THE SMART FARMING BY ADOPTING THE PHILOSOPHY OF THE SUFFICIENCY ECONOMY: THE CASE STUDY OF DUCK FARM, LATKRABANG, THAILAND

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A Dissertation Submitted in Partial
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ABSTRACT

Title of Dissertation	THE SMART FARMING BY ADOPTING THE PHILOSOPHY OF THE SUFFICIENCY ECONOMY: THE CASE STUDY OF DUCK FARM, LATKRABANG, THAILAND
Author	Phanita Phakdi
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Focusing on agricultural business seems promising. Considering on environment and capability of most Thai farmers, smart Farm in Thailand should be household-based farming by using simple and economical feasible technology will generate income for households on sufficiency economy basis. The objectives of this study are to develop farming and knowledge dissemination about the smart farming by adopting the philosophy of the sufficiency economy in duck farm prototype. To develop technology need assessment of duck farm in alignment with the concept of smart farm was applied to the concept of smart farm in duck farm system. The overall area smart farm is 320 square meters. The smart duck farm in this study consists of automatic duck feeder, automatic watering and drainage system, automatic temperature and humidity control system, automatic open-close door system, and power supply system by solar cell. The capital cost of investment is approximately 306,500 baht and the net positive benefit is 4,757,982 baht within 1 years. At the core of the small farm businesses make decisions to adopt appropriate technologies with limitation of area that most farmer can use, maintain, and develop by themselves. The expectation of the smart farm in this study will lead farmer to do sustainable agriculture and farmers should own their agricultural enterprise with sufficient agriculture.

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Finally, my grateful thanks are expressed to my father, my mother, and all brothers and sisters in my families who have always encouraged and inspired me to study further. Last but most importantly, I am indebted to my beloved husband, Mr. Pradit Deejai, for his hard work

taking care of me, tremendous supports, and enduring encouragement that push me to the successful end of my doctoral education at NIDA.

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CHAPTER 1
INTRODUCTION

1.1 Statement and Significance of the Study

Thailand has been known as an agricultural country, because topography is conducive to do agriculture and Thai culture is also tied up with agriculture, such as, Thai custom "Sukhuankao". From demographic information, there were 7.94 million households in agriculture (Department of Agricultural Extension, 2017). In addition, agricultural land was 46.53% of total land area in Thailand (The Office of Agricultural Economics, 2017). The survey of land use types in the year 2015/2016 is calculated by the application of GIS (Geographic Information System: GIS) and the weighting of the provinces area of department of military maps as shown in figure 1.1

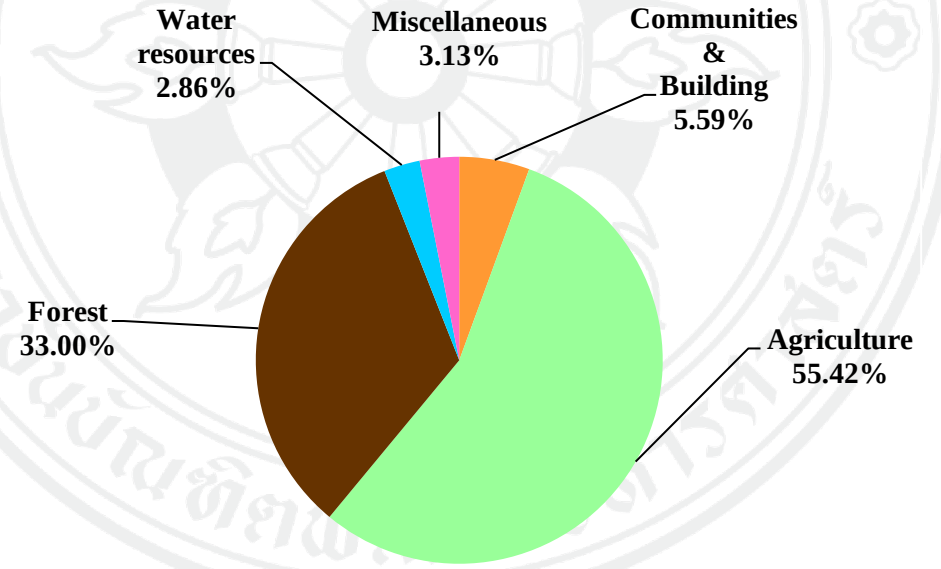


Figure 1.1 The Survey of Land Use Types in 2015/2016
Source: Land Development Department, 2017

Figure 1.1 showed the land use in Thailand in 2015/2016. The largest proportion of land use types was agriculture, accounting for 55.42 % of the total. The second largest land use types

was forest, 33.00 % of total, followed by 5.59 % of communities and building, 3.13% of miscellaneous, and 2.86% of water resources, respectively. It is evident that the most land in Thailand was used for agriculture.

When the number of Thai worker was categorized by each industrial sector as shown in figure 1.2. It showed that agriculture sector had the highest number of Thai worker. In 2017, the number of Thai worker in agriculture sector increased 560 thousands or 4.46% from the previous year (National Statistical Office, 2017).

