other human activity (World Bank, 2020a). Agricultural sector still supports the livelihood of over 2.6 billion people around the world, most of them is in low-income developing country, representing one thirds of all workers (United Nations Environment Programme, 2018). In least developed countries and countries who are experiencing rapidly rising populations, their workers can hardly enter into formal wage employment, they are thus, engaged in self-employment or unpaid family work, which is agricultural sector, especially subsistence farming. During an economic recession, employment

growth in the countries where their people depends on agricultural sector tends to be less impacted by economic downturns compared to industrialized countries where the workers work in the business cycle (Food and Agriculture Organization of the United Nations, 2012).

The world has been trying to improve agricultural sector by apply agricultural technology such as in 1960, there was an agricultural technology revolution or the first green revolution which leads to great increases in agricultural productivity. Increased productivity at that time came from changing farming methods that relied on the maintenance or development of plants, mainly for food product, chemical fertilizers and heavy irrigation system. This change helps address the issue of malnutrition in the developing world, especially in Asia between 1961 and 2004. (World Bank, 2008). According to Walter, Finger, Huber and Buchmann (2017), agriculture now is in. a fourth revolution as a result of the increasing use of ICT in agriculture. The fourth industrial revolution is a popular term and remains a growing interest in many countries. The summary of agricultural revolution can be shown in Table 2.1

Table 2.1 Agricultural Revolution

The first agricultural revolution	Occurring when humans started farming around 12,000 years ago.
The second agricultural revolution	The reorganisation of farmland from the 17th century onwards that followed the end of feudalism in Europe.
The third agricultural revolution (the green revolution)	The introduction of chemical fertilisers, pesticides and new high-yield crop breeds alongside heavy machinery in the 1950s and 1960s.

Table 2.1 Agricultural Revolution (Cont.)

The fourth agricultural revolution (much like the fourth industrial revolution)	The anticipated changes from new technologies, particularly the use of Artificial Intelligence (AI) to make smarter planning decisions and power autonomous robots. Such intelligent machines could be used for growing and picking crops, weeding, milking livestock and distributing agrochemicals via drone.

Source: Rose and Chivers, 2020

However, nowadays the production of agriculture is reducing and the yield per unit area of agriculture is also reducing, while the employment growth in world agricultural sector has declined since 2000 as there was a decrease in the importance of agriculture because of fast growth and industrialization as well as a change of population structure, such as out-migration urbanization. The role of service sector has gradually become more important than agriculture (Folnovic, n.d.). As a result, the global agricultural sector has not yet been able to meet the demand for the global food and agricultural products and end the hunger and malnutrition issues according to the United Nations's 2030 Agenda for Sustainable Development Goals (SDGs) (De Clerq, Anshu, and Alvaro, 2018)

While the world's agricultural sector still cannot meet SDGs, it is facing new challenges in many areas which are:

Firstly, by 2050 the world will need to produce around 70 percent more food to feed its population of 7.8 billion people which may reach 9.9 billion (Kaneda et al., 2020), but the share of global agricultural GDP is reduced to 3 percent compared to GDP of 9 percent a decade ago. Therefore, the world needs new technologies and production methods to eliminate the problems of food shortages and starvation for example, with the new agricultural technologies, the farmers will determine to use water and fertilizer with various amount according to the land location and also the local climate change, with the result of using minimal resources. (Puapongsakorn, Puntakua, and Wiwatwicha, 2020).

Secondly, the national resources, especially agricultural land and water nowadays, are not be as fertile as in the past. More than 25 percent of the world's agricultural land had become degraded due to the use of mono crop mainly for food. Furthermore, some farmers take up the forest and turn into farmland illegally. Agriculture is still considered as the main cause of around of 80 percent of deforestation worldwide. The agricultural sector also uses 70 percent of all water withdrawn from aquifers, streams and lakes. Global achievement in production in some countries, particularly where there is a rising population and incomes have been associated with degradation of land and water sources, and deterioration of ecosystem. (Food and Agriculture Organization of the United Nations, 2017).

Thirdly, the world is facing a global warming problem. Agriculture is not only a recipient of climate change consequence, but also one of the major contributors to greenhouse gas (GHG). Agricultural sector is responsible for roughly 21 percent of total global GHG emission. GHG emission can cause drought, more frequent and severe flooding, tropical storms, wildfires as well as heat waves (Intergovernmental Panel on Climate Change, 2007). As a result, agricultural products are highly damaged. Intergovernmental Panel on Climate Change (IPCC)'s researchers also concluded with high confidence that climate change will have substantive negative impact on food insecurity and undernutrition (Porter et al., 2014). Thus, agriculture in the future must reduce GHG at the same time and find ways to reduce the variability of agricultural products caused by climate change.

Fourthly, pests and disease outbreaks can also pose a serious risk to animal and plant life as well as the health of people working in the sector. They are considered as a biological disaster. Animal pests and diseases jeopardize food security and have board environmental, economic and social impacts. Armyworm, locusts, fruit flies, cassava diseases, banana diseases and wheat rusts are among the most destructive transboundary plant pests and disease (Food and Agriculture Organization of the United Nation, 2021).

Lastly, it is estimated that 33-50 percent of global food production (or 1.3% of global GDP) is spoiled food that must always be thrown away, although in the world there are 800 million people who are starving. These spoiled foods pose two environmental problems. First, the world agricultural sector needs 25 percent of water and land to

produce these spoiled foods. The second problem is that these spoiled foods will go to the landfill, producing 23 times more methane than carbon dioxide. The spoiled foods are the third largest source of GHG in the world (Puapongsakorn Puapongsakorn, Puntakua, and Wiwatwicha, 2020).

Therefore, all the problem mentioned has prompted the agricultural sector to come up with more productive approaches in order to solve all challenges, while create sustainable agriculture and produce high quantity and quality aiming to feed the increasing population.

2.3 Smart Agriculture in Thailand

2.3.1 Thailand's Agricultural Situation

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, 2022b). Thai farmers normally still lack in-depth knowledge about both marketing planning and agricultural production management. In addition, Kraipinit, Chantuk and Siriwong (2022) 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) Labour in agricultural sector: the population and labours 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 labours 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. (2022) 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.

All the problem mentioned 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 that can lead to more productive, profitable and sustainable food and agricultural system is needed. (Juhari, 2021; Musa et al., 2021)

2.3.2 Background and Concept of Smart Agriculture in Thailand

After agriculture 2.0 that uses machines and prepare the land for specific crop with available water irrigation aiming to reduce the effect on the environment, on the other hand, will increase the yield crop product, came a new technology called smart agriculture which make great improve to Thai agriculture 4.0. Smart agriculture plays an important role in Thai agriculture sector. It can introduce to other agriculture progress, such as precision farming, data system application for agriculture, for example agricultural map and many automatic control systems are used in the farm (Agriculture Research Developement Agency, 2018). However, Thailand's agricultural sector is still facing many challenges according to Minister of Agriculture and Cooperatives (2020) which are , for example a lack of labour, the problems of national resource, the problems of plan variety, the problems of natural disaster as well as the problems of pest and disease.

In 2018, 'smart farming' came into the spotlight as the first "National Strategy" has taken effect. Smart agriculture is one of the important national strategies of 20-year National Strategy (Agriculture Research Developement Agency, 2018). This 20-year National Strategy of Thailand will lead the country toward the vision which is: "Thailand becomes a developed country with stability, prosperity and sustainability" which means firstly, Thailand will be safe from threats and world changes in all areas which are economy, society, environment and politics. Secondly, Thai economy will grow steadily

and join the world's group of developed countries by reducing uneven development and increasing its competitiveness. Thirdly, Thailand will increase the Thai people's income and quality of life without excessive use of natural resource (Bangkok Post, 2018). In addition, the Principles of the Sufficiency Economy Philosophy have been also followed to plan Thailand's development path (National Strategy Committee, 2018).

The 20-year National Strategy consists of six primary national strategies that cover six essential areas of national administration. They will accompany the 20-year National Strategy and impose the principal methods to achieve the appointed targets. These six primary national strategies are:

1) National Strategy on Security,
2) National Strategy on Competitiveness Enhancement
3) National Strategy on Developing and Strengthening Human Capital
4) National Strategy on Broadening Social Opportunity and Equality
5) National Strategy on Eco-friendly Development and Growth
6) National Strategy on Public Sector Rebalancing and Development

In order to accomplish the goal of becoming a developed country and to achieve sustainable development, continually economic growth and increasing competitiveness will be needed. Thus, the national strategy on competitiveness enhancement is very important. It aims to make Thailand become a developed country with stable and sustainable economic growth as well as enhance the country's competitiveness by developing the country's potential and capacity in various dimensions based on three main ideologies which are:

1) Learning from the Past for Further Development
2) Adjusting the present
3) Creating New Future Values (Strategic Tranformation Office, 2019).

The National Strategy on National Competitiveness Enhancement has 5 key development guidelines which are:

1) Creating value-added agriculture which is the one that related to agricultural sector and very important. This first guideline will upgrade productivity in term of quantity and values as well as product diversity under the following concepts: the first

concept is farming that reflect local identity; the second concept is safe farming; the third concept is biological farming; the fourth concept is agro-processing industry; and the fifth concept is smart farming or smart agriculture.

2) Developing future industries and services in order to create future industries and services that can be key factors designed to push Thailand to become a developed country.

3) Creating diverse tourism in order to preserve Thailand's world-class tourist attraction and improve their quality for tourists from all over the world. 4) Developing high quality infrastructure in order to connect Thailand with the world which includes transport networks, regional development, technology and economic infrastructure, such as creating seamless transport networks, developing more special economic zone (SEZs) and developing modern technologies as well as innovations. 5) Developing a modern entrepreneurship-based economy in order to promote and encourage modern entrepreneurs who are equipped with required skills, entrepreneurial spirit, the sense of competitiveness, and clear identity (National Strategy Committee, 2018).

2.3.3 The Definitions of Smart Agriculture used in Thailand

Smart agriculture can be considered as an important strategy of the second national strategy, which is National Strategy on Competitiveness Enhancement. Smart agriculture is adopted in order to upgrade Thailand's productivity in term of quantity and values as well as product diversity. Smart agriculture is also the strategy that is related to Thailand 4.0 policy It is adopted in order to make the most of Thailand's abundant resources and improve Thai farming as well as productivity.

The concept of smart agriculture or smart farming is a concept that has been widely discussed. As smart agriculture is a very recent concept, its term and concept have not reached a consensus in the scientific literature yet (Pivoto, Waquil, Talamini, Finocchio, Corte and Mores, 2017). However, scholars have defined the definition of smart agriculture as follows:

Minister of Agriculture and Cooperatives (2019) and National Strategy Committee (2018) stated that Smart agriculture is one of the important strategies of Thailand that uses technologies and innovation in every step of agricultural production process in order to enhance Thailand's potential by focusing mainly on an increase of production both in term of quality. Moreover, National Strategy Committee also mentioned in 20-year National Strategy that beside the fact that smart agriculture strategy can help increase agricultural productivity, it also helps farmers to prepare for any negative impact brought upon by many challenges, especially climate change, to promote sustainable use of resources, to ensure farming plan and to design it in accordance with each area's geographical potential, to informe farmers to be aware of all risks, to promote the use of biotechnology, while reduce chemical use in agricultural sector in order to preserve and improve all national resources, to connect related databases from related agencies and organizations for further sustainable risk management, and to prepare country's databases on farming in order to monitor climate change and irrigation maritime as well as coastal management.

Some other scholars defined smart agriculture by focusing on the importance of data and communication. For example, Manwicha (2015) mentioned that smart agriculture is a new agricultural innovation in the digital era that adopted various information and communication technologies in farm, such as Geographic Information System (GIS), Global Positioning System (GPS), remote-sensing and decision support system (DSS) through the wireless network. The process of smart agriculture consists of data collection, data diagnosis, data analysis, implementation of the plan and evaluation. This process will be used with farm management in every step and in all conditions.

Due to technology advancement, a success of 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 (humidity, temperature, pressure, light, presence or absence of certain types of artifacts, mechanical stress level, and object size) then transforms them into a signal that can be interprets and collected as data (Lehmann, Reiche and Schiefer, 2012)

Smart agriculture is a concept that undergoes a fourth agricultural revolution. It is a development that emphasizes the use of information and communication technology in the cyber-physical farm management cycle. New technologies such as the Cloud Computing and Internet of Things are expected to help leverage this development and introduce more robots and artificial intelligence in farming. This is encompassed by the phenomenon of Big Data, massive volumes of data with a wide variety that can be captured, analysed and used for decision-making (ICT) process for farm management in traditional farming practices (Wolfert, Verdouw and Bogaard, 2017)

Moreover, many researchers defined smart agriculture by using its main advantages, such as National Science and Technology Development Agency (2020) stated that Smart Farming is an effort to develop agriculture in four areas which are reducing cost of production, increasing the quality of 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.

Dr. Teerayut Tuchinda, the senior researcher in plant biotechnology research and integration stated that smart agriculture is the use of technology. Information is used in farm for better productivity, quality and efficiency of products under the limited size of agricultural area and number of workers. Smart agriculture can also bring the well-being to mankind (National Science and Technology Development Agency, 2020).

Smart agriculture is the use of science and technology to increase agricultural and food production to meet the increasing world population but using fewer inputs in order to reduce the impact on the environment as well as be able to deal with climate change. Smart agriculture will change the world's agriculture system and food chain because farmers use appropriate production factors that are good for the environment. Thus, Smart agriculture can be considered as a green technology approach, since it can reduce the ecological footprint of traditional farming and further reduce leaching problems and emissions, as well as the impact of climate change (Puapongsakorn et al., 2020).

The above definitions demonstrate that smart agriculture is the concept of using new agricultural technologies and innovations in every step of farm management as shown in Figure 2.1 in order to help improve agricultural production process and productivity as well as reduce resources and costs of production and the impacts or risks caused by many challenges and immediate changes happening in agricultural sector. With smart agriculture, the agricultural sector will be improved and could finally achieve sustainable agriculture, while farmers would have a better work-life balance and enhanced quality of life.

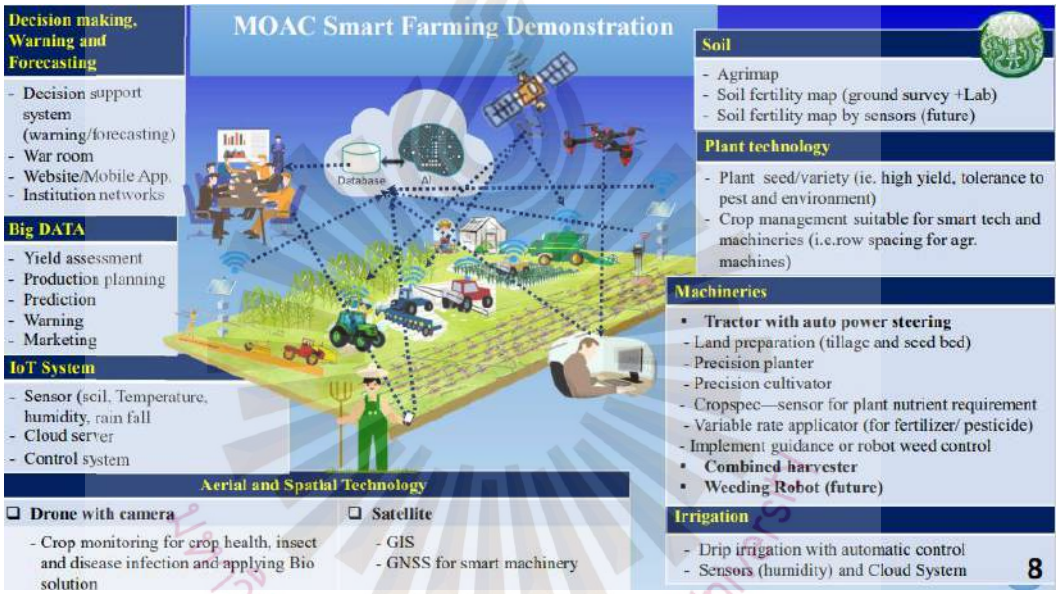

Figure 2.1 Smart Farming Demonstration

Source: Ministry of Agriculture and Cooperatives, 2020

2.3.3 The Implementation of Smart Agriculture

According to Ministry of Agriculture and Cooperatives (2020), an agricultural production process of Thailand's smart farming can be divided into two parts which are smart sensing and monitoring and smart analysis and decision.

For smart sensing and monitoring process, the main innovative agricultural technologies used in the process are:

1) Precision agriculture technology which is a part of smart agriculture. It is a technology that helps manage and cultivate so that farmers can use resources effectively. An important factor in precision agriculture is the information collected from the plot while doing activities and information obtained from other sources such as soil conditions, weather conditions, as well as knowledge of plant growth.

Moreover, as the world is entering the 4.0 era, Artificial Intelligence (AI) will play a huge role in increasing productivity. Machines and automatic system will be able to make precise decisions faster than human labor forces. Currently, the technologies have been transformed into a tractor that can be driven automatically and controlled from the distance. In the neat future, and drones or other equipment will be able to make its own decisions to do any farming activities under the observation of farmers, and only in case of emergency that farmers will do farming activities by themselves. However, AI in various machines requires continuous storage of large amount of data to make a precise decision (Puapongsakorn, Puntakua, & Wiwatwicha, 2020).

2) Geo-Informatic and Remote Sensing

Remote sensing is a technology that is used in smart farming in order to collect any necessary data at anywhere in the world. This technology will help collect data of environmental factors which is very important for crop growth. It can collect the data both from long range, such as aerial photography and satellite images, and short range, such as ground-penetrating radar (GPR) and electromagnetic induction. All the innovative technologies will provide accurate information of field variability with geopositioning. The ability to collect a large amount of data rapidly and cheaply fits with precision farming requirement (Usery, Stuart and Boydell, 1995) Moreover, Andreo (2013) also mentioned that with the use of remote sensing (RS), farmers can more precisely determine what inputs to put exactly where and in what quantities. This information helps farmers to effectively use expensive resources such as pesticides and fertilizers and herbicides. Thus, farmers who use this method would not only maximize their yields but also reduce their operating expenses, thus increasing their profits.

3) Internet of Things (IoTs)

According to The National Broadcasting and Telecommunications Commission (2018), IoT is one of the most revolutionary technologies in modern wireless communications. This technology is gaining wide interest among the research community. IoT is a conceptual framework of a network system that supports connecting devices together, such as computers, mobile phones network equipment electronic equipment, sensors which results in different systems able to communicate and can work together automatically. People can thus, access to a wider variety of information and control devices and systems effectively. It thus, can help create opportunity for very wide range of applications by connecting many different sensor devices to network. This allows a large number of different types of data to be measured or analyzed and then helps displayed the data graphically to aid decision making. The system is integrated with Big Data systems which will help analyze data that is more complex, large, and timely (Real-time). For the use of IoT in agricultural sector, there will be for example to determine the variation of soil, also to measure the temperature and humidity of soil and climate. Then, the information will be sent to the farmer's smart phone, allowing farmers to know the condition of the farm immediately and be able to plan as well as manage further cultivation. With this technology, farmers can expand their cultivation because they don't have to take care of their farms by themselves. Farmer can control the farm activities at long distance. However, IoT has significant limitations which are high cost and slow payback as well as a stable Wifi systems and a variety of industry standards for data handling of various applications.

For smart analysis and decision process, the main innovative agricultural technologies used in the process are:

1) Data Platform Management

Big data is the term that refers to breakthroughs in computer processing and analytics that allow researchers to efficiently analyze large quantities of complex data. Thus, Data platform is the platform that is used in order to create a decision support system which will help create higher productivity and analyze the solution or development guidelines for any changes that occur in production process (Brennan, n.d.).

2) Big Data (Clouds)

Data is the main factor that leads to precision farming that needs the accurate decision in order to manage agricultural production. For, the large scale agricultural farm, such as rice, sugarcane or cassava, it much relies on a making -decision system. The accurate decision is created by the use of satellites that track plants' growth. There is the relationship between aerial photographs and plants' growth. This system is suitable for creating policies and plans as well as a management of agricultural resources. For example, in Thailand, there is IoT technology system installed in the demonstration farm. This system is linked to Big Data's preparation system and then processed to present to the War Room of MOAC. The information is used for example in order to help track insects and diseases. Originally, academics were required, but now, farmers can use photo technology and image recognition, which connect to Big Data. If everything can be linked together, farmers can predict where the disease will spread out (National Science and Technology Development Agency, 2020). In conclusion, Big Data is used in order to provide predictive insights to future outcomes of farming (predictive yield model and feed intake model) derive real-time operational decisions, as well as reinvent business process (Wolfert et al., 2017).

3) Smart Intervention and Control

These mean technologies will facilitate and controlling the equipment and devices remotely, where robots have been used in agricultural operations, for example harvesting and weeding, and also drones have also been used to fertilize crops and monitor crop growth stages (Elsayed, Sameh, Mohammed, Gad and Zahran, 2021).

2.3.4 Example Case of Smart Agriculture in Thailand

Thailand is one of Asian counties that has been implementing technologies for farming efficiency. This is not only for generating the highest optimum yield with the least amount of resources and inputs but also generating lesser carbon footprint. Various organizations involving government agencies, private companies and educational institutions have launched and tried to make smart farming technologies available to small farmers. MOAC has placed high priority on smart agriculture. MOAC promoted

smart agriculture technologies through field demonstration. In 2019, it has cooperated with domestic or local government to create agricultural demons of smart agriculture. These demonstration fields are tested with six main crop which are paddy, sugarcane, maize, cassava, pineapple and tomato (Kwanmuang et al., 2020).

All the sectors both in Thailand and outside Thailand have collaborated to bring various technologies in order to apply them in the demonstration field, for example unmanned aerial vehicle (UAV), auto steering, Crop Spec, laser land leveler and weather station. Moreover, there are also the storage systems used in order to create Big Data for future efficient processing, decision-making process and future smart farming practices (Minister of Agriculture and Cooperatives, 2021).

There are many example cases of successful smart agriculture implementation, for example, the Food and Fertilizer Technology Center for the Asian and Pacific Region also conducted a field study of successful case of smart agriculture implementation. This successful farm belongs to Mr. Somboon Ngamsangiam with a cooperation and help from National Science and Technology Development Agency (NSTDA). Mr. Ngamsangiam has applied technology of plant watering control system to his durian farm in Rayong.

In the past, Mr. Ngamsangiam found that the cost of the common water pumping system using diesel fuel for durian trees each year was quite high. This happened because he did not know when the soil needed water, resulting in unnecessarily pumping water for durian trees. Thus, he decided to use technology of automatic water control system that use the sensor to measure soil moisture, temperature, air humidity and light intensity in his 50 rais farm.

By applying the automatic water control system, he could significantly decrease the production cost from using common pumping machine using diesel fuel which costed approximately 18,667 USD per year to 8,333 USD per year. This implied that he could save cost of production approximately 10,334 USD per year. Although in the first year he had to invest in technology and machine which account for approximately 26,666 USD, he could reach the breakeven point within three years. NSTDA also mentioned

that the parameters of the measurement of this system are used not only for the durian farm management, especially the water input according to the needs of durian trees during growing stage, flowering, and fruiting which helps famers to eliminate the problem of overwatering, but also helped reduce labour forces worked in farm and labour costs, production cost, production damage and control quality of fruit yield, resulting in the increase in farm revenue more than twice.

Mr. Ngamsangiam also concluded that the system of smart agriculture will be more effective if the government starts with the large-scale farming by gathering small-scale farms to collaborate into large-scale farm for reducing the production cost and sharing knowledge with each other (Kwanmuang et al., 2020).

Another example case is that Health Factory Company in Thailand uses artificial intelligence light for its indoor farming system connected with a smart control system in order to to supply organic vegetable and fruits to Thai market. The system results in high quality and high yield production under the controlled environment. Moreover, the IoT- based technologies allow farmers to plan their production, monitor and control their farming systems such as watering, lighting, nutrient adding, and temperature control. Thus, even though factory has limited spaces (173.85 m2 x 6 high), this plan factory can produce approximately around 55,000 heads of lettuce per month. The factory can also reduce the use of water resources due to a water control system. It also increases land use efficiency. As the vertical farming method provides a 99 percent reduction in land use. (Musa et al., 2021)

2.3.5 Benefits of Smart Agriculture Implementation

According to the research of Regan (2019) called Smart farming' in Ireland: A risk perception study with key governance actors, the benefits of smart agriculture can be divided into four main levels which are:

1) For consume level: consumers can benefit from smart agriculture and digital technologies as a result of the improved information flows and transparency introduced into value chains. So, smart agriculture is viewed as something which could

significantly engage consumers. Technologies can help create a connection between people and where the food comes from. These technologies could be a way to improve trust and shorten connections between people and where their food comes from.

2) For farmer level: Smart agriculture in its most basic description is considered as the use of technology to help farmers make more accurate decisions. Improving decision-making is viewed to enable efficiencies on the farm which would lead to many benefits for farmers, for example improving profitability through reduced costs and maximised outputs, allow for more efficient farm management, taking away burdensome jobs and improving time management which can lead to efficient time management including a better work-life balance and enhanced quality of life. Bronson and Knezevic (2016) also mentioned that the benefits of digital technologies for agriculture are various such as increased productivity and profit is promised for farmers.

3) For society level: smart agriculture or digital technologies are very important to combat serious societal issue. All technologies will enable more efficient farming practices, therefore leading to more sustainable, safer and traceable food production. They are considered as a way to meet changing consumers' demand (such as increased protein and cheaper produce). While, Carolan (2016) also mentioned that technologies can help to tackle issues such as food security and sustainability.

4) For industry level: the digital technologies in agriculture sector including smart agriculture help increase an availability of farm-level data. Thus, the tons of data which are collected by smart agriculture technologies, for example soil quality, weather conditions, crop's growth progress or cattle's health. This data can be used to track the state of your agricultural business in general as well as staff performance and equipment efficiency which will allow farmers or farm owners to plan for better farm management. Moreover, using smart devices, farmers or farm owners can automate multiple processes across production cycle, for example irrigation system, pest control, fertilizing. (Sharlimove, 2020)

2.3.6 Challenges of Smart Agriculture

As already mentioned, in principle, many viewed smart agriculture as a positive development for famers. Many viewed smart agriculture as the use of technology to help farmers make more informed decisions, improved profitability through reduced costs and maximized outputs, as well as increase productive and economic returns. Moreover, many believe that this technology would create more efficient farming practices which will lead to sustainable and safe food. However, there are researchers who studied about the potential of smart agriculture. They found that the idea of smart agriculture still has limitations, challenges or risks which are uncertain and unpredictable, like Biel (1999) warned that technology is a double-edged sword. Although it can yield positive impacts in developing countries by helping farmers with weather forecasting and crop yields, it also poses challenges and obstacles.

Regan (2019), who studies about risks or challenges of the use of smart agriculture in Ireland by interviewing 21 actors who have professional positions or responsibility for the growth of smart agriculture in Ireland, found that the participants were in agreement about the benefits of smart agriculture for country's agriculture and society. However, they also have different interpretations and opinions when talking about risk of smart agriculture.

According to Regan's research, risk or challenges of smart agriculture can be divided into four aspects:

1) The participants thought that smart agriculture must be prepared for the possibility of community opposition and consumer. They said that social acceptance of smart agriculture should not be broadly assume, but rather considered on a technology-by-technology basis because some technologies can cause some controversial issues. For example, genetics in particular is considered as a subset of smart agriculture and they could be resisted by some groups of consumers. Similarity, technologies which are viewed intrusive to a community, such as drones, could be also meet with resistance.

2) Many participants mentioned about the problems of the expectation of farmers who take smart agriculture technologies for their farm. A significant risk could easily incur by farmers given the high expense involved in purchasing and implementing smart agriculture technologies. The financial return may not always be guaranteed,or may only come after a lengthy period of time. There was a concern that some farmers may invest too quickly in new technologies without first understanding the true value and application for their farm. Readiness and skills of farmers can be one of important obstacles that farmers could encounter when adopting technology.

This concern corresponds with the research of Andrea, Maria, Klaus, Teresa, Friederike and Angelika (2019). who studied farmers' and other stakeholders' perceptions and attitudes towards smart agriculture technology in German with a multi-actor approach found that among 27 German farmers, most of the farmers who were successfully running their farms using smart farming technology recognized the benefits, however, the farmers did face major obstacles in adopting technologies to run their farms. First, they needed to learn needed new skills in order to operate new devices. It will take time for farmers to develop the technological readiness to apply new methods to their farms (Kwanmuang et al, 2020; Sayruamyat and Nadee, 2019).

In order to learn new skills, farmers also face the problems of accessing the technology. This became evident in country like New Zealand dairy farms where few farmers adopted AI options for robotic milking, even though this option cost less than conventional practices (Eastwood, Klerkx and Ayre, 2019). Farmers also become overwhelmed by information-overload when they are presented with new agricultural methods and applications (Sayruamyat and Nadee, 2019).

The statements from Pattama (2020) as well as Kuhasak and Srichumpa (2018) can also support the idea that farmers still have to face challenges once they decided to use smart agriculture. They have to know how to get access and take advantages from technologies and innovations as well as have to understand the use of technologies that are suitable for their farm to get the effective management pattern of smart agriculture.

Knowledge and readiness of farmers when they decide to use smart agriculture are really important.

Moreover, the participants interviewed by Regan also mentioned that smart agriculture technologies are viewed to be prohibitively expensive and out of the reach of many farmers, especially old and small farm holders who may not have the skills, capabilities, money or motivation, so that some farmers would be excluded from agriculture's development. This result match up with the concept of Fleming, Jakku, Lim-Camacho, Taylor, and Thorburn (2018) who point out that smart agriculture can cause unequal development between different persons (age, socio-economic or educational disparities), farm size (small and large), and territories (urban and rural). However, not every participant agreed with the agreement that small farms would be exclude from smart agriculture. Some believed that even though some technologies are best use at big scale, there could be models which would make small farmers accessible to smart agriculture in the future (Regan, 2019).

3) The participants discussed about a knock-on effect of farmer technology interaction. While some participants appreciate that the introduction digital technologies to assist in decision-making on the farm can be positive, they were concerned with the effect that widespread adaptation of technology could cause. The participants raised concerns that the introduction of certain technologies could lead to a changed behavioral pattern on the farms and the potential distancing and isolation of farmers from the farm community as in the future, with the idea of smart agriculture, there will be fewer and fewer humans needed. Certain technologies could lead to almost people free farms. Thus, people including skilled famers in the community would not interact with each other and farming could become a very lonely occupation. This potential would be a big worry in the future for social and cultural dimension and opportunities for god farming. Another concern discussed by the participants is that as smart agriculture is considered as an instrument to assist the farmers, thus it may affect farmers' skills and heuristics in long term (Regan, 2019).

This result matches up with what Carolan (2015) mentioned that in many communities, changes in rural workplaces could have a significant effect on social stability and the livelihoods of many workers. Osipov and Riliskis (2013) also mentioned that beside the increased efficiency and favorable environment created by smart agriculture technologies, the socio-ethical consequence concerns have been explored by some scholars. It has been proposed that smart agriculture, with less "hand-on" management and a more data-driven approach, would reshape farming practices and communities of farmers as well as agricultural labour.

4) The participants mentioned about data sharing and the need of privacy and transparency. The most discussed issue amongst participants related to the risks which can arise when data is collected from smart agriculture technologies and when there is the need to ensure the privacy of the farmer as well as to encourage more transparent actions in data sharing practices. All participants agreed that the farmers' rights need protection but at the same time, any solutions identified to address the aforementioned problems needed to ensure that industry development and innovation was still supported. Moreover, some participants cautioned that strict rules, particularly in form of legislation sharing of data could prevent progress of the entire industry.

Participants also mentioned that there are circumstances in which farmers may be less willing to share their data, particular areas of sensitivity related to insecticide in agricultural product and animal health which are associated with a farmer's fear of being stigmatized and penalized. The concept of data sharing triggered concerns over the ability to maintain and assure the privacy of individual farm-level data. Farmers still have a lack knowledge about to which their data is shared and used by third parties.

There are also some concerns that where commercial outlets may financially benefits form farmers'data and although they did. They may not have sufficient bargaining power. Participant felt that power dynamics and inequities in existing relationships between farmers and industry would leave farmers at risk of being exploited by data-sharing business model (Regan, 2019).

Besides the four challenges or risk of smart agriculture that are already mentioned above, there are also other researchers who studies about smart agriculture and raised about challenges and disadvantages of smart agriculture, for example:

Agricultural Research Development Agency (2020) indicated that the investment on smart agriculture is another problem, especially for countries with small-scale farms and farmers, such as Thailand. As farmers in Thailand are normally small-scale farmers, changing to do smart farming requires a lot of money and the return on investment is still uncertain for small-scale farmers. Moreover, as agricultural production processes have many steps and different methods and technologies used for each step could have different standards and difficult to work together effectively. This may also increase cost of investment, so many farmers are not affordable to smart agriculture.

The promotion of smart agriculture can reduce production costs and increase production effeciency or yeild per unit. However, reducing production costs and increasing productivity also depend on uncontrolled external factors, such as disasters, floods, and epidemics. Moreover, farmers lack access to adequate water sources for their cultivation and also lack access to continuous transfer of smart agriculture reseach and invovation (Office of the National Economic and Social Development Council, 2021).

Finally, The last challenge of smart agriculture that was mentioned is that in order to enable and integrate smart farming technologies, needed skills and advisory structures would be required around farming team, in order to relocate farm labor force and service providers. By integrating detailed monitoring, agricultural machinery manufacturers, input vendors, processors, and retailers, several changes can have a crucial impact on what it means to be a farmer, since a more formal and assessed approach in smart farming will replace the old concept of "your land, your way" (Bronson and Knezevic, 2016; Carolan, 2016).

2.4 Successful Countries in Smart Agriculture Management

Food demand is increasing, while farmers around the world still have to face a lot of problems. Thus, in order to meet the needs of the world's growing population, the world agricultural sector has tried to find the way to speed up its production. This increases interest and attention in role of smart agriculture which will replace the present agricultural model.

Asia is considered as a very important food producer as it can support about 60 percent of the global food needs on about 23 percent of the world's agricultural land (Thomas, 2019). However, many challenges, such as climate changes and a rapid urbanization, an increasing population and a decreasing land mass have threatened its food supply, so technological approaches are needed in order to develop sustainable agriculture. Many countries in Asia contribute the largest number of scientific studies to smart agriculture's concept. Countries that invest more in research and development (R&D) and generate the most publications could be leaders in smart farming

So, in order to find an effective smart agriculture management, this research will study from two countries in Asia which are Japan and China. These two countries are the Asian countries that have many studies about smart agriculture (Pivoto et al., 2017) Japan and China's agricultural sector also face the two big problems as Thailand which are an average age of the farm workforce increasing and a lack of farm workforce which could negatively impact the agriculture industry (Pattama, 2020). Moreover, these two counties also face the problems of the decline of area under cultivation or arable lands amid the rapidly growing population trend, however they both can still prepare foods both for their population and the world's population (Chaudhury, 2020).

In 2019, they became top ten agricultural producing countries in the world according to Statistic Division of Food and Agriculture Organization of United Nations (FAOSTAT). Two thirds of the Japan's surface are mountainous; many areas are hard to reach (Temmen, 2021). In 2018, only around 4,142,000 ha in Japan are under cultivation (Trading Economics, 2018), yet Japan was still ranked the 8th agricultural

producing country in 2019. Meanwhile, China also became the 1st agricultural producing country (Tractor Junction, 2020), especially in terms of the producer of crops, including cotton, rice, potatoes, cereals, fruit, and many other vegetables (BASF SE, 2021), although China lost her arable land to urbanization and industrialization and has the arable land less than India, the United States and Russia (Knoema, 2018). China feeds 22% of the world's population (nearly one-fifth of the world's population) with less than 10 percent of world arable land (BASF SE, 2021). This is considered as a great achievement in pursuit of food and nutrition security not only in China but also in the world (Food and Agriculture Organization of the United Nations, 2021a).

2.4.1 Japan

The demands for Japanese in agricultural product are rising, while Japan is staring to struggle to meet these demands and also supply its own domestic market. Moreover, the income of Japanese agricultural sector is declining significantly because of three main problems. Firstly the agricultural sector in Japan is facing acute labour shortage. Japan faces the lack of expert skills as farmers age and retire. The number of workers in Japanese agricultural sector has been declined about 50 percent in the past thirty years in the past thirty years. Furthermore, the average age of people who work in Japanese agricultural sector is being on the rise — around 65 percent of farmers being over 65 years of age. This average is predicted to rise over time. Secondly, most of the Japanese agricultural workers are small-scaled farmers. About 80 percent of farmers in the country own an area smaller than 13 rais. Thirdly, the problems of water shortage, The Japanese government believes that the country's water supply will drop by 39 percent in 2030.

There are also other uncontrolled problems that Japanese agricultural sector has to face, such as problem of production efficiency and the other risks from climate change and pest outbreak (Science and Technology Office of Embassy of Switzerland in Tokyo, 2018).

The Japanese government wants to address theses problems by vigorously promoting the use of smart agriculture. Thus, Japan is one of the countries with the most application of smart agriculture. The most used technology in Japan is the Global Navigation Satellite System (GNSS) which is the use of information processed from photographs or signals from satellites. GNSS will provide information via mobile phone. With this technology, Japanese farmers do not have to spend the high cost for installing basic infrastructure and also additional equipment.

From a literature review process about the history and improvement of smart agriculture in Japan since 2000, it was found that Japanese a small-scale farmers which have a variety of plant types in single plots as well as the use of space that is blended with other uses such as homes or residences.

Therefore, Japan comes up with a project to develop a technology mainly for rural farmers, for example Soil Spectrophotomerter that farmers can access by themselves (commercially available) There is also Field Servers, where each plot of land has sensors to form a wireless sensor network. Field Servers have the ability to collect environmental data and the ability to use a wide variety of applications. Japanese researchers have developed a Field Server by reducing power consumption and improving a communication signal in order to reduce cost for famers (Puapongsakorn et al.,).

Moreover, Japan has applied Information Communication Technology (ICT) system in agricultural sector for many years, such as the development of the overall environment control system in a Green House, a sensor system to detect temperature, humidity control, GPS system to control machinery and automatically cultivate and harvest etc.

After that, Japan tries to enter to a new era of agriculture by using artificial intelligence (AI) to reform agricultural sector. The Japanese government thus created its policy. This policy aims to develop a current Japanese agricultural sector by using AI, Internet of Things (IoT), Robotic and Big data in agricultural sector which in line with the policy “Creating Japan as the world’s leading IT nation” (Pattama, 2020).

Japan has developed many technologies and innovations for using in smart farm, for example Japan have tried to enable all farmers in country to do smart agriculture. They can start from collecting information such as weather, temperature, as well as agricultural characteristic of skilled farmers who use the eye camera during the time where they operate their farms in order to record all important information. After that, all information will be analyzed by AI system and used as an advice for other farmers. Moreover, Japan also created a robotic or an automatic harvester using with the AI system, this robotic or the automatic machine can do more complex agricultural tasks which in the past only human beings can do, such as a harvester can pick only the red tomatoes that are in the appropriate stage for harvesting. Another important development is the Big Data collected by a sensor system and writing information by previous farmers. This information then will be analyzed by AI systems and finally used as information for decisions making process as well as advising other farmers in real time (Foreign News Agency in Hiroshima, 2018).

These developments will facilitate farmers and reduce farmers' workload by taking care of easily automatic processes (Science and Technology Office of Embassy of Switzerland in Tokyo, 2018). They can also help increase country's productivity and competitiveness in both domestic and export agricultural and food markets. Being a smart agricultural country, Japan can now boost its agricultural exports. Japanese agricultural products are able to compete in the world market. In 2020, the export value of Japanese agricultural, fishery and forestry commodities amounted to around 926 billion Japanese yen, an increase from around 451 billion Japanese yen in 2011 (Engelmann, 2021).

For agricultural operations, Japan has a very systematic and concrete plan. In addition, there is an integration between all relevant sectors. The Ministry of Agriculture, Forestry and Fisheries are considered as the main host. Their roles are creating as well as launching the country's policies about agriculture; coordinating all relevant sectors; and supervising the overall picture. For other ministries, private sectors, researchers and farmers will join and help in the relevant part. In other words, the operators or people who take action are the private sector, academics, and farmers, while the government plays a role in supporting, facilitating, supervising and following up the results in order

to set up the most suitable performance for the future plan. Moreover, Japan has carried out R&D on all agricultural field, including marketing and safeguarding intellectual property (Pattama, 2020).

The private sector has mainly helped develop technology development and create business model. For example, OPTiM Corporation Company collaborated with Saga prefecture and experts from Saga University and created drones that autonomously fly along a set path through the fields and spray insecticide at targeted areas where many insects gather. However, OPTiM has known that farmers are getting older and are not ready to use new technologies or would be scared of the technologies' high cost. So, the company developed its business model, for example the company will lend hardware (drones) and provide the software for free (Science and Technology Office of Embassy of Switzerland in Tokyo, 2018). The successful case of smart agriculture implementation was also mentioned by GMO Research (2022) that Tome, a city in Japan, is well-known for its rice production. The local agricultural cooperative, JA Miyagi Tome, has successfully used drones to tackle the labour shortage issues as Japan has a large elderly population, while young generations prefer to work in the cities. Moreover, drones have also helped produce rice in an environmentally friendly manner as well as decreased resources usage, especially water.