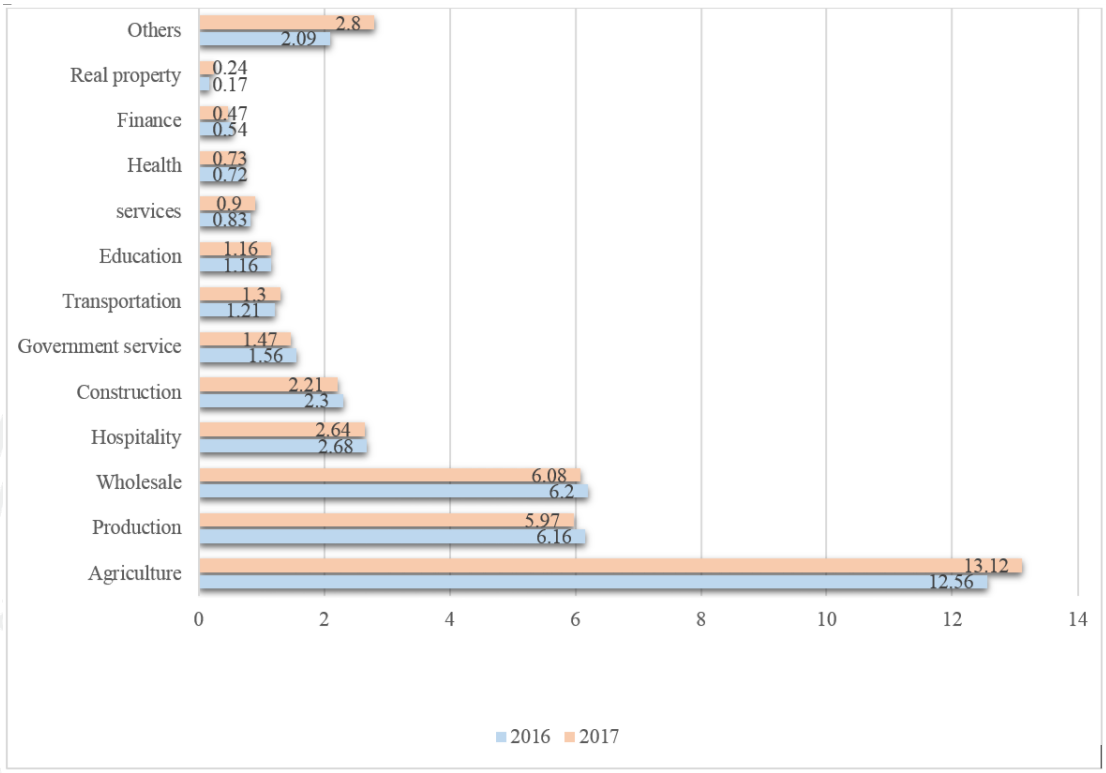


Figure 1.2 The Number of Thai Worker of Each Industrial Sector in 2016/2017 (Unit: Million People)
Source: National Statistical Office, 2017

From the above, it is pointed out that the majority of the population and local Thai culture are mostly associated with agriculture.

Meanwhile, the lifestyle of the population has changed rapidly with the advancement of technology in every second. The industry has applied modern technology to help production to serve human needs of consumption. In addition, agricultural culture has faded away because of the change of the economy. Most of Thai farmers are becoming just agricultural workers. Farmers do not own the land to do farming because most agricultural area were bought by the capitalists (Kunawongkrit, 2017). Moreover, there is different income between agricultural and industrial sectors which persuaded workers to work in industries. According to demographic information of The Office of Agricultural Economics (2017) reported that the average income of agricultural households was about 11,610 baht per month and the non-agricultural household income was about 25,929 baht per month. Thus, Entering an industrial occupation makes people is more comfortable in working to gain more income. Most people prefer to enter the industrial sector to the agricultural sector. In other words, the industrial sector is the host of labor flows from the

agricultural sector. The continuous increase of migrant workers from the agricultural sector to the industrial sector cause the problem of urban congestion and lacking labors in the agricultural sector. Moreover, farmers are facing many problems in agricultural sector, for example, there are some uncontrollable factors that cause unpredictable yields, such as rain, which do not correspond to the seasons, natural disasters, insects, plant diseases, etc. The changing circumstances and current problems have a significant impact on Thai agriculture and farmers. In addition, when the number of people in the agricultural sector is small, technology is needed to play a vital role in order to reduce costs, labors and time.