2.4.2 China

China has the largest population in the world and thus, the most demands of food. The well-being of Chinese population depends on the country' ability to produce food with nutritious and safe food that are grown sustainably (Hengde, 2021). Moreover, by 2020, China aims to achieve the building of a moderately prosperous country in all respects, especially achieving the increase of China's productivity and other composite national strength as well as poverty eradication by 2020 (Wei, 2018).

Under the great development of technology, China is forging ahead steadily and rapidly in the area of smart agriculture. In the last decade, Chinese government has carried out strategies to promote its economic development in agriculture.

Chinese President Xi Jinping once, said that China's modernization could not be completed without the modernization of agriculture and rural areas, emphasizing that technology and talent are two keys to achieve China's goals (China Global Television Network, 2019).

Since 2004, the No 1 Central Document launched by Chinses government has focused on helping agriculture and rural area as well as rural people which will lead to the goal of achieving poverty eradication and deficiency improvement. Once accomplished, China will step closes to the goal of building a moderately prosperous society in all aspects by 2020 (China Global Television Network, 2020).

China is the country that has very strong policies for an investment in national agriculture. Moreover, China also has a unified and aligned agricultural polices. The Chinese central government, local governments, universities, private sector and business sectors try to comply with the policies as well as support each other, for example the Chinese government supports the Chinese university in order that they can create new technologies and innovation.

In 2015, Mr. Li Keqiang, the premier of the State Council of the People's Republic of China issued Made In China (MIC) 2025, an initiative that strives to secure China's position a global powerhouse in high-tech industries. This initiative aims to reduce China's reliance on foreign technology imports and invest heavily in its own innovations in order to create Chinese companies that can compete both domestically and globally.

In 2016, the Chinese government launched plan to invest three trillion Chinese Yuan in modernizing the country's agricultural sector by 2020. This loan from the state-owned policy lender Agricultural Development Bank of China will be used for the agricultural activity and industry development, such as increasing efficiency with modern equipment and improve incomes in rural areas, protecting national food security and supporting overseas business.

There are many pressures in Chinese agricultural industry which include the largest and fastest urbanization, a collective land ownership right of Chinses farmers resulting in fragmented land plot that make large-scale agribusiness difficult to operate without land transfer, a problem of arable land shortage, a problem of land quality, a rising concern over national food security from the problem of increasing food demand as well as to rely on global markets or to keep up production domestic, which requires heavy subsidization as well (Jin, 2016).

1) In order to tackle all problems in agricultural sector, China has shaped policy toward agricultural modernization as follow: 1) Focusing on creating innovations in the agricultural sector and promoting science and technology for the agricultural sector in order to reform production process in farm level production. For example, AI, IoT, big data, and 3S technology which is remote sensing technology (RS), GIS, and GPS start being used widely to accelerate the modernization of Chinese agriculture. These technologies are applied mainly in planting and agricultural service (Chen, 2019).

2) Supporting agricultural startups and new entrepreneurs as well as promoting rural residents and farmers in order to be able to do business.

3) Emphasizing on product quality, safety, and environmental friendliness of the agricultural sector as well as aiming to create over 53 million hectares of farmland by 2020.

4) Improving the quality of higher education in agriculture in order to prepare more talent farmers. China tries very hard to educate her people in order that they can drive and improve Chinese agricultural sector. For Chinese government, talents are important for pushing the agricultural towards modernization and food security, and that they also play an important role in poverty reduction and rural revitalization.

5) Increasing the caution in water using, in particular, the underground water level must be maintained. Moreover, by 2020, Chinese government aims to increase the area of forest up to 23 percent by making a transformation of agricultural land into forest (Pattama, 2020).

For the implements of smart agriculture model in China, there are the uses of modern precision agriculture techniques which are applied to both small-scale and large-scale farming in China. Agricultural input enterprises, such as Sinochem that helped develop Modern Agricultural Platform (MAP) which is operated in many provinces with various weather and geography data for the planting. This system also provides suggestions for farmers, such as weather forecasts with the accuracy of one square kilometer to help with harvesting, watering, spraying and sowing. The type and the amount of pesticides and fertilizers can also be automatically calculated corresponding to crops and other conditions. Farmers can also check humidity and temperature conditions, and even receive disease and pest warning on their smartphone via application.

New technologies can also help support technical services. The Agricultural Technology Center of Kailu government in Northeastern Neimenggu has developed a smartphone application for end-user technical services. This application provides all important information for operating farms and expert video consultations. Farmers can use the application to remotely observe their crops and send photos of a discovered pest or disease to get advices or suggestions. It's also possible to make an appointment with and expert for online consultation via the application, saving farmers from visiting a city for such services. Applications aims to provide farmers with efficient and convenient solutions.

AI technologies, remote sensing and drone are also being used by many Chinese insurance companies for on-site damage investigation and determination as well as to improve efficiency and reduce costs. For example, in Northwestern Ningxia, the Science and Technology Department has used an extraction and classification for local crops, such as Goji, grape, melon and jujube. The remote sensing model is developed by studying the relationship between the satellite image and the hyperspectral

data of plants. The support vector machine-based classification methods us disaster distribution surveys and other data as a basis for risk assessment and determination. This technique can help reduce insurance investigation costs (Chen, 2019).

At present, the Chinese government is transforming Chenjiadian into the first unmanned farm. This village is located in Nongan county, Jilin province, which is the largest agricultural products production area in China. The Chinese government has introduced modern technologies to this unmanned farm. There are such as the first unmanned demonstration farm of eco-agriculture of China that can let technology take care of plants, an unmanned tractor, a drone etc. Moreover, the unmanned farm also takes advantage of a new wave of information technologies, such as big data, artificial intelligence 5G and cloud computing. The process that uses technologies includes plowing, sowing, watering, spraying pesticides and harvesting. Every production process uses fully automated technology. A single farmer can control everything with the press of a button and remote control in order to take care of large agricultural plots. There is also a smart agricultural greenhouse with the use of technology that is used in order to stimulate plants in low temperature conditions. Thus, tropical plants can be grown during winter. This greenhouse can be also considered as an IoT monitoring station that can accurately capture plant growth data.

Chenjiadian village is now becoming agro-ecological area for tourism, which combines all activities, such as eating, traveling staying. In 2005, the village's population owed more than 5 million baht. However, in 2020, the total assets of the village worth more than 1 billion baht (Junhong, 2021).

Although many new agricultural technologies have been developed in China and Smart agriculture has been a part of the national development strategy, there are still many obstacles to apply these technologies in agricultural sector. Many farmers are hesitated mainly because of the initial investment high cost and the effectiveness of these new technologies.

Thus, Chinese government has tried very hard to promote smart agriculture by starting with encouraging development of AI, IoT and 5G in order to provide more effective solutions. Moreover, the government has also built new research institutes and databases. Currently, more and more local governments are cooperating with research institutions and enterprises to create technical support and information. Finally, the government provides incentives, such as subsidies, loans and tax breaks in order to encourage farmers to adopt smart agriculture's concept. China really believes that new technologies can build a bright future for Chinese farmers (Chen, 2019).

After all, China, the county that traditionally has struggled to feed its large population and famine periodically ravaged China's population even in the twentieth century (Smil, 1999). Thus, the government has always placed high priority on the development of agriculture, rural areas and farmers. And now, China can feed its population and also the world's population with less than ten percent of the planet's arable land (Food and Agriculture Organization of the United Nations, 2021a). Moreover, the number of Chinese farmers living under poverty line has also dropped rapidly, from 770 million to 5.5 million people (China Global Television Network, 2020).

The main obstacles that make Thailand's smart agriculture management different from that of Japan and China are , for Japan, Japanese government set ups agricultural policy very clearly, there are strong cooperation between government and private sectors both in The cabinet always sets up a special body or unit to improve agricultural technique by setting up a special committee which consists of government units, university, private company, and many specialists in order to make an advance on agriculture and also give a big budget to support all agricultural projects, such as R and D process.

While China, the Chinese government also has similar projects as Japan. However, for Thailand, Thailand still need the combined cooperation between all sectors that are involved in the agricultural problems. Moreover, Thai government still

lacks a budget improving agricultural problems, for example the problems of smart agriculture and irrigation system management.

2.5 Laws and Plans Related to Smart Agriculture

2.5.1 Millennium Development Goals and Sustainable Development Goals

2.5.1.1 Millennium Development Goals (MDGs)

In 2000, the member states of the UN adopted the Millennium Development as a commitment to human development. This Declaration includes eight MGDs. Every target aims to motivate international community and provide an accountability mechanism for actions taken to help all poor people to improve their livelihoods.

All eight MDGs have direct or indirect linkages with agricultural sector, however the MDG that is directly influence by agriculture is the first MDG, or MDG1- halving the proportion of people who suffering form extreme poverty and hunger. Agriculture contribute to MDG1 through agriculture-led economic growth and through improved nutrition. In low-income countries, economic growth, which can increase employment and rising wages, is the only means by which the people can satisfy their need sustainably.

Other MDGs have indirect linkage to agriculture. For MDG 2 which is achieving universal primary education, investments in agricultural sector will increase productivity and lead to higher incomes, a more dynamic agricultural sector will change economic returns to educating children better than the returns from keeping children out of school to work in household agricultural enterprises. For MDG 3 which is promoting gender equality and empower women, the agriculture can help empower women farmers and reduce the time burden on women for domestic task. For MDG 4 which is reducing child mortality, agriculture helps increase diversity of food production and make more resources available in order to manage childhood illnesses. For MDG 5 which is

improving maternal health, agriculture, directly contributes to maternal health through more diversified food productions and higher-quality diets, and indirectly through reduced time burdens on women and increased incomes. For MDG 6 which is combating HIV/AIDS, malaria, and other diseases, agriculture can directly help combat all diseases through higher-quality diets and also indirectly by creating additional income that can support health services. For MDG 7 which is ensuring environmental sustainability, proper agricultural practices can be important solutions to environment degradation. Moreover, productive agriculture technologies will help farmers to escape from sensitive environment. For MDG 8 which is developing a global partnership for development, MDG 8 will help maintain agricultural trade and increase development assistance for agricultural sector which will be the benefit for agriculture in the long term (World Bank and International Food Policy Research Development, 2006).

By 2015, Thailand aimed to further reduce the share of poverty to below four percent of the total population (Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific, 2007). As normally, many poor people live in rural areas, an agricultural sector thus has to play an important role in creating jobs and improving their life. According to Thailand's National Economic Development Plan (NESDP), Thailand has tried to create economic opportunity through knowledge, technology, innovation, and creativity, taking into account that production and consumption have to stand in eco-friendly foundations towards stable and sustainable development. Moreover, agricultural sector as well as food and energy security will be also emphasized at all level in this plan in order that Thailand could be self-reliant and able to confront challenges (Teanravisitsagool, n.d.).

So, Thailand made a remarkable progress in meeting most of MDGs. From 2011 to 2015, agricultural sector has grown by an average of 1.3 percent, and contributed a share of 10 percent toward overall GDP while employing 38 percent of the country's labour force (The Compact 2025 Team, 2017). Between 1988 and 2015, poverty rate in Thailand has greatly declined from 65.2 percent to 7.2 percent (World Bank, 2020b). Thailand finally became an upper-middle income country with low rates of poverty in 2011 (World Bank, 2011). However, between 2005 and 2015 Thailand's

economic growth slowed to an average of 3.5 percent. Moreover, at the end of Millennium Development agenda, there are around 80 percent of 4.85 million Thai poor people who lived in rural areas and earned their living by working in an agricultural sector and had no economic participation. This problem is mainly created by the disparity between development in urban and rural and a lack of basic needs. Rural people could not access all resources and services They also could not afford education (Borgen, 2017). Thus, when they had to work in agricultural sector, they were vulnerable to the threat of climate, natural disaster, problem of environment and natural resources as well as economic catastrophe.

In term of undernourishment, Thailand aimed to become "kitchen-of-the-world". The food production and productivity have increased. In international level, Thailand became one of the major rice exporters contributing world food security. Thailand has made great improvement in food security and reducing hunger. However, Thailand still needs to produce safer and higher quality products and invest in agricultural research and development to stratify changing demands (Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific, 2007). At national level, from 1990 to 2016, due to Thailand's agricultural development and fertility planning program, the prevalence undernourishment fell from 35 to 7 percent and the number of hungry people also fell from just under 20 million to 5 million in the same period (The Compact 2025 Team, 2017). However, there are still many undernourished people and hungers that Thai government need to deal with. Moreover, some critics still noted that Thailand was well behind to achieve the 2015 objectives in hunger reduction.

Moreover, unappropriated management of national resources accompanying rapid growth and increasing productivity has resulted in environmental degradation (Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific, 2007).

2.5.1.2 Sustainable Development Goal (SDGs)

In 2015, the SDGs were adopted by the UN as a universal call to action to end poverty, protect the planet, and ensure that all people will enjoy peace and prosperity by 2030.

The 17 SDGS continue the work begun by the MDGs, which aimed mainly to improve people's livelihood. MDGs only applied to developing countries, but SDGs will apply universally to all UN member countries and are considerably more comprehensive and ambitious the MDGs. The SDGs will both maintain the thematic work on poverty eradication targeted by the MDGs and will focus on international development as well as sustaining human life on the planet. Moreover, SDGs will also emphasize the cooperation and relationships with private sectors and local (Woodbridge, 2015).

As MDGs, SDGs also have relationships with the agricultural sector. The relationship between the agricultural sector and the SDGs are not all one way. While the agriculture provides inputs to attain the SDGs' targets, the improvement in human's need to reach SDGs will also provide the foundation for more productive and effective agriculture.

Brook (2016) mentioned that the goals the are mostly related to agriculture and food are SDG 2 which focuses on food in ending hunger, achieving food security and improved nutrition as well as promoting sustainable food system, and SDG 1 which focuses on challenges in the food system where it focuses on eradicating poverty – where agriculture and food play a significant role. Other, SDGs that are related to the achievement of sustainable agriculture are 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. According to Brook, this shows that the SDGs are interconnected with each other, meaning that when one of the goals is achieved, this gives an impact on the other goals as well.

Moreover, in order to eradicate poverty as well as hunger, several innovative technologies have been made for the agri-food sector. Some countries such as The Netherlands and Japan have been using technology in farming, which is in line with the 4.0 industrial revolution and contributing to the SDGs, especially SDG 9 in building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation. Over the years, the agri- food sector has become essential sector, especially for economic and food security challenges, as well as agricultural systems, but the works of literature on the digital transformation in agriculture are still lacking (Musa et al., 2021).

According to Farming First Organization (2015), developing the agricultural sector can address not only hunger and malnutrition but also other challenges including such as poverty, climate change, water and energy use, as well as unsustainable production and consumption.

The SDGs that have relationships with agriculture are:

1) SDG1 which is ending poverty in all forms everywhere. Food Agriculture Organization of the United Nation (2017) indicated that around two thirds of the global extreme poor live in rural area and they are normally from agricultural sector. Thus, the investment and growth in agriculture is more affective in reducing poverty than the investment and growth in any other sectors.

2) SDG2 which is ending hunger, achieving food security, improving nutrition and promoting sustainable agriculture, especially for children and vulnerable people: the world populations are increasing. Thus, agricultural sector has to play and important role in addressing the problems of hunger and malnutrition.

3) SDG4 which is ensuing inclusive and equality education as well as promoting life-long learning opportunities for all. A more effective agricultural sector can help farmers to access the skills, knowledge, tool and inputs they need to thrive.

4) SDG5 which is achieving gender equality and empowering all women and girls. Food Agriculture Organization of the United Nations indicated that agriculture contributes to gender equality through the empowerment of women famers and also through reduction of the time burden on women for domestic tasks. Women can produce over the half of the food globally.

5) SGD6 which is ensuring availability and sustainable management of water and sanitation for all. Global water demand can increase more than 50 percent by 2030. Thus, world will need proper water resource management. Thailand emphasizes having adequate water management and national proper hygiene and sanitation as well as protecting and restore water-related ecosystems such as mountain and rivers.

6) SDG7 which is ensuring access to affordable, reliable, sustainable, and modern energy for all. Energy demand is also expected to around 50 percent. Thus, more crops and agricultural products are very important as they are likely to be diverted for use as biofuels.

7) SDG8 which is promoting sustained, inclusive and sustainable economic growth, full and productive employment, and decent work for all. The better agricultural production and productivity can help improve national economic growth. An agriculture can be considered as an engine of pro-poor economic growth in rural areas. Moreover, agricultural or food sectors can also generate employment.

8) SDG12 which is ensuring sustainable consumption and production patterns. Despite population increase, average per capita consumption is expected to grow through 2030. In addition, around one third of food produced is wasted.

9) SDG13 which is taking urgent action to combat climate change and its impacts. Agricultural sector's carbon mitigation potential may reach as much as 7.5 percent of total global emission, depending on the adaptation of agricultural productivity measures and the price of carbon. Thailand aims to prepare all resources in order to support the country in adapting to climate change and develop low-carbon management.

Moreover, Thailand aims to reduce disaster risks and manage natural resources as well as emphasize develop human security issues in order to be in line with the national strategy.

10) SDG 15 which is protecting, restoring and promoting sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation, and halt biodiversity loss. Improving the efficiency of farmland management can help meet the global growing consumption demand while minimizing the loss of national resources and habitats as well as forests.

For the relation between agriculture and SDGs, Dr. Noguchi Noboru, a leading researcher in smart agriculture in Japan also emphasized during his interview with Hokkaido University that nowadays food shortages are becoming severe due to population growth, global warming and climate change. Thus, he believes that innovative and new technologies of smart agriculture, such as IoT and AI will play an important role in producing food efficiently with consideration for the environment as well as contribute to global supporting the lives of people (Hokkaido University,2020).

2.5.2 United Nations Decade of Family Farming (2019-2028)

In September 2019, The Food and Agriculture Organization (FAO) and the International Fund for Agricultural Development (IFAD) launched the United Nations' Decade of Family Farming 2019-2028 global action plan to boost support for family farmers, particularly those in developing countries and to put family farming at the center to achieve the SDGs (Taft, 2019).

According to the UN, Family farming is the ownership and management of the farm that is carried out at the family level or the family lives on farm or the farm relies predominantly on family labour. Family farming represent over 90 per cent of all farms globally and produce around 80 percent of the global food. It offers a unique opportunity to ensure food security, develop livelihoods, improve natural resource management, protect the environment and achieve sustainable development, particularly in rural areas

(Food and Agricuture Organization of the United Nations & International Fund for Agricultural Development, 2019).

People who play an important role in Family farming are called family farmers. Although family farmers produce most of our food, they still face many challenges, especially poverty problem of family farmer in developing country because, for example they lack access to resources and services that support their food production and marketing, their infrastructure is poor, political processes still do not suitable for them, the climatic and environmental conditions on which they rely are under threat (Taft, 2019).

The Global Action Plan of the Decade of Family Farming was launched to be a guide helping develop policies, programs and regulations to support family farmers. It details specific activities to address all challenges for all sectors or actors involved. The important actions are, for example: developing an enabling policy environment to strengthen family farming; supporting young family famers and ensuring the generational sustainability or family farming; promoting gender equity in family farming and the leadership role of rural women; strengthening family farmers' organizations and capacities to generate knowledge, representing farmers and providing inclusive services in the urban-rural continuum; improving socio-economic inclusion, resilience and well-being of family farmers, rural households and communities; prompting sustainability of family farming for climate-resilient food system; and strengthening the multidimensionality of family farming to promote social innovations contribution to territorial development and food systems that safeguard biodiverse, the environment and culture (Food and Agricuture Organization of the United Nations & International Fund for Agricultural Development, 2019).

2.5.3 Constitution of the Kingdom of Thailand 2017

Section 65 of the Constitution of the Kingdom of Thailand 2017 mentioned that the State should set out a national strategy as a goal for sustainable development of the country under the principle of good governance to be used as a framework for formulating consistent and integrated plans in a congruous force to achieve such goal.

The formulation, determination of goals, prescription of time for achieving such goals and contents that should be in the national strategy shall be in accordance with the rules and procedures as provided by law. Such law shall also contain provisions relating to people's participation and public consultation throughout every sector. The national strategy shall come into force upon its publication in the Government Gazette (Ministry of Agriculture and Cooperatives, 2020**)**.

2.5.4. Master Plan under the National Strategy on Agricultural Issues

Ministry of Agriculture and Cooperatives (2020) stated that Master Plan under the National Strategy on Agricultural Issues is one of Thailand's 23 Master Plans under the National Strategy. Master Plan under the National Strategy is an important part in transferring the goals and strategic issues of the national strategy into plans in different levels, which will take into account all common issues or inter-strategic issues and will link the goals of each master plan under the national strategy together in order to be in the same direction. Each Master Plan under the National Strategy consists of situations and related trends of master plan's goals as well as indicators that will be divided into four periods (five years each)

Master Plan under the National Strategy on Agricultural issues focus on raising the potential and capacity of national production in order to meet the quality and safety standards. It also focuses on the use of application, modern technology and innovation in farm production and management. Master Plan under the National Strategy on Agricultural Issues has a smart agriculture sub-plan as its important plan. This sub-plan focuses on the development of production capacity both in term of quantitative and qualitative by relying on technology and agriculture in various forms.

This Master Plan under the National Strategy has three guidelines for future agricultural development, which are 1) Promoting the development of plant and animal species, production factors, agricultural machinery and tool, as well as technology and innovation; 2) Developing farmers' potential access to agricultural technology and

innovation as well as emphasizing management of eco-friendly agriculture; 3) Promoting smart farming by supporting the famers who apply smart agriculture to their farms and ensuring that the farmers can achieve the knowledge and technology under reasonable cost; 4) promoting product creation and expanding marketing channels with information technology systems as well as giving importance to trademark building and intellectual property protection.

Goals and Indicators

The government has set up the goals and indicators about smart agricultural for Master Plan under the National Strategy on Agricultural Issues as follows:

Table 2.2 The goals and indicators for smart agriculture mentioned in Master Plan under the National Strategy on Agricultural Issues

Goals	Indicators	Expected Rate			
		Year 2018-2022	Year 2023-2027	Year 2028-2032	Year 2033-2037
1. Values of Products that derive from modern /smart technology increase	Values of products that derive from modern /smart technology (%)	Increasing 3 percent	Increasing 4 percent	Increasing 5 percent	Increasing 6 percent
2. Productivity per unit of farms agricultural lands that are managed by modern/smart technologies increases	Productivity per unit of farms agricultural lands that are managed by modern/smart technologies (%)	Increasing 10 percent	Increasing 15 percent	Increasing 20 percent	Increasing 25 percent

Source: Office of the National Economic and Social Development Council, 2021

2.5.5 The 12th National Economic and Social Development Plan (2017-2021) and The 20-Agricultural and Cooperative Strategy (2017-2036)

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-ongsakul , 2020), throughout strategic guidelines, such as increasing the productivity and quality standards of agricultural commodities, increasing competitiveness in the agricultural sector, strengthening the farmers and farmer institutions. Hence, smart agriculture has become one of important approaches used to support Thai agriculture and farmers (Pongsrihadulchai, 2019).

2.6 A Model Related to Smart Agriculture

2.6.1 Large – Scale Farming Management Model

Because of various problems in Thailand which include the problem of small-scale farmers who lack farming land plots and opportunities to negotiate in the market as well as the problem of a high cost production, especially expensive machineries and technologies but low yield, thus in 2016, Thailand has launched a program called "large-scale farming model" aiming to 1) increase the opportunity to access technology and power for farmers, 2) increase production efficiency 3) promote the policy of market demand to lead the supply production , 4) manage and balance between the demand and supply of agricultural product 5) maintain products' price stability 6) encourages farmers to use technology appropriately to reduce production costs and increase the efficiency of agricultural production 7) support the second national strategy which is national strategy on Competitiveness Enhancement by creating 'value-added agriculture' and also to support smart agriculture strategy (Ministry of Agriculture and Cooperatives, 2020)

Large-scale farming is not a new model to Thailand, but it has been used since the influence of green revolutionary in 1968. The concept of large-scale farming is a universal concept that was once widely practiced in agricultural activities in western capitalist countries. During green revolution, agricultural sector produced products for sale and export by using modern management. Farmers tries to manage cost and sales for maximum commercial profit.

Then it has been implemented extensively in Thailand, especially during agriculture in the technology and digital era where industrial agriculture or agribusiness becomes more important. Nowadays, the Thai government uses large-scale agriculture to be an important policy guideline in the country's development towards Thailand 4.0 following Thailand's 20-year national strategy (Atthakorn, 2017).

This model will allow smallholder farmers who have adjacent small-scale land plots to merge their own land plots together and jointly set production goals together. They also learn how to use new technologies and innovation help each other to operate production process in every step, in order to create economy of scale (Ministry of Agriculture and Cooperatives, 2020), while the farmers still have their ownership in their farm plots. The processes are as follows:

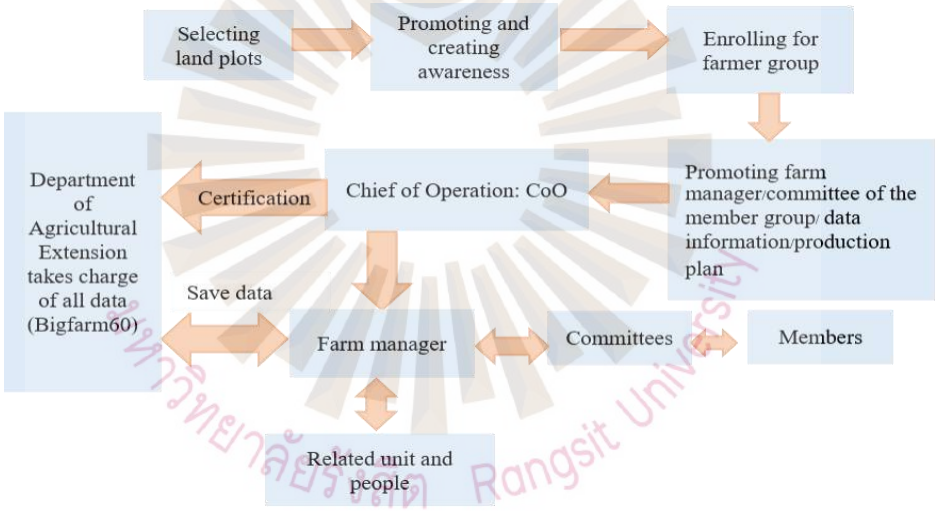

Figure 2.2 The processes for joining the large-scale farming in Thailand
Source: Department of Agricultural Extension, 2021

The administration of large-scale farm in Thailand is under the government where the main teams are 1) provincial agricultural teams who take care of increasing productivity, developing land plots 2) provincial cooperatives who take care of marketing plan and process 3) district agricultural or district livestock officers or district fishery officers or irrigation officers who play the role as a plot manager.

According to Mae Tha District Agriculture Office, they found that people are very important for the success of large-scale farming. The main factors that can make the successful target of large-scale farming were large-scale land plot managers and chairmans of the large-scale land plot group.

2.6.2 Large scale farming's operation

According to the Department of Agricultural Extension, the operation of large-scale farming in Thailand can be divided into three steps.

1) The first step is preparation and development of farmers and officials/staffs.

2) The second step is input support such as machinery and other quipment and upgrading of standards/adding product value.

3) The last step is connecting marketing planning with large-scale farming management.

2.6.3 Conditions for large-scale farming model

2.6.3.1 Conditions for land plots.

According to the Department of Agricultural Extension (2021) the conditions for land plots participating large-scale farming model consists of the factors as follows:

1) Locating in a nearby area

2) Land plots' size suitable for managing

3) Able to create potential bargaining (power) requirement

2.6.3.2 Condition for farmers

1) Farmers have to voluntarily form the groups in order to join large-scale farm project. Every member of the group must produce the same agricultural product. Their lands do not need to be adjacent to combined into one piece but should be adjacent land plot or located near each other.

2) The project only supports three types of products: the first type consists of rice, crops, palm oil and rubber trees; the second type consists of fruit trees, vegetables, flowers, and herbs; the third type consists of aquaculture, livestock, and certain insects. Each group should have at least 30 farmers who voluntarily join the project and at least 300 rais of farm land (Duangbootsee, 2018).

2.6.4 Advantages of large-scale farming

Klaidang (2018) studied on the large-scale farming model (rice) in Mae Tha District of Lampang province and found that farmers who participated in large-scale farming model were able to reduce production cost by up to 22 percent and increase yields by 10 percent. They were also able to improve the quality of their agricultural products with guaranteed market demand.

Moreover, farmers also receive benefits in other ways as follow:

Environmental issue: a lost nature is restored which is a result of good and safe farming. The condition of the soil has improved. The ecosystem is more balanced.

Health issue: this model will help produce products that are safe for producers and consumers. Producers and consumers are healthy and have better quality of life due to the use of chemicals fertilizer correctly as well as a safe production process helps balance the ecosystem.

Social issue: large-scale farming will emphasize a cooperation among farmer families or small-scale farmers who produce the same products in the areas that are managed and operated in the same way (Ministry of Agriculture and Cooperatives, 2020). Farmers can meet, discuss exchanges knowledge to each other which create more unity and make the community stronger and more sustainable (Klaidaeng, 2018).

Economic issue: grouping or co-management give farmers more bargaining power as well as the exact market support. In addition, the merge of the produce led the merchants to buy more products as the products are reliable in both quality and quantity

as large-scale farming allows farmers to access advantages of expensive smart technologies and innovations which would be costly for small-scale farming. Many proponents of large-scale farming indicated that large farms are assumed to be associated with large machines, better access capital, stronger incentives to adopt technology as well as the ability to self-provide infrastructure and service (Duangbootsee, 2018). Moreover, farmers also have more income because they can reduce costs of production and directly. align their production with market demand (Atthakorn, 2017).

2.6.5 Difficulties of large-scale farming

However, it is too quickly to conclude that large-scale farming has been successful because there are many criticisms about the weaknesses of large-scale faming.

1) Farmers are quite old. This becomes a problem for introducing farmers to participate in large-scale farming and carry out large-scale farming.

2) It is very hard to find a skilled large scale-farming managers who can supervise both production and marketing plans, especially when there is no reward. The government's long-term plan, however, is to get farmers involved in the necessary training and management activities so that some of these so called "smart farmers" can replace the interim bureaucratic managers.

3) Weak governance structure can harm the large-scale farming program. The program membership is flexible because participants is free and voluntary exiting at will incurs no cost. There is no legal enforcement. This flexible helps attract farmers to the program. However, the unstable number of groups members makes long-term planning on both production and marketing strategies difficult and complicated to control. For example, inefficient use of inputs such as machines and water. The remaining members may not be able to increase their production to meet the amount agreed to buyers, which can consequently reduce the credibility of the group.

4) Enticing benefits in short run which means at the beginning, government personnel and staff were dispatched to recruit farmers to the large-scale farming program. Many farmers were unware of objectives and benefits of the program. However, they participate because of the enticing benefits offered in the beginning in terms of input subsidies such as access to organic fertilizers, seeds, access to soft loans with a preferential rate, and multiple trainings. In some areas, farmers were even offered a guaranteed price which is higher than market price if selling their products through the program. However, evidence shows that the disagreement and failure to establish the guaranteed price are the factors that drive some farmers away from the program. Moreover, for some farmers, the opportunity costs of time spent on multiple training sessions and the failure to establish a guaranteed price have offset the gain from the distribution of subsidized physical inputs (Duangbootsee, 2018).

5) The implementation of large-scale farming model needs to use a large budget. Moreover, with combining multiple plots, farmers have to plan to buy inputs and use tools together. They also have to sell their products at the same time. These would make famers feel a loss of freedom. If there are large companies who manage the land plots, farmers will become only agricultural workers (Atthakorn, 2017).

2.6.7 Large-scale farm project for smart farming progression

1) Government and private sectors work together in order to drive common goals (increasing yield per unit area and improving product quality) through large-scale farm project, which farmers are the center of operation. For example, the groups of farmers, government and private sectors together provide inputs and raw material with low cost (due to large scale purchase) that have a good quality and lower prices as well as provide suitable smart agriculture technologies which will help improve farmers' income and quality of life.

2) There is a network development of smart farmer and young smart farmer. This network helps increase knowledge and skills of farmer community so that they can develop agricultural yield products both in term of productivity per unit area and value.

3) Provincial or district agricultural offices takes charge of informing farmers about the benefits and operating methods of the project.

4) There will be a plan for each large-scale farm and also a business plan in order to achieve the five main goals which are reducing production costs, increasing yield per unit, increasing quality of products, developing effective market plan and developing effective farm management (Ministry of Agriculture and Cooperatives, 2020).

2.7 Relevant Researches

2.7.1 Kendall et al. (2017) wrote "Precision Agriculture in China: Exploring Awareness, Understanding, Attitudes and Perceptions of Agricultural Experts and End-Users in China" in order to study about precision agriculture (PA). PA is also referred as smart agriculture. It relies on various technologies and infrastructures, such as data gathering and management systems, geographic information system (GIS) as well as global positioning system (GPS). PA is about supporting farming decision with a view to use the right amount of inputs in the right place at the right time (Kritikos, 2017). In China, PA is a technologies hold the potential to address Chinese agricultural challenges, which are, for example ensuring food security for a growing Chinese population. It is also considered as a solution to reduce-chemical input and reduce negative environmental impacts that affect Chinese agriculture (Kendall et al.2017).

Although PA has a high potential to improve Chinese agriculture, according to this research PA also has its limited awareness. For the experts, consensus amongst experts indicates that PA technologies in their present form are suitable only for larger farms. It focuses on improving agronomic production on large farms (Daberkow and McBride, 2003; Adrian, Norwood and Mask, 2005). Moreover, larger farms were also thought to be more likely to have the requisite capital to invest in expensive PA technologies (Plant, 2001). Besides that, farmers lack current relevance and consideration given to this technology **(**Kendall et al., 2017).

For end-users and farmers, The lack of skills and motivation to learn new farming and agricultural practices was identified as problematic in small to medium farms and benefits of PA technologies are still difficult to be recognized and evaluated (Adrian et al, 2005). Farmers and end-user are not perceived to be relevant to the agronomic and socio-economic conditions in small to medium farms. The high capital costs of PA technologies were also considered outweighed any perceived advantages.

Higher order risks such as the consequences of the adoption of PA technologies on rural communities and issues associated with data privacy have been noted in other cultural contexts by the experts (Daberkow and McBride, 2003). However, farmers did not raise these concerns as they still have a very low levels of awareness of PA technologies. Experts believed that the perceptions of risk could arise if rates of PA adoption increase.

In order to make PA become better suited to the Chinese agricultural landscape which is small to medium farms with greater agronomic variation over smaller areas. The active demonstration of simplified PA technologies was recommended. Experts also suggested to do research and engagement activities within rural communities in order to co-construct technological solutions to farming challenges and improve farmer's relational engagement with the technologies The need for support and advice from experts identifying a gap for independent agronomy services are also important. **(**Kendall et al, 2017).

2.7.2 Srivetbodee and Igel (2021) also wrote their research, "Digital Technology Adoption in Agriculture: Success Factors, Obstacles and Impact on Corporate Social Responsibility Performance in Thailand's Smart Farming Projects"

The research of Srivetbodee and Igel has the aims that are correspondent to examine technology, such as IoT, AI and big data technology as a means for improving agriculture productivity for and secondly, to identify the success factors and impediments that farmers encounter when adopting smart technologies and thirdly, to explore the link between technology adaptation in two Corporate Social Responsibility (CSR) projects in Thailand with the CSR performance. This research has the two firm, DTAC and Siam

Kubota that have CSR project aiming to use technologies to improve Thailand's agricultural sector and minimize any negative effects on society and the environment.

As this research focused on the impact of smart farming technologies on CSR performance in an agricultural sector. Smart farming project in the study can be considered as CSR project. This study thus illustrates the benefits of the implementation of technologies by emphasizing there was a positive link between technology innovation in framing and the organization and firm's business performance in three aspects. First, it strengthens the brand image and the brand's competitive and brand's market position (Wolfert et al., 2017). which means the firm was widely accepted by the public as it can benefit. Secondly, smart farming CSR project can promote a goodwill among the staffs as all staffs are proud to be working on the project and to be working for firms, they think of doing something good for society (Carlini and Grace, 2021). However, it was not clear that the firms found any new market opportunities from their investments in smart farming. Thirdly, implementing smart farming technology have positive impact on local communities as it can help small-scale farmers to better manage resources such as crops, fertilizer inputs as well as environmental costs.

The common obstacles found from implementing technologies in both firms'CSR projects are access to credit and financial loans for farmers, poor technology infrastructure, the complexity of the technologies, farmer's conservative attitudes, the lack of knowledge applications related to resource a farming management for specific crops and a farmer's age and skills were discussed as DTAC in particular found that the optimal age range for participating smart farmers was between 18 and 45 years old. This age group was most receptive to learning digital literacy and to adopting new technology options.

For the recommendation section, the researchers mentioned that the interviewed executives from DTAC and SKC observed that agricultural management in Thailand is complex and requires a national roadmap to urgently improve the current agricultural sector's situation, such as soil and water resource management plan. Moreover, Thai government should invest in more research and development to foster Thai agricultural innovation, better access to loans might encourage farmers to implement and invest in

new technology and innovation on their farms. Thai government should also encourage farmers to become more entrepreneurial by launching agricultural start-ups and digital marketing workshops as the best way to encourage farmers to implement technologies in their farms is through training workshops (Srivetbodee and Igel, 2021).

2.7.3 Sayruamyat and Nadee (2019) also conducted the research focusing on the acceptance and readiness of Thai Farmers toward digital technology. They mentioned that Thai government launched, in 2018, a national strategic plan that was planned to be the main guideline for Thailand's the next 20 years. One of its main improvement plans is digital and technological infrastructure for agricultural sector which would help to extend the capabilities of Thailand's economic competition, enhance farmers' potential to be ready for recent market competition and offer well-being as well as better revenue for farmers (Office of the National Economic and Social Development Council, 2018). Moreover, Thai farmers need to understand and realize the benefits of technology and smart agriculture in order that they can improve their productivity in both qualitative and value aspects. While It is also the duty of the Thai government to support all the education and knowledge about smart agriculture which will help Thai farmers to survive in the competitive market nowadays.

2.7.4 Juhari (2021) wrote the research called "How the Agrifood Sector can be more sustainable in meeting SDG1 and SDG2" in order to explore the strategies to make the agri-food sector more sustainable in meeting SDG1 and SDG2-which to have no poverty and zero hunger respectively. The result show that there are three main strategies which are implementing smart farming, supporting farmer in term of finance and encourage youth involvement would contribute to the sustainable agri-food and agricultural sector. Each strategy also has positive impacts to the interlinked aspects of environment, social and economic. With these all positive impacts to the environment, social and economic of the three strategies, it can help in achieving the goals of zero hunger (SDG2) as well as poverty eradication (SDG1)

Chapter 3

Research Methodology

Thai government has tried to use the concept of smart agriculture in order to change Thai traditional agriculture into smart agriculture aiming for improving Thai agriculture sector which can help increase economic growth, improve quality of life as well as ending many social problems, especially the poverty and hunger.

Since Smart Agriculture is a new policy that will affect Thai people who work in agricultural area, particularly Thai farmers, semi-structured interview will be used to gather information from people who work as a farmer, a government field officer from Ministry of Agriculture and Cooperative (MOAC) as well as a policy maker from MOAC in order to improve effectiveness for agricultural policy in the future.

3.1 Population and Samples

Approximately eighteen participants were selected by purposive sampling technique. These eighteen participants consist of eight farmers, five government field officers from MOAC and five policy makers from MOAC. They were divided into three groups. Then, these three groups were interviewed by using semi-structured, open-ended questions.

3.1.1. The Group of Farmers

The first group includes four Thai farmers who apply smart agriculture to their farms. These six farmers were divided into two groups. All four 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 five years as a farmer in Thai agricultural sector

4) Being successful at applying smart agriculture to their farms (the farmers who are successful at applying smart agriculture to their farms means the farmers who use smart agriculture technologies for their farm production and management. And they can increase yield per unit of smart farm more than10 percent according to Thailand's Master Plan under the National Strategy on Agricultural Issues)

The second group also has four farmers. All four 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 five years as a farmer in Thai agricultural sector

4) Being less successful at applying smart agriculture to their farms (the farmers who are less successful at applying smart agriculture to their farms means the farmers who use 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)

This research focused mainly on farmers in Ayutthaya because this province has many large-scale paddy fields together with good irrigation system that connects to Chao Phraya River and Pa Sak River. Ayutthaya also can achieve Good Agricultural Practices (GAP) standard. Moreover, it also has enough quality of production to meet the demand of many famous chain supermarkets.

3.1.2 The Group of Government Field Officers from MOAC

Beside the group of farmers, the group of government field officer which consist of five government field officers from MOAC was also interviewed. Officer in this group regularly work in field and work closely with farmers in Ayutthaya province All five government field officers in this group 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

3.1.3 The Group of Policy Makers from MOAC

This group has five policy makers. All five policy makers in this group are also from MOAC. They 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

Thus, the list of intended participants will be shown in the following table:

Table 3.1 The Intended Participants and Type of Work

Number of people	**Type of intended Participant**	**Work details**	**Work experience (Year)**
Four	Farmer	- Owning or managing farms or growing crops or plants as a business - Having farms or doing farming in areas of Ayutthaya province - Working as a farmer in Thai agricultural sector - Being successful at applying smart agriculture to their farms	At least 5

Table 3.1 The Intended Participants and Type of Work (Cont.)

Number of people	**Type of intended Participant**	**Work details**	**Work experience (Year)**
Four	Farmer	- Owning or managing farms or growing crops or plants as business - Having farms or doing farming in areas of Ayutthaya province - Working as a farmer in Thai agricultural sector - Being less successful at applying smart agriculture to their farms	At least 5
five	Government field worker	- Having a work experience in MOAC or in an area of Thai agriculture - Working in field or alongside with the farmers in Ayutthaya province - Being an officer of MOAC	At least 5
five	Policy maker	- Having a work experience in MOAC or an area of Thai agriculture - Having work experience or working in the field of smart agriculture with the position of executive or policy maker - Being an officer of MOAC	At least 5

The researcher planned to interview four to three participants that fit criteria for each group (group of successful farmers, less successful farmers, officers from MOAC who work in the field closer with farmers as well as officers from MOAC who work as executive or policy maker and)

However, as it became clear that there were more than three people who fit criteria for each group, the researcher decided to use simple random sampling method to select only three people from all people that fit criteria of each group for final participants.

3.2 Interview

The interviewed participants consist of eight farmers who apply smart agriculture in their farm in Ayutthaya province, five government field officers from MOAC and five policy makers in MOAC. In order to protect identify them as follows: Participant A, Participant B, and Participant C. The details of all participants are as follow:

Table 3.2 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
16	Participant P	The senior officer of the Rice Department, MOAC

Table 3.2 List of Interviewed Participants (Cont.)

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

3.3 Research Instruments

In order to provide and gather as much relative and informative evaluation, this research used the semi-structured interview as the main source.

Interview is a direct communication. It is considered as one of the most effective approach for qualitative research. Interview questions are usually open-end questions so that in-depth information will be collected (Connaway and Powell, 2010). McNamara (1999) mentioned that interview allows researchers to get all information of the participant's experience. Researchers can pursue in-depth information around the topic and follow-up certain respondents for a further information.

A semi-structured interview is one of the important interview types. It is an in-depth interview that is commonly used in qualitative research. This method allows the researcher to collect open-end data in order to deeply explore participants' though, opinion and beliefs about particular topic or research's topic (DeJonckheere and Vaughn, 2019).

Advantages of a semi-structured interview are as follows: firstly, semi-structure interview can create positive rapport between interviewer and interviewee. Thus, the researcher can easily get things that cannot be easily observed such as emotions and feeling; secondly, participants are able to talk about all important information in detail and depth; thirdly, the interviewer can probe areas suggested by th

e respondent's answers, and can also learn from the answers which can help create picking-up information, the information of which interviewer had no prior knowledge; fourthly, with the pre-set questions in semi- structured interview, the interviewer is not pre-judging what will or will not be discussed in the interview; fifthly, Easy to record interview, for example video and audio tap (Newcomer, Hatry, and Wholey, 2015).

Three sets of question will be prepared for the interview. The first set will be used to interview Thai farmers who apply smart agriculture in their farms in order to gather relative information, direct experiences and recommendations from Thai farmers. The second set of question will be used to interview MOAC officers who works in the field with Thai farmers in order to get relative information and recommendations about Thai agricultural and smart agriculture from the government officer's perspective. The last set of question will be used to interview policy maker from MOAC as This research needs some points of view high position government officers in order to analyze the recommendation for the improvement of the Thai government policy on smart agriculture.

For an effective outcome of the research, the researcher also tried to use secondary sources, for example official statistic information and researches from MOAC as well as case study about smart agriculture management in other countries.

3.4 Data Collection

This research was conducted in the pattern of qualitative method. The research also used information and personal opinions obtained from semi-structure interview as the primary source for the analysis and used the existing information such as reports, and article related to the topic as well as statistic as a secondary data to support the primary source. The data got from the participants will be divided into the information from the government side and the farmer side.

3.5 Data Analysis

The data analyzed in this research was conducted in the pattern of qualitative method. Grounded theory is one of the well-know methodologies used in qualitative research. Thus, grounded theory was employed in this research as the main method to analyze the research findings.

Grounded theory is a research method concerned with the generation of theory, which is "grounded" in data that has been systematically gathered and analyses. Grounded theory used to discover social processes, such as social relationships and behavior of groups.

Glaser and Strauss (1967) identify that there are three stages of data analysis in Grounded theory which are: 1) developing categories which illuminate the data; 2) saturating the categories with many appropriate cases in order to demonstrate the relevance; and 3) developing the categories into more general analytic frameworks with relevance outside the setting.

Nable and Mitchell (2016) also divided grounded theory's data analysis into three stages. The first stage was code opening. At this state, after the interviews, the researcher read through all the transcripts and notes from the interviews line by line. Key phrases were highlighted. The researcher started to summarize and reflect on what the researcher was understanding from the data, then tried to create tentative labels for chunk of data.

The second stage was axial coding. At this state, the researcher analyzed all information along with notes that received from interviews and identified relationships among the open codes (similarities and differences of the answer from each participant to each participants). All highlighted or key information was moved into subcategories, then the categories. This turned data and information into conceptual components.

The last stage was selective coding. This stage involved identifying the core categories or comparing the similar themes that arose from each question. The similar themes found at this selective coding stage would lead to the presentation of research findings.

The structure and steps of grounded theory which is qualitative data analysis is presented below:

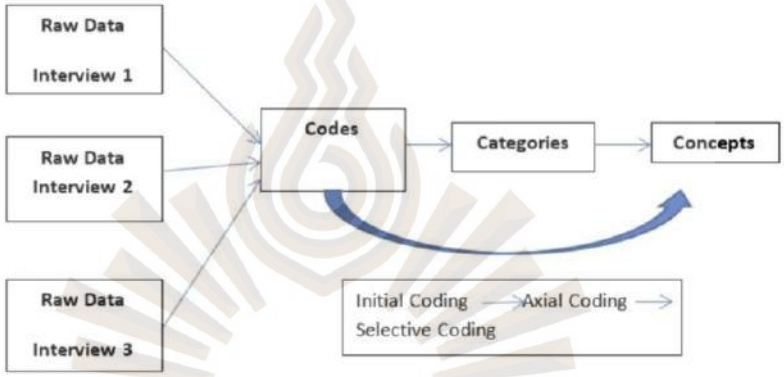

Figure 3.1 Structure of Qualitative Data Analysis

Source: Chetty, 2020

Chapter 4

Research Results

This chapter presents the research results collected by semi-interviews with the three groups of participants which are: 1) farmers in Ayutthaya province who apply smart agriculture to their farms, 2) government field-officers from Ministry of Agriculture and Cooperatives (MOAC) who work with farmers in Ayutthaya province and 3) government policy makers who have work experience in a field of Thai agriculture and smart agriculture.

4.1 Research Finding

All participants will be interviewed with the same question in order to answer three research questions. However, some participants will also be interviewed with specific questions in order to get additional information that can help the researcher to answer the research questions more comprehensively.

This session will show systematically the perspectives of each group of participants on each research questions and research problems. It will also reflect the ideas of some participants that useful for finding the results of this research.

4.1.1 The Situation and problem in Thai agricultural sector

According to the interview with farmers and government field workers who work with farmer in Ayutthaya province about the situation of Thai agricultural sector, there are fifth important problems that were mentioned. These problems could indicate current situation and problems that Thai farmers are facing in Thai agricultural sector in general nowadays.

First problem is irrigation system management. Inadequate water management is still the main problem in Thai agricultural sector and can be divided into two main problems which are water shortage and floods. This problem was mentioned by all interviewed farmers as well as one out of five interviewed government field. For example, participant K reported that:

> "Thai agricultural sector also faces problems with inadequate water management, causing farmers to experience frequent droughts and floods." (Participant K, Personnal Communication, 28 November 2021)

For water shortage problem, Thailand has the total agriculture area of 323 million rais, but only 23 percent of the total agriculture area or 33.8 million rais have the facility of water irrigation management. Therefore, the majority of 115.5 million rais or 77 percent of the area only depend on the water from rain fall and some natural reservoir. Thus, the majority of farmers who use only rain fall for their farm have to face with drought and flood that has been affected more severely by climate change, natural disaster, forest invasion and also global warming.

> "At the present time, the farmers have to depend on rain fall in order to have water for their farms, therefore the water storage is one of the problems to be overcome. Then any new technology is needed to predict the amount of rain fall or to reduce the use of water and as climate change and disaster." (Participant A, Personnal Communication, 28 November 2021)

> "The farmers who have their farms' position downstream of The irrigation system hardly get enough water for their farms while the farmers who live up stream have enough water for their farms." (Participant F, Personnel Communication, 28 November 2021)

For flood problem although the farmers are facing with drought for their farms during hot season, however they also face with flood during rainy season because Thailand still does not have enough reservoir of lake to keep rainwater. In 2021, farmer can harvest only some of their agricultural product because of flooding problem. Other farmers had to harvest even though the crop is under proper time.

> " Farmers in recent years, some people harvest rice and get only 70 baht per bucket or 3 buckets of 100 baht because they have to rush to harvest rice before the rice is ready avoiding flooding conditions. Today's world has changed a lot. There are many changes in environment and climate. Thus, many problems arose. For farmers who depend on rainfall water, their farming activities will begin in June and July, resulting in late harvest because of flooding. Thus, their products are not up to standard because they have to harvest their product before proper time. Farmers then, get a bad price for their products or cannot sell it." (Participant G, Personnel Communication, 28 November 2021)

These two kinds of water irrigation management problem cause serious damage to agriculture product, therefore, they have to ask for help from official units, such as Royal Irrigation Department, Department of Water Resources, Department of Groundwater resources, Department of Disaster Prevention and Mitigation and also military unit within the local area to bring in some water for them.

The second problem which is high production cost. This problem was also mentioned by all eight farmers. Recently, Thai farmers have to face with the problem of high-cost production such as seed, harvesting cost and also the production inputs such as fertilizer and pest control substances as its prices increase considerably (around seventy to hundred percent from last year). They also face the cost that they have to spend on the labour wage and renting machineries.

> "The cost of fertilizer is very expensive and there is no serious price control policies. The government should control the price of fertilizer to meet the standard price." (Participant A, Personal Communication, 28 November 2021)

> "Production cost for me also includes the cost of labour that I have to pay for rice harvesting and milling process. It is very high." (Participant B, Personal Communication, 28 November 2021)

Three out of five government field workers also reported about the problem of high production costs. Even though cost of production is increasing, the price of the product is much lower than before because of the current economic conditions. For example, Participant I reported that:

> "At present, the Thai agricultural sector is in critical condition. Many agricultural products have low prices. Some periods they cannot be sold, but the cost of production is higher, whether it is chemical fertilizer or other important chemical substance for weed and pest control. The prices are increasing around one hundred to three hundred baht. Moreover, farmers become older, while the younger generation want to work in industrial factory Thus, farmers have to hire the outside labour." (Participant I, Personal Communication, 28 November 2021)

The third problem is the dropping of agricultural commodities' prices. Whenever there are the products that exceed demand in the market, then the products' price always dropdowns. The Ministry of Commerce has to help by trying to export the extra products abroad. This problem was reported by three farmers, for example:

> " Thai farmers have to face with high production cost which always comes at the same time with the drop of agricultural commodities' prices problem. In many times that the government has to use the

> policy of price guarantee for various agricultural products. However, the same problem still continues the following year and the farmers once again cannot get out of the problem." (Participant G, Personal Communication, 28 November 2021)

> "Even though the government has been trying to help us, the problem that I would like the government to tackle the most is still the problem that agricultural products' price in Thailand is very low, while the production costs become higher every year." (Participant H, Personal Communication, 28 November 2021)

Three out of five government field workers also reported about the problem of the declining of agricultural product prices, for example:

> " The first problem that I would like to mention is the economic problem. Agricultural products can be currently sold with low prices Thai farmers prefer to grow only one type of crop or only popular plants resulting in more products than the demand of consumer. Thus, making the production supply overwhelm the market needed and reduce the product price. Moreover, the situation of the epidemic of COVID-19 causes the agricultural sector to slow down as power of consumers per product is reduced. In addition, farmers cannot export their products." (Participant L, Personal Communication, 28 November 2021)

The fourth problem is the problem of land ownership. Many farmers are not a landowner. They have to lease land with a high price in order to grow crops. Moreover, they cannot make any land development can access to water resource. This creates the large inequality of accessing to land and natural resources. This land ownership problem was reported by participant B.

> "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." (Participant B, Personal Communication, 28 November 2021)

The last problem is that Thai agricultural sector is facing serious labour 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 reported that:

> "Most of farmers are elderly people. They do not have inheritance who will continue to do farming activities. In addition, young generations whose father or mother is a farmer are not interested in farming activities because the income from agricultural sector is not as much as the income from other sectors." (Participant L, Personal Communication, 28 November 2021)

4.1.2 Advantages of the Implementation of Smart Agriculture.

After using smart agriculture technologies, participant found that implementing smart agriculture technologies in their farms has advantages. There are three main advantages or benefits of using smart agriculture that were mentioned by them.

Firstly, smart agriculture can help farmers to work with fewer mistakes help reduce production costs and all expenses that farmers have to pay unnecessarily. As smart agriculture provides many technologies and system that can correct needed data accurately and effectively, hence farmers can make maximum use of resources and can use smaller number of inputs and resources which can bring more profits to farmers. This benefit was mentioned by all interviewed farmers.

> " When using smart agricultural technologies, we will know quite for sure how many rice grains we sow per rai, for example, nowadays we use only eight to ten kilograms of rice grains per rai, while before, when we used traditional agriculture, we used two and a half buckets, or around 25 kilograms, this shows that smart agriculture can help reduce the cost of production and input." (Participant G, Personnel Communication, 28 November 2021)

> "Smart agriculture enable farmer to manage precision farming and, hence minimize the use of water, therefore paddy field can be made every year by using small scale of water from the pond with the size of two rai and three meters deep on his farmland, for his 12 rai of paddy field successfully." (Participant C, Personnel Communication, 28 November 2021)

> "After using smart agriculture, farming is much better and easier than before. Farmers can produce agricultural products with precision system. Farmers can determine the use of chemicals and biological substances accurately. In the past, when farmers use tradition farming system, farmers had to spray pesticides or plant nutrients unsystematically. Moreover, during seedtime, farmers did not know the quantity of rice grains they used. It is very difficult to control costs when they still did not use smart agriculture technologies." (Paricipant F, Personnel Communication, 28 November 2021)

Three out of five government field officers also reported about this advantage. For example, Participant K reported that:

> "The core of smart agriculture is to apply technology in order to manage and increase agricultural productivity and to reduce the wastage of resources, factors of production as well as all inputs. It can help farmers use resources effectively and accurately. Thus,

> farmers can reduce production costs while they can produce more agricultural products." (Participant K, Personnel Communication, 28 November 2021)

Secondly, 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 out of eight farmers, for example:

> "Smart agriculture allows farmers to produce their agricultural products according to technical principles, for example, farmers can properly fertilize according to soil analysis values or they know the correct fertilization period according to principles such as type or amount of fertilizing before harvesting. The correct and good management in field can make agricultural products more standardized and can be sold and required by the market." (Participant D, Personnel Communication, 28 November 2021)

> "Using smart agriculture can increase agricultural productivity. resulting in more productivity and better quality of agricultural products which leads to more incomes or returns while consumers get quality agricultural products. For example, implementing land leveling or a laser area adjustment system in rice fields can make the area to have an even slope, making it is more convenient to use chemical fertilizers in farms. For water management and also reduce the use of water in the plots. As a result, crops receive consistent water, which make an even growth for the plant throughout the field, hence increase the quality and quantity of product." (Participant H, Personnel Communication, 28 November 2021)

Two out of five interviewed government field officers also reported that smart agriculture can help increase agricultural productivity, for example:

> “Smart agriculture helps farmers to produce more agricultural products, while the products maintain a good quality. This will also result in farmers receiving more returns.” (Participant J, Personnel Communication, 28 November 2021)

Third advantages of the implementation of smart agriculture that was reported is about labour. The implementation of smart agriculture and technologies could help reduce number of labour and the cost of labour. This advantage was reported by four out of five interviewed farmers, for example:

> “I use smart agriculture, which is drones. After deducting costs, I found that it is more profitable than hiring labour.” (Participant B, Personnel Communication, 28 November 2021)

> “Smart agriculture reduces human labor usage, which is great because it can increase productivity. Ten workers can work in farms less thanhundred rai per day. If you are afraid of the problem of unemployed people, don't be afraid because now it is very difficult to hire agricultural workers due to the death of a large number of old agricultural laborers.” (Participant F, Personnel Communication, 28 November 202)

> “I use smart agriculture, which is drones. After deducting costs, I found that it is more profitable than hiring labour.” (Participant G Personnel Communication, 28 November 2021)

For this advantage, the three out of five interviewed government field officers also reported that smart agriculture technologies can help reduce labour forces and labour costs. For example Participant I reported that:

> "In the case of farmers that have farms with high productivity, smart agriculture can help farmers reduce their expenses, in particular, labour costs. Moreover, smart agriculture can also replace labour forces when agricultural sector is facing labour shortage trends and entering an aging society." (Participant I, Personnel Communication, 28 November 2021)

4.1.3 Achievement of Smart Agriculture in Thailand

All policy makers were asked about achievement of smart agriculture in Thailand and how it can improve Thai agriculture. They reported that smart agriculture in Thailand was just getting started. Smart agriculture was put in 20-year National Strategy launched in 2018 aiming that it can help increase the competitiveness enhancement. It is still in an early stage for Thai farmers and also for government field officer and policy makers to follow the plan. Thus, it is difficult to tell how smart agriculture can help farmers and improve Thai agricultural sector. However, all interviewed policy makers have a positive perspective towards Thailand's implementation of smart agriculture. In order to develop smart agriculture, Thai government still needs to support smart agriculture in more concrete way, so that Thailand can cope with agricultural problems such as climate change, aging society, labor shortage and pest infestation.

> "Smart agriculture can help the Thai agricultural sector but not yet systematically because the MOAC's policy is not yet strong because of budget limitation. The government cannot create new programs and plans to promote the use smart agriculture technologies. However, many private sectors in Thailand are trying to support the government, such as many private enterprises try to rent their smart technologies out with low prices. There are also many service providers provided by famous enterprises whose services' are not expensive. For the perspectives of Thai farmers towards smart agriculture, when we talk about smart agriculture, most of Thai farmers still think of machineries that can help facilitate farming activities and they

normally use in paddy field, such as drone, rice harvesting machines, seeding machine, fertilizer spreader machine and pesticide sprayer machine. This kind of technologies can be categorized into "Agricultural Robotic". Moreover, smart agriculture is still often used only for high-value agricultural products, such as tomatos and melons." (Participant N, Personnel Communication, 20 November 2021)

"Smart agriculture has just been implemented in Thailand three to four years ago. The implementation is being in an early stage. The overall outcome or success of smart agriculture in Thailand is not very noticeable, however, for me, applying of modern technology in the agricultural sector shows a positive trend for farmers, both in terms of cost, time, labour and resource reduction. Smart agriculture can make agriculture more eco-friendly. Nowadays we start to have researches from both government and private sectors confirming that smart agriculture can really help Thai agricultural sector and farmers, such as MOAC officers found that flying drone can reduce water consumption by more than 80 percent, as well as reduce time and cost of production." (Participant O, Personnel Communication, 20 November 2021)

"The results or achievements of smart agriculture implementation in Thailand are still limited because smart agriculture implementation has just started to be used officially in Thailand in the past few years. In most cases, we can see the success of using smart agriculture, but only in large-scale farms of private sectors that have supported funding and young farmers who are ready to use new technologies. In my opinion, the government should not expect or set goals that smart agriculture will help solve all Thai farmers' problems or can improve situation of the Thai agricultural sector as a whole because smart agriculture concept mainly focuses on improving agricultural sector development in economic dimensions, while MOAC have to improve agricultural sector in all economic, social and environment

dimension. (Policy maker, Personnel Communication, 20 November 2021)

4.1.4 Smart Agriculture Implementation and its Role in Helping Thailand to Achieve the Sustainable Development Goals (SDGs).

According to interviewed policy makers, smart agriculture related to various SDGs. Participant O, P, Q and R reported that smart agriculture is related to hunger problems which is SDG2. Smart agriculture can help decrease time of production, while it can increase production capability as technology and innovation can help agricultural production to better adapt and respond to adverse environmental conditions. So, overall products including vegetables, or any other edible products will also increase even there are the environmental changes.

> "When all eatable products are increased from agriculture, it would be easier for people to get enough food." (Participant O Personnel Communication, 20 November 2021)
>
> "The famine situation in Thailand is better than many countries in South Asia and Africa. However, smart agriculture can still be considered as an important tool to increase agricultural products to meet all demands." (Participant D Personnel Communication, 20 November 2021)

All these four participants also reported that smart agriculture can also be one of important factors that can help eradicate extreme poverty in Thailand which is SDG1

> "Smart agriculture can increase agricultural products which can also increase income for farmers." (Participant P,Personnel Communication, 20 November 2021)

However, Participant N has a different perspective from others reporting that smart agriculture is not the answer for both hunger and poverty problems. For smart agriculture implementation in Thailand goal, its goal is still very far from these two SDGs which are ending poverty and hunger.

> "In Thailand, smart agriculture is just the concept that can help facilitate farming processes to be more stable and secure. It is still far from eliminating poverty and hunger. In Thailand, we consider that agriculture can help to support farmer's life, help them to live but still not enough to help end poverty or hunger problems. Smart agriculture in Thailand still need more support from the government in order to help Thailand reach the SDGs." (Participant N, Personnel Communication, 20 November 2021)

Beside the fact that smart agriculture is related to poverty and hunger problem, according to Participant N, O, P, Q and R, it can be considered as one of important factors that can help manage natural resources and foster eco-friendly production, while reduce waste and boost recycling.

Thus, SDGs that is related to smart agriculture is SDGS6 which is ensuring availability and sustainable management of water and sanitation for all. Policy makers believed that smart agriculture could help farmers to use water effectively.

> "Even Though Thailand has an average rain fall of around 280,000 million cubic meter per year. Thailand is still facing with drought problems because the rain in Thailand continues to fall unevenly due to climate change and the construction of reservoirs or dams are not enough to keep the rainfall. Technology, such as smart agriculture can help Thai farmers to use water in the most efficient way. Smart agriculture can help reduce farmers' water use to an appropriate level. without affecting agricultural productivity. It is an approach that should be a guarantee that Thailand will have

> sustainable hygienic water management for everyone." (Participant R, Personnel Communication, 20 November 2021)

SDG12, which is ensuring sustainable consumption and production patterns, is also related to smart agriculture. Participant N, O, P, Q and R reported that one of main global challenges is to integrate environmental sustainability with economic growth and welfare. Smart agriculture could be the good solution fort his challenges as smart agriculture can help increase productivity to meet increased demands. To feed the world sustainably, producers need to grow more food while reducing negative environmental impacts such as water, soil and nutrient loss, greenhouse gas emissions and degradation of ecosystems. Moreover, consumers must be encouraged to shift to nutritious and safe diets with a lower environmental footprint. Smart agriculture can help farmers to produce enough products to meet population's needs in effective way. Farmers can produce agricultural products, while creating sustainable agriculture by reducing the use of the natural resources and negative impacts on the planet. Smart agriculture can also collect important information about, for example production factor that will lead to farmer's success.

> "Smart agriculture can lead to sustainable agriculture as it helps farmers to collect all the important information that can help farmers to avoid loss of production factors, resource waste and environment degradation as before doing farm activities, farmers should have knowledge about natural resources and environment in their farm's area. Farmers should consider soil quality, humidity, weather and a lot of other things before starting their farming process." (Participant P, Personnel Communication, 20 November 2021)

For SDG13, which is taking urgent action to combat climate change and its impacts, Participant N, O, P, Q and R reported that smart agriculture and SDG13 are very relevant.

> "In order to combat with climate change, the smart farmers have data about weather." (Participant N, Personnel Communication, 20 November 2021)

> "With smart agriculture knowledge farmers can build agricultural greenhouses that can control their own environment. It can reduce the impact of climate change. However, the Ministry of Agriculture and Cooperatives needs to work with the Thai Meteorological Department and build guidelines for Thai farmers in order to reduce loss and accomplish." (Participant P, Personnel Communication, 20 November 2021)

4.1.5 Disadvantages of Smart Agriculture Implementation

After using smart agriculture technologies, participants found that implementing smart agriculture technologies in their farms still has disadvantages that should be concerned. There are four main disadvantages of using smart agriculture that were mentioned by participants.

First disadvantages that was reported is that smart agriculture. technologies require a lot of money for an investment. It is very expensive. Therefore, they are non-affordable for farmers, especially for small-scale farmers which still dominate Thai agricultural sector. This problem was reported by five out of eight interviewed farmers. For example, Participant E reported that:

> " Smart agriculture technologies require a very high investment. Moreover, for an agricultural loan, farmers still have to pay high Interest rates" (Participant E, Personnel Communication, 28 November 2021)

Moreover, the disadvantages about the cost of cost for the investment in smart agriculture was also reported by all interviewed government officer. For example Participant I reported that:

> "Smart agriculture requires high costs of investment. This make farmers who are interested in smart agriculture hesitate to invest in smart agricultural technology. (Participant I, Personnel Communication, 28 November 2021)

Secondly, smart agriculture makes use of high technologies that require technical skills, precise and specific experiences to make it success. The farmers thus will need to have technology experience as smart agriculture acquire new skills of farming management, knowledge and also updated information. Thus, using smart agriculture seem to be difficult and complicated for farmers as they technology do not have the required skills, especially aging farmers who lack education, knowledge and access to technology. This disadvantage was reported by five out of eight farmers, for example:

> "Smart agriculture is something that farmers need to be approached by others who have experience, such as officers from MOAC, leader of farmers. Moreover, farmers also have to constantly search for new information about it all the time." (Participant C, Personnel Communication, 28 November 2021)

> "Farmers still have very little knowledge of the technology, which may make the use of smart farming technologies not as effective as they should be. Farmers lack knowledge in the maintenance of smart tools and machines. In addition, it has the possibility of accidents during the time of using smart agriculture technology that can cast a lot of money." (Participant E, Personnel Communication, 28 November 2021)

> "For farmers, using smart Agriculture effectively will take time. Farmers need to acquire new knowledge and skills and information in order to be able to use smart agriculture successfully and effectively. When farmers decided to use smart agriculture, seeking guidance from knowledgeable people such as local officers and leaders of farmer groups who have experience are very important. They have to go around in order to observe examples from farmers who have used smart agriculture before them. Moreover, farmers who are interested in using smart agriculture need to find out an updated information all the time in order to use smart agriculture successfully and effectively." (Participant F, Personnel Communication, 28 November 2021)

Moreover, this disadvantage was also reported by four out of fives government field officers. For example, Participant J and L reported that

> "Most farmers do not dare to start using new technology in their farms and do not know how to start applying technology because they do not have enough knowledge and experience about smart agriculture." (Participant J, Personnel Communication, 28 November 2021)

> "Farmers have not yet reached new technology for many reasons, one of them is that farmers still lack the skills and knowledge, especially old farmers they have never used technologies in their entire life." (Participant L, Personnel Communication, 28 November 2021)

The third disadvantage is that applying smart agriculture into farms 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 benefits and risks of using technology in

agriculture. They do not believe that smart agriculture will be useful. This disadvantage was reported by two out of five farmers.

> "Changing believes and attitude of farmers to use smart agriculture is difficult because aging farmers are not open to new technologies." (Participant E, Personnel Communication, 28 November 2021)
>
> "Aging farmers are still not open to the use of technology. Aging farmers normally only stay in their house and rarely leave the house. Therefore, they do not know what is happening around them. Farmers who are interested in technologies and innovations, such as young smart farmers, when they use smart agricultural technologies in farms. Aging farmers will come to hire these farmers who know how to use new technologies instead of using the technologies by themselves." (Participant H Personnel Communication, 28 November 2021)

This disadvantage was also reported by four out of five government field officers, for example:

> Farmers are not open to smart agriculture technology because they do not believe that this technology can help reduce costs of production and resource. Farmers, especially ageing farmers still adhere to a traditional or an old farming." (Participant K, Personnel Communication, 28 November 2021)
>
> "We can see that there are just only young farmers who are interesting in learning technology literacy and in adopting new technology options." (Participant M, Personnel Communication, 28 November 2021)

The last disadvantage is that 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 workers. For example, Participant J, L and M mentioned that:

> "Supports from the government are still limited There are still only few smart agriculture service centers in Thailand which do not cover all areas. In addition, smart agriculture applications do not cover throughout agricultural production cycles and plant species. The data used for agricultural production is usually a general statistical data. which is inconsistent with the reality and problems met by Thai farmers. If farmers want to meet their needs, farmers may have to work and develop the system themselves." (Participant M, Personnel Communication, 28 November 2021)

> "There are still constraints on setting main goals and budgets when the government tries to create projects in order to develop farmers' skills together with relevant agencies. In addition, although the budget has already been approved, officers still cannot develop farmers throughout the production process because limitations of government regulations and the amount of support is small." (Particicpant L, Personnel Communication, 28 November 2021)

> "Because smart agriculture is new Therefore, most farmers are not interested in the smart farming system due to the lack of technological capabilities. They also do not receive continuous support in term of knowledge and information from the government. The government should therefore focus on educating. and develop farmer skills, especially for the young generation farmers who are ready to learn from advice from the government" (Particicpant J, Personnel Communication, 28 November 2021)

Policy maker N and O also reported about the budget support from the government. This challenge is budget supports by the government. To set up the budget for any policy, Thailand still uses an old process which does not match the development plan presently. The 20-year National Strategy was planned to be main method for developing the country. Many new projects were created including Smart agriculture. However, the budget supports from the government is not sufficient for the policy makers, if the government would like to run all their projects continuously and efficiently. Moreover, new technology and innovation are very expensive. They also need maintenance which costs a lot of money which most farmers cannot afford.

> "Thailand's allocation of the budget still uses the same process which was set with old ceiling. This means new projects aiming to develop smart agriculture have not been given proper enough attention. Thailand started to use technology and machinery, but the government's supports still not enough in order to drive the policy. Farmers were invited by the government to come together in order to buy technology and machinery which is also known as large-scale farming project, but this project is still not very concrete. Budget and funding are the main factors driving the smart agricultural policy to create a machinery pool model and service provider. If the government is unable to find funding to help farmers, MOAC can help in the form of a service provider, such as supporting drone or various applications. There is no single policy. Must help as a start for farmers as well." (Participant N, Personnel Communication, 20 November 2021)

> "Source of funds in Thailand are inaccessible for most of the farmers. In addition, the allocated budget is limited and lacks continuity. The government should allocate the budget in line with national development strategies to achieve the objectives and produce tangible results." (Participant O, Personnel Communication, 20 November 2021)

4.1.6 Recommendations from Participants

There are four main recommendations suggested by participant which are firstly, they suggested that the government should focus mainly on water resource or irrigation problems which are very important for farming. Currently, there are very few water resources in Thailand compared to the areas used by farmers for farming. This was mentioned by Participant A,B, C, D and F

> "What I would like the government to help is to provide water sources for farmers to use in an adequate way and enough for farming throughout the year." (Participant A, Personnel Communication, 28 November 2021)

> "I want the government to help or support the agricultural sector in term of allocation of water resources appropriately so that it is enough to use in agriculture." (Participant F, Personnel Communication, 28 November 2021)

Secondly, government should pay attention to support the development of knowledge and training skills about smart agriculture for both farmers and officers. This was mentioned by four out of eight farmer which are:

> "If farmers are really interested in using smart agriculture, the government should support them by developing knowledge, together with cooperation with agricultural institutes, universities in order to get right information." (Participant B, Personnel Communication, 28 November 2021)

> "I want the government to support in the matter of training by visiting various smart agriculture areas. This will be able to help farmers to use smart agriculture successfully and effectively." (Participant H, Personnel Communication, 28 November 2021).

For Participant G, this participant also suggested about the development of farmers' knowledge and skills by focusing on young smart farmers. Participant G said that:

> "The Ministry of Agriculture and Cooperatives has initiate young smart farmers campaign for five years hoping that young generations will share their experience about using technologies in their farmers and will persuade other older farmers in their community to use technologies and innovations in order that Thai agricultural sector will be improved. Nowadays, there are Young Smart Farmer Center and Community in all 77 provinces around Thailand, but there is very little budget and fund from the government to support all these Young Smart Farmer. Center. Some centers still do not get any support." (Participant G, 28 November 2021)

Two out of five interviewed government field also suggested about training government officers.

> "In order to develop the agricultural sector, Thailand must begin to train and support government officers, make them realize the importance of the use of technology in agricultural sector in the same direction in order to help drive the government agricultural policy." (Participant K, Personnel Communication, 28 November 2021).

> "In order to recommend and convince farmers to use smart agriculture. The staffs need to be experienced and have correct understanding about agriculture and technology so that farmers." (Participant M, Personnel Communication, 28 November 2021).

Four out of five interviewed policy maker also emphasized the same suggestion, for example:

> “To develop government departments and train the officers in various areas in order that they will become an expertise and a good consultant for farmers in progressing into a smart agricultural is an production model another important factor.” (Participant P, Personnel Communication, 20 November November 2021).

> “Taking farmers to learn from model farmers who are successful in using smart agriculture is a good way to give farmers needed information and practicing farming skills. They can see with their eyes that using smart agriculture, such as using phones in order to record and search for information on the internet, using technology to assess environment in the production plot as well as using sensors to detect and report to farmers' phones, is not that difficult. This way of teaching will make farmers more comfortable to learn.” (Participant Q, Personnel Communication, 20 November 2021).

The government also need to focus on creating learning space especially, the smart agricultural demonstration model farm for farmers in order to persuade then to use technologies and innovation in their farm. Nowadays, the role model farm only started with a small target and only for some kinds of plants. It needs to be expanded which would bring more interest from farmers. The government needs to work together with famers who are already successful in using smart agriculture.

> “The farmers would believe in smart agriculture when they see it from their own eyes.” (Participant N, Personnel Communication, 20 November 2021).

Thirdly, they suggested that the government should support smart farming tools or machineries that are suitable for farmers to do smart farming in Thailand. The government could also support funds that can be borrowed by farmers to buy the above intelligent tools. This suggestion was mentioned by five out of eight farmers as three farmers emphasized the importance of supporting smart farming tools, while two farmers focused on budget support, for example:

> "The government should consider the policy that can keep the price of machine tools for smart agriculture to minimum for farmers and ensure that the quality of all tools and machineries can be used for a long time. Also, the government should arrange a center for renting agricultural machinery at a cheap price to help farmers." (Participant C, Personnel Communication, 28 November 2021).

> "The government should help arrange budgets for farmers, especially for young farmers to buy smart farming tools. I am sure that the new generation of farmers can use these budgets for maximum benefit and help old farmers to reduce costs of production." (Participant G, Personnel Communication, 28 November 2021).

This suggestion was mentioned by all interviewed policy makers, for example:

> "The government should consider the policy that can keep the price of machine tools for smart agriculture to minimum for farmers and ensure that the quality of all tools and machineries can be used for a long time. Also, the government should arrange a center for renting agricultural machinery at a cheap price to help farmers." (Participant O, Personnel Communication, 20 November 2021).

> "Nowadays, technology is advancing rapidly. Thus, the government should encourage government agencies to learn and apply various technologies in order that they can advice and train about agriculture

technology properly,. Technologies for agricultural sector should be technologies that can be used in practice or easily to use. Moreover, all government agencies that take charge of agriculture should help facilitate farmers to have access to technology sources, in terms of materials, equipment, sources of loans, and should support the private sector or agricultural consumers to support products that obtained by smart agriculture system." (Participant P, Personnel Communication, 20 November 2021).

"The government should help arrange budgets for farmers, especially for young farmers to buy smart farming tools. I am sure that new generation farmers can use these budgets for maximum benefit and help old farmers to reduce costs of production." (Participant Q, Personnel Communication, 20 November 2021).

Fourthly, participants emphasized the importance of funding supports and loans as an farmers in rural areas may not be able to afford modern technologies. They suggested that the government should prepare better access to loans for farmers and groups of service provider. Thai government has been trying very hard to encourage farmers to use smart agriculture system, the implementation of smart agriculture in Thailand has not been successful. There are only some groups of farmers, such as large-scale farmers who are successful in using technology because of an inaccessibility to technologies and to credit and financial loans as well as lack of funding supports. This was mentioned by all interviewed government field officers.

"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, Personnel Communication, 29 November 2021)
"Budget support and accessible loans will help attract and drive farmers to use smart agriculture. because it is an important issue

> that farmers are still concerned about." (Participant M, Personnel Communication, 29 November 2021).

All interview policy makers also suggest about budget from the government and funding.

> "Smart agriculture needs a lot of money at the beginning of the process. The government needs to work together with the Bank for Agriculture and Agricultural Cooperatives and provide low interest loans for farmers which lead them to become entrepreneurs. Moreover, the cooperation from more ministries is also important. To achieve the goal, all the products from smart agricultural farms need the right market. So, the Ministry of Commerce and industry council would play an important role in business and marketing and make sure that the farmers would gain reasonable income." (Participant P, Personnel Communication, 20 November 2021)

4.2 Discussion

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

4.2.1. 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 senses to 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. These two problems are related. 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 labour 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. This research finding is aligned with Attavanich et al. (2019) who reported that an average age of farmers rose from 54 years in 2008 to 58 years in 2018. This demographic trend put Thailand's agricultural sector under pressure as this demographic trend may reduce agricultural productivity and increase food security issues as according to Salvago, Phiboon, Faysse and Nguyen (2019), outputs from farms operated by older farmers could lead to food insecurity issues Therefore, smart agriculture approach has been engaged in Thailand's 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 labour 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 labour almost 100 percent and also give better results. Moreover, Musa et al. (2021) also emphasized that smart agriculture can solve the problem of agricultural labour 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.

4.2.2 Advantage and Disadvantages of the Implementation of Smart Agriculture

4.2.2.1 Advantages of Smart Agriculture Implementation

Smart agriculture can firstly help farmers to work with fewer mistakes which help reduce resource inputs and cost. Secondly, it also helps increase productivity in term of both quantity 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). Another case study is the implementation of smart agriculture in Japan. Tome, a city in Japan, is well-known for its rice productions. The local agriculture cooperative called JA Miyagi has successfully transitioned into applying drones for agricultural activities in order to tackle the labour shortage problem and increase its profits and productivity. The result shows that drone have helped decrease water usage to one percent of what was used before the application of smart agriculture. Moreover, drones can also perform farming activities at a much faster rate. Drones can spray a 1-hectare field in ten minutes compared to the 90 minute it takes using traditional methods (GMO Research, 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 derived 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%. All together, 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). (Ayutthaya Agricultural Cooperative, 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 also 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 labour during labour shortage trends. It also helps unnecessary expense for labour cost as Participant B decided to use drone to sow the seed and spray pesticide in his farm because it is cheaper than hiring labour. While participant G also reported that drone can minimize the use of human labour almost 100 percent and it gives better result than hiring human labour. 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 labour 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 the Participant N believes that smart agriculture implementation is at the beginning state and it may still not be the solution of eradicating poverty (SDG 1) and alleviating hunger (SDG 2). The researches of Musa et al. (2021) 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.

4.2.2.2 Disadvantages of Smart Agriculture Implementation

There are four disadvantages mentioned by participants which are firstly, smart agriculture requires an expensive investment so that not every farmers 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. This research finding is congruent with the research finding of Flemiming et al. (2018) who pointed out that smart agriculture is very expensive to invest in and non-affordable for some groups of farmers. While, the research finding of Regan (2019) also show that smart agriculture technologies are viewed to be prohibitively expensive and non-affordable for some groups of farmers, especially old and small-scale farm holders who may not have the skills and money, so that they would be excluded from agriculture's development easily. Thus, according to Flemiming et al. (2018) 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 a lot of 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 famers’ 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 Sayruamyat and Nadee (2019) as they found that the use of technologies for farming activities has yet to be in attention of old farmers. Their research about the acceptance and readiness of Thai farmers toward digital technology show that farmers who are 50-year-old on average, are willing to accept the use of technologies, which they are not familiar with, but they actually did not perceive the usefulness of technologies. They are leaving the responsibility to their children. Moreover, they also found that farmer who are older than 45 years old are less likely to be willing to adopt new farming practice because they do not want to invest in smart technologies, such as buying a smartphone or paying any expenses for and agricultural information application. The case study of DTAC enterprise, Thailand can reaffirm this finding as it has been trying to encourage farmers to use technologies in order to facilitate their career and this campaign was responded by only farmers between 18 to 45-year-old farmers (Srivetbodee and Igel, 2021). Besides all the research finding motioned above, Chu-ongsakul (2020) also found 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.

4.2.3 Recommendation from Participants

From the interviewed with participants in this study which are farmers, government field officers and policy makers, there are four important recommendations that were mentioned and the relevant sector should focus on.

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 Srivetbodee and Igel (2021) found that the best way to encourage farmers to implement technologies in theirs farms is through technology trails and training workshops because farmers will experience and recognize the benefits of technology themselves. the model of sharing knowledge and experience from one group to others have a high potential to encourage and motivate larger group successfully (Sayruamyat and Nadee , 2019). 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). as Participant G reported about the importance of young farmers. He believes that young generations will share their experience about using technologies in their farmers and will persuade other older farmers in their community to use technologies. While Irungu, Mbugua and Muia (2015) also emphasized the importance of new generation as they tends to be the most important group who are enthusiastic about the implementation of technology in

agricultural sector and they want to integrate new skills and technology into their farm management at the fastest pace. Thus, governments, entrepreneurs, state agencies, as well as partners should work together in order to find ways to invest more in encouraging and educating these groups of farmers. They should persuade the young generation to be as a bridge to communicate with the older generation to realize the important of technology and innovation on farms.

Secondly, the government should support suitable smart farming tools or machineries for farmers to do their smart farms. Moreover, Participant N and R 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 Chuongsakul (2020) 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. All the farmers, government field officer and policy maker believe that the government should prepare better access to loans for farmers and become a service provider in order to support them. Participant M reported that budget support and accessible loans will help attract and drive farmers to use smart agriculture since it is important issue that farmers are still concerned about. The suggestion of participants is aligned with the research finding of Srivetbodee and Igel (2021) who studies about smart farming champagnes for farmers and found that better access to loans might encourage farmers to implement and invest in new technology and innovation on their farms. Technological devices come with a cost and financial support. Thus, the ministry of Agriculture and Cooperatives should play an important role by offering special low interest rates for farmers who are interested in investing smart

technology on their farms in order to help lower barriers and risks for small-scale farmers. All interviewed policy maker reported that the government should support agricultural tools such as smart farming tools or machinery that is suitable for smart agriculture. They also need to be supported with funds to buy the expensive tools which are one of the main problems for farmers in starting smart agriculture. Moreover, Participant N and R reported that Thai government can help farmers who are interested in starting smart agriculture by supporting them and becoming their service provider. The government needs to work together with the Bank for Agriculture and Agricultural Cooperatives and provide low interest loans for farmers which lead them to become entrepreneurs.

Lastly, the government should focus on proper water resource or irrigation management. Participant A, B, C and D also suggested that the government should emphasized mainly on water resource or irrigation problems which are very important for farming. This is aligned with Chu-ongsakul (2020) who 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. While, Ministry of Agriculture and Cooperatives (2021) also stated that Thailand is an agricultural-based country and water resource is the main factor supporting agricultural activities in the countries, thus it should be managed properly. Therefore the government should emphasize and put more budget on solving the water shortage problem in various parts of Thailand, which has been defined in the 20-year national strategy by making a master plan under the national strategy on the issue of Management of the entire water system with the implementing of the 20-year water resource management master plan (2018-2037), for example: to increase the water within the irrigation area of up to 13 million rai and the water outside the irrigation areas up to 18 million by the year 2037.

Chapter 5

Conclusion and Recommendation

5.1 Conclusions

This research has studied Thailand' s smart agriculture and its impacts on Thai farmers: A case study of smart agriculture in Ayutthaya Province. The research collected information by interview with: 1) farmers who use smart agriculture and do farming in Ayutthaya province, 2) the field officers from the Ministry of Agriculture and Cooperative (MOAC) who work with farmers in Ayutthaya province and 3) policy makers from MOAC.

5.1.1 Examining the situation and problem of Thai agricultural sector

From the interview with participants, Thailand's agricultural sector have fifth main problems that should be improved. Thee five main problems are:

1) The problem of irrigation system management which can lead to drought and flood.

2) Thai farmers still face with high cost of production, especially the cost of inputs such as fertilizer and pest control substance.

3) There is still the problem of the decline of agricultural commodities prices, leading to farmers' low income and debt.

4) The fourth problem is the problem of land ownership. Farmer have to lease land with a high price in order to grow their crops and they cannot do any development in their farms.

5) The problem of farmer aging society that puts Thai agricultural sector under pressure as this demographic trend may reduce agricultural productivity and increase food insecurity.

5.1.2 Examining the advantage and disadvantage or challenges of smart agriculture implementation in Thailand

From the interview with participant, there are three main advantages of the smart agriculture implementation which are:

1) Smart agriculture technologies can help reduce production cost and all expense that farmers have to pay unnecessarily.

2) Smart agriculture can helps increase productivity as well as quantity and quality of agricultural products which can bring better incomes and economic returns.

3) Smart agriculture can help reduce the use of labour when labour shortage in the agricultural sector tends to rise during the time that demand of global food is increasing.

Even though the research finding show that the participants have positive perspective towards the use of smart agriculture technologies. Four main disadvantages or challenges of using smart agriculture were mentioned. The four main disadvantage or challenges of smart agriculture implementation are:

1) Smart agriculture is very expensive. Therefore, they are non-affordable for some groups of farmers.

2) Smart agriculture seems to be difficult and complicated for farmers, especially aging farmers who lack education, knowledge and access to technology.

3) Perspective of farmers themselves can also be an important challenge as farmers, especially aging farmers still do not open to the use of technologies.

4) The supports from the government are still limited, such as there are only few service centers in Thailand which do not cover all areas and the government has limited budget to support smart agriculture activities.

5.1.3 Examining the recommendations from three groups of participants.

There are four important recommendations that were mentioned by the participants. These four recommendations are:

1) The government should emphasize mainly on water resource or irrigation problems which are very important for farming.

2) The government should support knowledge and training skills about smart agriculture both for farmers and the officer so that they can realize the importance of using technology for the Thai agricultural sector and be able to help and educated Thai farmers with correct information.

3) The government should prepare better access to loans with low interest rates for farmers who are interested in smart technologies and become a service provider for them. Moreover, they should also adjust their budget ceiling so that the government can support all plans and programmer continuously.

5.2 Recommendations

From the interviewed with intended participants, the recommendations could be divided into three relevant parts which are 1) Thai farmers 2) Government officers and Policy Makers 3) Government and Ministry of Agriculture and Cooperatives.

5.2.1 For farmers

1) Find out for more information and attend the training program about smart agriculture project which organized by the government through the Local Agriculture office

or at the learning center for increasing the efficiency of agricultural production and also visit some demonstration farms for smart agriculture.

2) Work 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 or use the service provider to help with farm work in order to reduce farm cost for example the use of drone for sowing seeds, fertilizing, or spraying pesticides.

3) Follow information from the Ministry of Agriculture and Cooperatives continuously to be able to receive assistance from the government in cases such as receiving grants in case of damaged from disaster on agricultural products according to the rule set by the government, also the farmers can prepare or preventing their farms in case of outbreaks of diseases and insects.

4) For the difficulty in accessing for 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 agricultural cooperatives for other loans to improve their smart agriculture farms.

5) Record and collect some important agricultural data as statistics in order to improve the future farming.

5.2.2 For Government Field officer and Policy Maker

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) Organize smart agriculture programs for farmers to study and setup some visiting program on successful smart agriculture farm or attend the training and learning center for increasing the efficiency of agricultural production, on 882 center units throughout the Country.

3) Inform 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) To become 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.

5.2.3 For Government and Ministry of Agriculture and Cooperatives

1) Implementation of 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) Encourage farmers, private sectors and local government organizations to develop and build some more small water sources for agriculture.

3) To expand and increase 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.

References

Adrian, A.M., Norwood, S.H. & Mask, P.L. (2005). Producers' perceptions and attitudes towards precision agriculture technology. *Comput Electon Agr*, *48*(3), 256-771.

Agriculture Research Developement Agency. (2018). *Smart agriculture, the new hope of the Thai agricultural sector*. Retrieved from https://www.arda.or.th/knowledge_ detail.php?id=7

Agricultural Research Development Agency.(2020). *Smart farming: sucesses and challem llenges of the era*. Retrieved From http:// arada.or.th/knowledge_detail.php?id=6

Andrea, K., Maria K., Klaus E., Teresa K., Friederike B & Angelika, W. (2019). Smart farming technology innovations – Insights and reflections from the German Smart-AKIS hub. *NJAS - Wageningen Journal of Life Sciences,* (90-91), 1-8.

Aon Benfield. (2012). *2011 Thailand Floods Event Recap Report Impact Forecasting.* Chicago: Impact Forecasting LLC.

Attavanith, W., Chantarat, S., Chenphuengpawn, J., Mahasuweerachai, P., & Thampanish vong, K. (2019). *Farm, farmers and farming: a perspective through and behavior al insights.* Bangkok: Puey Ungphakorn Institute for Economic Research.

Atthakorn, W. (2017). Political economy analysis of large-scale farming and sustainable agriculture. *Journal of Public and Private Management*, *25*(1), 5-21.

Ayutthaya Agricultural Cooperative. (2022). *Report on the results of farming in Ayutthaya province.* Ayutthaya: Ayutthaya Agricultural Cooperative.

Banchongduang , S. (2018, May 31). Survey finds 40% of farmers live under poverty line. *Bangkok Post*. Retrieved from https://www.bangkokpost.com/thailand/ general/1475901survey-finds-40-of-farmers-live-under-poverty-line

BASF SE. (2021). *China's future farming*. Retrieved from https://www.basf.com/cn/en/ media/BASF-Information/Food-nutrition/future-farming.html

Borgen, C. (2017, August 21). Why is Thailand poor ? Retrieved from The Borgen Project website:https://borgenproject.org/why-is-thailand - poor/?fbclid=IwAR0TWiOmN 4nKhhxqPVT5t6GFPTUlWTIiCrPqCH-Rh8ySiAcnj1pcjBiDp64

References (Cont.)

Brennan, E. (n.d.). *Building a big data platform for agriculture*. Retrieved from Foodtank website: https://foodtank.com/news/2018/08/cgiar-big-data-platform-medha-devare/?fbclid=IwAR31xa_X-sWEiQVOxsClW53hZFYZ-mnHjFsRix-fSbi5uQaaWNdWlr-iwFI

Bronson, K., & Knezevic, I. (2016). Big Data in food and agriculture. *Big Data & Society*, *3*(1). doi: https://doi.org/10.1177/2053951716648174

Brooks, J. (2016). *Food Security and the Sustainable Development Goals*. Paris: OECD Publishing.

Carolan, M. (2015). Publicising food: big data, precision agriculture, and co-experimental technique of addition. *Sociologia Rularis*, *48*(3), 135-154.

Chaudhury, D. R. (2020, September 5). With rising population and declining arable land, China may be staring at a major crisis. *The Economics Times*. Retrieved from http://m.economictimes.com/news/international/world-news/with-rising-population-and-declining-arable-land-china-may-be-staring-at-a-major-food-crisis/articleshow/77942570.cms

Chen, S. (2019, October 12). *How AI Is modernizing Chinese agriculture*. Retrieved from https://syncedreview.com/2019/10/12/how-ai-is-modernizing-chinese-agriculture/

Chien, L.H., Sukprasert, P. and Thaipakdee S. (2011). Does a long-run relationship exist between agriculture and economic growth in Thailand?. *International Journal of Economics & Finance*, *3*(3), 277-233. Retrieved from https://www.stou.ac.th/schoolsweb/sec/UploadedFile/7875-34254-1-PB.pdf

China Global Television Network. (2019, September 6). *Xi says China needs more experts and tech innovation to achieve agricultural modernization*. Retrieved from https://news.cgtn.com/news/2019-09-06/Xi-encourages-more-experts-tech-innovation-in-agriculture-JLeMIZfSCs/index.html

China Global Television Network. (2020, May 15). *How China improves millions of farmers' livelihoods*. Retrieved from https://news.cgtn.com/news/2020-05-15/How-China-improves-millions-of-farmers-livelihoods-QvlBpWJTu8/index.html

Chu-ongsakul, O. (2020). *Challenges and opportunities of smart farming implementation.* (Master's thesis). Retrieved from https://archive.cm.mahidol.ac.th/bitstream/12m/123456789/3706/1/TP%20GM.019%202020.pdf

References (Cont.)

Coxhead, I. and Plangprphan, J. (1998). Thailand's economic boom and bust, and the fate of agriculture. *TDRI Quarterly Review*, *13*(2), 15-24.

Daberkow, S.G. & McBride, W.D. (2003). Farm and operator characteristics affecting the awareness and adoption of Precision Agriculture Technologies in the US, *Precision Agriculture*, 4 ,163-177.

Daxue Consulting Agency. (2022, January 20). *Agricultural tech in China: Feeding 20% of the world's population with 7% of its arable land*. Retrieved from https:// daxueconsultingcom/agricultural-technology-a/?fbclid=IwAR3s3dKCBU3ai M6vES3E696gNphJ8M7-gg87NbS-BDsxi-0pkQ_ae0c65Lg

De Clerq, M., Anshu, V., & Alvaro, B. (2018). *Agriculture 4.0: the future of farming tech nology*. The World Government Summit, Dubai: OliverWyman. DeJonckheere, M.&Vaughn, L.M. (2019). Semistructured interviewing in primary care research: a balance of relationship and rigour. *Family Medicine and Community Health, 7*(2), 1-3.

Department of Agricultural Extension. (2016). *Farmers' Registration Database.* Bangkok: Ministry of Agriculture and Cooperatives.

Department of Agriculteral Extension. (2021). *Promotion of large-scale agriculture.* Bangkok: Ministry of Agriculture and Cooperatives.

Dollar, D. and Kraay, A. (2004). Trade, growth and poverty. *The Economic Journal*, *114*(2), 22-49

Duangbootsee, U. (2018, October 30). *Thailand's large-scale farming model: problems and concerns*. Retrieved from Food and Fertilizer Center for the Asian and Pacific Region website: https://ap.fftc.org.tw/article/1347?fbclid=IwAR1jTU_mS7zX6 UGoWUN4QObB __fQCd8P5xb3pTfXTP8XPU3m2eYZfcoTBhg

East-West Management Institute. (2018, July 9). *Sustainable Development Goals*. Retrieved from https://thailand.opendevelopmentmekong.net/topics/sustainable-development-goal

Eastwood, C., Klerkx, L., Ayre, M. (2019). Managing socio-ethical challenges in the development of Smart Farming: From a fragmented to a comprehensive approach for responsible research and innovation. *J Agric Environ Ethics* 32, 741–768.

References (Cont.)

Ebeid, R. (2017, April 10). *Striving to end world hunger: 20 key fact* . Retrieved from https://borgenproject.org/tag/world-hunger-facts/

Elferink , M., & Schierhorn, F. (2016). *Global demand for food Is rising, can we meet it?* Retrieved from https://www.researchgate.net/publication/302466629_Global_Demand_for_Food_Is_Rising_Can_We_Meet_It

Elsayed, S.M., Sameh, K.A.E., Mohammed, A.E.S., Gad, & Zahran, M.B. (2021). Smart farming for improving agricultural management. *The Egyptian Journal of Remote Sensing and Space Science, 24*(3), 971-981.

Engelmann, J. (2021, April 16). *Export value of agricultural, forestry and fishery commodities from Japan from 2011 to 2020.* Retrieved from Statista website: https://www.statista.com/statistics/750643/japan-export-value-of-agricultural-forestry-and-fishery-products/

Fan, S. (2015, April 9). *How agriculture can improve health and nutrition* Retrieved from https://www.weforum.org/agenda/2015/04/how-agriculture-can-improve-health-and-nutrition/

Farming First. (2015). *The story of agriculture and the sustainable developemnt goals*. Retrieved from https://farmingfirst.org/sdg-toolkit#home

Farming First. (2019, July 15). *Inequalities in Agriculture: a threat to sustainable develop ment*. Retrievd from https://farmingfirst.org/2019/07/inequalities-in-agriculture-a-threat-to-sustainable-development/

Farming Solutions. (2016, June 2). *The pros and cons Of small scale farming*. Retrieved from http://www.farmingsolutions.org/pros-cons-small-scale-farming/

Fechter, J. (2012). *Agriculture and employment.* Frankfurt: Sector and Policy Division Agriculture and Natural Resources, KFW.

Fleming, A.J., Jakku, E., Lim-Camacho, L., Taylor, B., & Thorburn, P. (2018). 'Is big data for big farming or for everyone? Perceptions in the Australian grains industry. *Agronomy for sustainable development, 38*(3), 1-10.

Folnovic, T. (n.d.). *Employment in agriculture* ? [Web log message]. Retreived from https://blog.agrivi.com/post/employment-in-agriculture

References (Cont.)

Food and Agriculture Organization of the United Nations (2007, August). *Reforms in Thai agriculture and rural sectors needed for further poverty reduction.* Retrieved From http://www.fao.org/asiapacific/news/detail-events/en/c/46134/?fbclid=IwAR1jp2FTBxmY1Iq_TwkoQCrJEOuuCXI4OqrNSM6lCwzpt3ZkWUzwsCzsZbs

Food and Agriculture Organization of the United Nations (2008). *The state of food insecu rity in the World 2005.* Rome: Author.

Food and Agriculture Organization of the United Nations (2011). *The state os the wold's land and water resources for food and agricutlure (SOLAW) – Managing systems at risk.* Rome & London: The Food and Agriculture Organization of the United Nations and Earthscan.

Food and Agriculture Organization of the United Nations (2012). *FAO statistic yearbook 2012: world food and agriculture.* Rome: Author

Food and Agriculture Organization of the United Nations (2017). *The future of food and agriculture: trends and challenges.* Rome: Author

Food and Agriculture Organization of the United Nations (2020, December). *A statement by FAO Director-General QU Dongyu*. Retrieved from https://www.fao.org/director-general/speeches/detail/en/c/1334894/

Food and Agriculture Organization of the United Nations (2021a). *FAO in China: China at glance*. Retreived from http://www.fao.org/china/fao-in-china/china-at-a-glance/en/

Food and Agriculture Organization of the United Nations (2021b). *The impact of disasters and crises on agriculture and food security.* Rome: Author.

Food and Agricuture Organization of the United Nations, & International Fund for Agricultural Development. (2019). *Introducing the UN decade of Family Farming*. Retrieved from http://www.fao.org/family-farming-decade/home/en/

Foreign News Agency in Hiroshima. (2018). *Smart agriculture developement in Japan.* Hiroshima: Author.

Garnjanakarn, S. (2019, June). *Global innovation report: How Hitachi drives Thailand 4.0* Retreived from https://www.hitachi.com/rev/archive/2019/r2019_03/gir/index.html

Glaser, B. and Strauss, A. (1967). *The discovery of grounded theory: Strategies for qualitative research*. Chicaco: Aldine.

References (Cont.)

Hazell, P. and Diao, X. (2005). *The Role of Agriculture and Small Farms in Economic Development.* Washington, D.C.: International Food Policy Research Institute.

Hengde , Q. (2021, Febuary 18). *Smart farming technology can transform Chinese agriculture and help feed the plane.* Retrieved from https://www.globaltimes.cn/page/202102/1215818.shtml

Hokkaido University. (2020, October 1). *Toward the realization of a smart agri-city* by *Professor Noguchi, Research Faculty of Agriculture*. Retrieved from https://www.osc.hokudai.ac.jp/en/topic/7569?fbclid=IwAR0X_JI9DkgD_gHwYTp8zl0qlFllO3Mq3D6yaA9AafEAUGxEENPiaY qAnU

Intergovernmental Panel on Climate Change. (2017). *Climate Change 2007: Impacts, adaptation and vulnerability*. Cambridge & New York: Cambridge University Press.

Irungu, K.R. G., Mbugua, D., & Muia, J. (2015). Information and communication technologies (ICTs) attract youth into profitable agriculture in Kenya. *East African Agricultural and orestry Journal*, *81*(1), 24-33.

Jatuporn, C., Chien, H.L., Sukprasert, P., & Thaipakdee, S. (2011). Does a long-run relationship exist between agriculture and economic growth in Thailand?. *International Journal of Economics and Finance*, *3*(3), 227-233. doi 10.5539/ijef.v3n3p227.

Jin, W. (2016, September 30). *Betting the farm: modernizing China's agriculture sector*. Retrieved from https://www.china-briefing.com/news/modernizing-china-agriculture-sector/

Johnston, F.B. and Mellor,J. W. (1961) The role of agriculture in economic development. *The American Economic Review*, *51*(4), 566-593.

Juhari, H. (2021). *How the agrifood sector can be more sustainable in meeting SDG 1 and SDG 2?* (Master's thesis,: Universiti Brunei Darussalam). Retrieved from https//www.researchgate.net/publication/356407573_How_the_Agrifood_Sector_can_be_more_Sustainable_in_meeting_SDG_1_and_SDG_2 m

Junhong, H. (2021, April 27). *Corn growing goes high-tech and unmanned*. Retrieved From https://www.chinadaily.com.cn/a/202104/27/WS6087cc0ea31024ad0babaca5_2.html?fbclid=IwAR3MP_hSSzIFeA3Ei2YNug43h0WlLaphzaUKp8HOXHZLWU500yDtel_db4

References (Cont.)

Kamsow, J. (2018, March 3). Technology, community and passion-the secret sauce of smart farmer. *The Nation Thailand*: Retrieved from https://www.nationthailand.com/edandtech/30340118?fbclid=IwAR2kfywOYrkFM7UrpkRl9DDmn55Dw2MlA9fW8fEE8hWUZrDH1slbvWIN7t4

Kaneda, T., Greenbaum , C., & Kline , K. (2020, July 10). *2020 world population data sheet shows older populations growing, total fertility rates declining.* Retreieved from Population Reference Bureau website: https://www.prb.org/2020-world-population-data sheet/?fbclid=IwAR20iLTu42J_oKgzKW8XsEEmDjkJc6ED0bGP4kUPMTGzR912sEo_FOguAB8

Kendall, H., Naughton, P., Clark, B., Taylor, J., Li, Z., Zhao, C.,...Frewer, L.J.(2017). Precision Agriculture in China: Exploring Awareness, Understanding, Attitudes and Perceptions of Agricultural Experts and End-Users in China. *Advance in Animal Bioscience*,8, 703–707. doi: 10.1017/S2040470017001066

Klaidaeng, W. (2018). *Large-scale agriculture.* Bangkok: The Secretariat of the House of Representatives of Thailand.

Kraipinit, Y., Chantuk, T., & Siriwong, P. (2022). New agricultural Management of Thai land.*VRU research and development journal science and technology*,*12*(2) 115-127.

Kritikos, M. (2017). *Precision agriculture in Europe: Legal, social and ethical.* Strasbourg: Scientific Foresight Unit.

Kuhasak, N., & Srichampa, R. (2018). *Smart farm business management for Small-to-Medium melon Business Enterprises (SMEs).* Chonburi, Thailand: Graduate School of Commerce, Burapha University.

Kwanmuang, K., Pongputhinan, T., & Jabri, A. (2020, November 26). *Small-scale farmers under Thailand's smart farming system.* Retrieved from rom Food and Fertilizer Techenology for the Asian and Pacific Region website: https://ap.fftc.org.tw/article/2647?fbclid=IwAR0AOqmtVLNSfWiXCUTxv6D2UkWGaiRXhUYlKERFgDreliCgcycdmCElweU

Lehmann , R. J., Reiche , R., & Schiefer, G. (2012). Future internet and the agri-food sector: State-of-the-art in literature and research. *Computers and electronics in agriculture*, *89*(2012), 158-174.

References (Cont.)

Logindarat, P. (2011). Effecting of changing agricultural population structure on food security reseach project in Thailand. *TRF Policy Brief Journal*, *12*(4), 1-7.

Manwicha, J. (2015). Smart farms technology. *Hatyai Academic Journal*, *4*(2), 201-209.

Meijerink, G., & Roza, P. (2017). *Market, chain and sustainable development strategy & policy paper : the role of agriculture in economic development.* Amsterdam: Research Institute of Wageningen University and Research Center.

Minister of Agricultture and Cooperatives. (2017). *The twenty-year agriculutre and cooperative strategy and the five-year agriculture development plan under the twelfth national economic and social development plan.* Bangkok: Author.

Minister of Agriculture and Cooperatives. (2019, April 26). *Ministry of Agriculture and Cooperatives all sectors to drive smart agriculture*. Retrieved from https://www.moac.go.th/news-preview-411191791414

Ministry of Agriculture and Cooperatives. (2020). *2020 handbook of the annual project: large-scale farm project.* Bangkok: Author.

Minister of Agriculture and Cooperatives. (2022, August 14). *2021 Summary report of the Ministry of Agriculture and Cooperatives*. Retrieved from https://www.data.moac.go.th/?fbclid=IwAR1NT597M3_uUe4o39XYKm8dHPwE4nogxD-gQSnLNlCvYPu2iwxUz_cNg4

Musa, S.F.P.D., Basir, K.H. & Luah, E. (2021). The role of smart farming in sustainable development. *International Journal of Asian Business and Information, Management*, *13*(2), 12-20. doi: 10.4018/IJABIM.20220701.oa5

National Science and Technology Development Agency. (2020). *Smart Farming.* Bangkok: Ministry of Higher Education, Science, Research and Innovation.

National Strategy Committee. (2018). *National Strategy 2018-2037.* Bangkok: National Strategy Secretariat Office and Office of the National Economic and Social Developement Council.

Nations Thailand. (2018, March 3). *Technology, community and passion – the secret sauce of the smart farmer*.The Nations Thailand. Retrieved from https://www. nationthailand.com /Startup_and_IT/30340118

References (Cont.)

Nebehay , S. (2020, October 12). *Natural disasters surge in past 20 years, likely to continue to wreak havoc: U.N.*. Reuters. Retrieved from https://www.reuters.com/article/usenvironment-disasters-un-idUSKBN26X18O

Newcomer, K. E., Hatry, H. P., & Wholey, J. S. (2015). *Handbook of practical program evaluation*. Washington, D.C.: Jossey-Bass.

Noble, H. & Mitche, G. (2016, February 12). What is grounded theory?. *Evidence- Based Nursing*, *19*(2), 1-2.

Nuthalapati, C. R., Kumar, A., Bathla, S., & Jha, G. (2018). *Agriculture and sustainable development goals: an overview and issues*. Retrieved from https://www.researchgate.net/publication/302466629_Global_Demand_for_Food_Is_Rising_Can_We_Meet_It

O'Neill, A. (2021, March 31). *Thailand: share of economic sectors in the gross domestic product (GDP) from 2009 to 2019*. Retrieved from Statista website: https://www.statista.com/statistics/331893/share-of-economic-sectors-in-the-gdp-inthailand/

Obaisi, A. (2017). *Overpopulation: a threat to sustainable agriculture and food security In development country?*. Retreived from https://www.researchgate.net/publication/324792051_OVERPOPULATION_A_THREAT_TO_SUSTAINABLE_AGRICULTURE_AND_FOOD_SECURITY_IN_DEVELOPING_COUNTRIES_A_ Review

Office of Agricultural Economic. (2020). *Thailand agricultural system in the future.* Bangkok: Author.

Office of the National Economic and Social Development Council. (2021). *Summary report on the implementation of the National Strategy* for the year *2020*. Bangkok: Author.

Office of the National Water Resoutces. (2021). *Development of water resources and irrigation for agriculture*. Commitee on Agriculture and Cooperatives. Bangkok: Commitee on Agriculture and Cooperatives.

Online Reporters. (2018, October 13). 20-year National Strategy comes into effect. *Bangkok Post*. Retrieved from https://www.bangkokpost.com/thailand/general/1557462/20-year-national-strategy-comes-into-effect

References (Cont.)

Osipov, E., & Riliskis, L. (2013). *Educating innovators of future Internet of Things* 2013 IEEE Frontiers in Education Conference (FIE), 2013, 1352-1358. doi: 10.1109/FIE.2013.6685053.

Pattama, N. (2020). *The development of smart farming systems in Thailand.* Bangkok: Bureau of Parliamentary Studies, The Secretariat of the Senate.

Patterson, S. (2019, September 20). *What is monocropping: disadvantages of monoculture in gardening.* Retrieved from https://www.gardeningknowhow.com/plant problems/environmental/monoculturegardening.htm?fbclid=IwAR18Sk7EL 047rQo2zBNzecuknGJ7_TuLP_1J7GU6u_I_17CHcvnDhRaUWFA

Phumwiangsri, S., Sinsupan, N., & Chanawongse, A. (2021). The development of a sustainable management model for pesticides contamination in fruits, vegetables and agricultural products with the participation of community and network partners in Nongnakham District, Khonkaen province. *Research and Development Health System Journal*, *14*(1) 37.

Pivoto, D., Waquil, P. D., Talamini, E., Finocchio, C., Corte, V., & Mores, d. G. (2017). *Scientific development of smart farming technologies and their application in Brazil*. Beijing: Elsevier B.V.

Plant, R.E. 2001. Site-specific management: the application of information technology to crop production. *Comput Electron Agr*, *30*(1–3) 9-29.

Plecher, H. (2021, May 7). *Thailand: distribution of employment by economic sector from 2010 to 2020*. Retrievrf from Statista website: https://www.statista.com/statistics/332341/employment-by-economic-sector-in-thailand/

Porter, J.R., Xie, L., Challinor, A.J., Cochrane, K., Howden, S.M., Iqbal, M.M.,…Travasso, M. (2014). *Climate Change 2014: Impacts, adaptation, and vulnerability*. Cambridge and New York, Cambridge University Press.

Post Today. (2019, March 3). Thai agricultural sector under the National Council for Peace and Order. *Post Today*. Retrieved from https://www.posttoday.com/social/think/ 582117

Puapongsakorn, N., Puntakua, K., & Wiwatwicha, N. (2020). *Farming 4.0 policy.* Bangkok: Thailand Development Research Institute.

References (Cont.)

Regan, Á. (2019). 'Smart farming'in Ireland: A risk perception study with key governance actors. *NJAS-Wageningen journal of life sciences*, 90, 100-292.

Reuters. (2022, September 8). Thailand targets higher rice exports of 7.5 mln tonnes this year. *Reuters*. Retrieved from https://www.reuters.com/markets/asia/Thailand-targets-higher-rice-exports-75-mln-tonnes-this-year-2022-09-08/

Rieber, L. (2013). Making the rice bowl bigger: agricultural output and rural poverty in Thailand. *Global Majority E-Journal, 4*(1), 4-14.

Rose, D., & Chivers, C.-A. (2020). *The fourth agricultural revolution is coming – but who will really benefit? The Conversation*. Retrieved from https://theconversation.com/the-fourth-agricultural-revolution-is-coming-but-who-will-really-benefit-145810

Rujivanarom, P. (2018, March 9). Food security report points to increasing malnourishment and obesity in Thailand. *The Nation Thailand*. Retrieved from https://www.nationthailand.com/national/30340610

Salvago, M., Phiboon, K., Faysse, N., & Nguyen, T. (2019). Young people's willingness to farm under present and improved conditions in Thailand. *Outlook on Agriculture*, *48*(1), 1-8. doi: 003072701988018. 10.1177/0030727019880189.

Sangiam, T., & McNeil, R. (2020, March 18). *Thailand eyes food export opportunities amidst COVID-19 pandemic.* Retrieved from National News Bureau of Thailand website: https:// thainews.prd.go.th/en/news/detail/TCATG200318172345480

Saokaew, D. (2020, April 24). *COVID-19: labor shortage on Thai farms could threaten food supply*.CGTN News. Retrieved from https://news.cgtn.com/news/2020-04-24/COVID-19-Labor-shortage-on-Thai-farms-could-threaten-food-supply-PWHjzzJ7SE/index.html?faodatalab=2020-04-24&fbclid=IwAR2At2SZkVFMY_5vpeQS5MOI4EWtpw2qdCdkuaj1q2Ajcnnnd-UHXnPJSGM

Sayruamyat, S. & Nadee, W. (2020). 3rd International Conference on Smart Trends for Information Technology and Computer Communications, SmartCom 2019. *Acceptance and Readiness of Thai Farmers Toward Digital Technology*. (pp.75-82). Springer.

Science and Technology Office of Embassy of Switze. (2018). *Agriculture in Japan: new developments in smart agriculture.* Tokyo: Author.

References (Cont.)

Shahbandeh, M. (2021, January 20). *Principal rice exporting countries worldwide in 2018/2019.* Retrieved from Statista website: https://www.statista.com/statistics/255947/top-rice-exporting-countries-worldwide-2011/

Singhapreecha, C. (2014, May 9). *Economy and agriculture in Thailand*. Retrieved from Food and Fertilizer Technology Center for the Asian and Pacific Region website: https://ap.fftc.org.tw/article/682

Smil, V. (1999). Education and debate-China's great famine: 40 years later. *Thebmj*, *319*(7225). 1619-1620.

Strategic Tranformation Office. (2019). *Thailand's 20-year National Strategy.* Retrieved from https://www.moac.go.th/pyp-dwl-files-402791791893

Suwannarat, P. (2011). *Agricultural Productivity and Poverty Reduction in Thailand.* Bangkok: Faculty of Economics, Thammasat University.

Taft, K. (2019, May 29). *Launch of the UN's decade of family farming to unleash family farmers' full potential*. Retrieved from International Fund for Agricultural Development website: https://www.ifad.org/en/web/latest/-/news/launch-of-the-un-s-decade-of-family-farming-to-unleash-family-farmers-full-potential

Teanravisitsagool, P. (n.d.). *Post-2015 development agenda: perspectives from Thailand.* Bangkok: Social Database and Indicator Development Office, Office of the National Economic and Social Development Council.

Temmen, N. (2021). *Smart farming technology in Japan and opportunities for EU companies*. Osnabrueck, Germany: EU-Japan Centre for Industrial Cooperation.

Thailand United Nations. (2021). *Thailand global goals for Sustainable Development*. Retrieved from https://www.un.or.th/globalgoals/the-goals/

Thaiprasert, N. (2006). *Rethinking the role of agriculture and agro-industry in the economic development of Thailand: input-output and CGE analyses* (Unpublished Doctoral dissertation). Nagoya University, Nagoya, Japan.

Thairath. (2019, February 14). Budget of 2019, more than 200 billion Baht, MOAC dreams big and throws money to build "Smart Farmer". *Thairath*. Retrieved from https:// https://www.thairath.co.th/business/economics/1203958

References (Cont.)

The Compact2025 team. (2017). *Thailand food security and nutrition case study Successes and next step.* Bangkok: Author. Unpublish manuscript

Thomas, J. (2019, May 12). *Myanmar's farmers go hi-tech*. The Asean Post. Retrieved from https://theaseanpost.com/article/myanmars-farmers-go-hi-tech

Tiseo, I. (2021, January 27). *Leading natural rubber exporting countries worldwide based on export value in 2019.* Retrieved from Statista website: https://www.statista.com /statistics/652791/leading-natural-rubber-exporters-by-country/

Tractor Junction. (2020, November 6). *Top 10 agricultureal producing countries in the world.* Retrieved from https://www.tractorjunction.com/blog/top-10- agricultural-producing-countries-in-the-world/

Trading Economics. (2018). *Japan - Arable Land (hectares)*. Retrieved from https://tradingeconomics.com/japan/arable-land-hectares-wb-data.html

Tonsri, K. (2012). *Labour and the change in Thai agricultural sector.* Retrieved from https://www.bot.or.th/Thai/MonetaryPolicy/NorthEastern/DocLib_Research/04-Labor%20with%20Agri%20Changing.pdf

Udomkerdmongkol, M., & Chalermpao, N. (2020, December 2). *Thai agricultural sector: from problems to solutions.* Retrieved from United Nations Thailand website: https://thailand.un.org/en/103307-thai-agricultural-sector-problems-solutions

United Nations Deveopment Programme. (2021a). *Sustainable Development Goals: background on the goals*. Retrieved from https://www.undp.org/content/undp/en/home/sustainable-development-goals/background.html

United Nations Development Programme. (2021b). *Goal 1: no poverty* . Retrieved from https://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-1-no-poverty.html

United Nations Development Programme. (2021c). *Goals 2: zero hunger*. Retrived from https://www.th.undp.org/content/thailand/en/home/sustainable-development-goals/goal-2-zero-hunger.html

United Nations Environment Programme. (2018). *2.6 billion people draw their livelihoods mostly from agriculture.* Retrieved from https://www.cbd.int/article/biodiversity forfood-1

References (Cont.)

Usery, L., Stuart , P., Boydell, B., & Usery, E. L. (1995). *Precision farming data management using geographic information system.* Retreived from American Society for Photo grammetry and Remote Sensing Association website: https://www.asprs.org/wpcontent/uploads/pers/1995journal/nov/1995_nov_13831391.pdf?fbclid=IwAR26PI5cqbuvNUVJWohlsr4vuKuJGyvbAxus9itbJIhGZ_6eawqyrWmFbE

Verónica, A. (2013). *Remote sensing and geographic information systems in precision farming.* Córdoba, Argentina : Instituto de Altos Estudios Espaciales.

Walter, A., Finger, R., Huber R. & Buchmann, N. (2017). Opinion: Smart farming is key to developing sustainable agriculture. *Proceedings of the National Academy of Sciences of the United States of America*, *114*(24), 6148–6150. doi:10.1073/pnas.170746211428611194

Wei, L. (2018). The new plan for China's modernization: the transformational decisions of the 19th CPC National Congress. *Horizons: Journal of International Relations and Sustainable Development*, 10, 12-21.

Wolfert, S., Ge, L., Verdouw, C., & Bogaard, M.-J. (2017). Big data in smart farming. *Agricultural System*, *153*(2017), 69-80. doi: 10.1016/j.agsy.2017.01.023

Woodbridge, M. (2015). *From MDGs to SDGs: what are the Sustainable Development Goals?* Bonn: ICLEI - Local Governmetns for Sustainability.

World Bank, & International Food Policy Research Institute. (2006). *Agriculture and achieving the Millennium Development Goals.* Retrieved from International Food Policy Research Institute website: https://www.ifpri.org/publication/agriculture-and-achieving-millennium-development-goals

World Bank. (2008). *Agriculture for development.* Washington, DC: Author.

World Bank. (2011, August 2). *Thailand now an upper middle income economy*. Retrieved from https://www.worldbank.org/en/news/press-release/2011/08/02/thailand-now-upper-middle-income-economy

World Bank. (2020a, September 30). Agriculture and Food. Retrieved from https://www.worldbank.org/en/topic/agriculture/overview?fbclid=IwAR0yGVzwW_FjklRr27FnNc21bfhv7XSwnIA7CyRRAT6VgwgKmpAj_icLbaw#1

References (Cont.)

World Bank. (2020b, March 5). *Thailand's poverty on the rise amid slowing economic growth*. Retrieved from https://www.worldbank.org/en/news/pressrelease/2020/03/03/thailand-poverty-on-the-rise-amid-slowing-economic-growth

World Bank. (2021, January 29). *Employment in agriculture (% of total employment) - Thailand*. Retrieved from https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?end=2019&locations=TH&start=1991

World Bank. (2022a, October 21). *Rural Thailand faces the largest poverty challenges with high income inequality.* Retrieved from https://www.worldbank.org/en/news/press-release/2022/10/21/rural-thailand-faces-the-largest-poverty-challenges-with-high-income-inequality

World Bank. (2022b, October 20). *Thailand rural income diagnostic: Challenges and opportunities for rural farmers*. Retrieved from https://www.worldbank.org/en/country/thailand/publication/thailand-rural-income-diagnostic-challenges-and-opportunities-for-rural-farmers

Appendices

Questionnaires

Appendix

Questionnaire for Farmers

1. What is the main problems that you have faced in Thai agricultural sector?
2. Why did you decide to apply smart agricultural concept to your farm?
3. How do you start the smart agriculture?
4. What is your experience about smart agricultural management system?
4. After applying smart agriculture, do you receive any benefits from smart agriculture's implementation?
6. Do you have any difficulties with smart agriculture technique, after applying it to your farm?
7. In your opinion, what could be the key-success factors and key-failure factors in smart agriculture management?
8. Do you think you would like you encourage other farmers to apply smart agriculture?
9. In which way that you would like the government to support or help you?
10. Do you have any recommendations to improve smart agriculture?

Questionnaire for Officers (Field Officer)

1. What is the situation of Thai agricultural sector and farmers?
2. In your opinion, what is the overall outcome or achievement of smart agriculture in Thailand, does it help Thai farmers or help to improve the situation of Thai agricultural sector?
3. How can you encourage the farmers to use smart agriculture in their farm?
4. What are the problems or difficulties of transforming information about smart agriculture to the farmers?
5. As you are a field officer, do you have any difficulties following government policies?
6. Do you have any recommendations for Thai government that could help improve Thailand's smart agricultural management?

Questionnaire for Officers (Policy Maker)

1. What is the situation of Thai smart agriculture nowadays?
2. In your opinion, what is the overall outcome or achievement of smart agriculture in Thailand, does it help Thai farmers or help to improve the situation of Thai agricultural sector?
3. What are the problems or difficulties of the implementation of smart agriculture in Thailand?
4. How can smart agriculture help Thailand to achieve the Sustainable Development Goals?
5. How does the government help and support farmers to apply smart agriculture?
6. What are the government's long-term plans for smart agriculture improvement?
7. Do you have any recommendations for Thai government that could help to improve Thailand's smart agricultural management?

Biography

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