Thailand has continuously been improving its economic model, starting from "Thailand 1.0," which focused on the agricultural sector, to light industries with "Thailand 2.0," where the country utilized cheap labor with a focus on domestic productions. To work in the industry, "Thailand 3.0" focused on more complex industries to attract foreign investments making Thailand a production hub for exports. Finally, the government transformed Thailand's economic structure to "Thailand 4.0."(Thailand Board Investment, 2017). Thailand 4.0 model focused on using of innovation and technology to develop country at least 3 transformative shifts from (1) producing commodities to innovation, (2) from industrial emphasis to technology and creativity, and (3) from trade in goods to trade in service (Aeknarajindawat, 2016). The agricultural sector is a main sector in which government will place major emphasis on. There will be a shift from traditional farming to smart farming, in which farmers receive higher profits and gain entrepreneurships (Aeknarajindawat, 2016). Director-General of the Department of Agricultural Extension, Somchai Charnnarongkul mentioned that smart farming 4.0 would transform farmers into "smart farmers" and reform the agriculture sector to greater efficiency through the new technology (The Government Public Relations Department, 2017). Thai government believed that smart farming 4.0 will elevate well-being of the farmer. The government expected that the agricultural sector should focus on preparing and developing farmers for being smart farmers who have advanced technology in production and marketing for agricultural readiness in being smart farm 4.0. If the policy "model Thailand 4.0" will be achieved in concrete practice in the future and the agricultural sector can develop well-being and quality of life that can be self-sustaining, the government does not need to enact any subsidy policies to address problems and support farmers as in the past (The Office of Agricultural Economics, 2015).

Smart farming 4.0 project focuses on developing a large scale of farm and considering farmers who have investment ability to participate in smart farming 4.0 project. The smart farming 4.0 direction of government is including 1) combining small individual farms, combining to a large scale farms 2) increasing productivity by training and supporting loan for farmers (Research Management and Quality Assurance Division, 2016). The large agricultural land plot will be controlled and managed by government officers. It seems that Thailand tries to do smart farming 4.0 following the same path of developed countries e.g. the United States. The US is a large country and mostly does agriculture as large agricultural land plot which requires technology to produce a large amount of product to meet the needs of the local population. In the US, there is the farm bill, agricultural act, that governs an array of agricultural and food program (Johnson & Monke, 2017). The farm bill has

addressed major issues: for example, 1) providing farm payment to major commodity when crops prices decline; 2) offering direct government loan to farmers; 3) enhancing the permanently authorized federal crop insurance program; and 4) supporting agricultural research and rural development (Johnson & Monke, 2017). While Thai agricultural policy in long term has never supported the agricultural sector seriously and explicitly, as a result, it makes the agricultural sector is more difficult to grow up and more insecure than other sectors. At the same time, the European Union or the EU has a policy, Common Agricultural Policy or CAP, to help their farmers (European Commission, 2017). When the US and EU countries supported and helped farmers explicitly, it also resulted in increasing of agricultural products in the world and the crops price competition are getting worse. This will have an impact on Thai farmers who may be forced to sell agricultural products in lower price than it should be in the market.

The smart farm project seems promising. However, the government should consider various factors i.e. culture, environment, operational capabilities, and feasibility. For example, Thailand is a small country, thus, we do not need to use advanced technology to produce a large amount of product because the consumption of the population does not require a single product only. Thus, it is more appropriate to divide the area to produce adequately to meet the diverse needs of domestic consumption. According to Relf (2016) stated that smart farm is not only concerning about technology but also think about what is right for farm's situation, then doing it to the best of your abilities. Smart decision will enhance farmers' business more robust (Relf, 2016) which the opinion of Relf (2016) was consistent with the philosophy of sufficiency economy. Sufficiency Economy is the philosophy that based on the fundamental principle of Thai culture. It is a method of development that based on moderation in performance, reasonableness, and creating immunity for oneself and society. Firstly, Sufficiency Economy leads to know and understand the capabilities, then build immunity before growing up by learning and accumulating experience. When the foundation is strong enough, business will be expanded and moved forward. Sufficiency Economy can be applied to all levels, branches, and sectors of the economy. It is not necessarily limited to the agricultural or rural sectors, or even the financial, the real estate, and the international trade and investment sectors (The Chaipattana Foundation, 2017). For example, to adopt Sufficiency Economy in agriculture has been called The New Theory that teaches farmers to divide farmland for pond, rice cultivation, growing fruit and perennial trees, vegetables, field crops and herbs, and feeding animal for optimum benefits. Thus, it is interesting to do smart farming in response to the need of household level. Sufficiency Economy with smart farm is suitable for Thai agriculture production without having too much investment but using sufficient application of technology to increase productivity and the quality of the agricultural product and also reduce number of labors and costs in the long term. Moreover, Thai agricultural development should support sustainable agricultural career and farmers should own their agricultural enterprise. Sufficient

agriculture should develop from small-scale agriculture which has system of agricultural cooperatives to small agricultural communities' development, then it is cooperative integration and transformation to international agricultural industry finally. Development of sufficient agriculture to be industrial agriculture will create economic stability and social stability for the farmers. Farmers would have immune and confident to agricultural career in the future.

Well-being of farmer is an interesting point to study. The agricultural problems also need to be addressed. Thus, the researcher accessed to the agricultural community to find the information. It found that the farmer's working is relatively low profitable because there are no sufficient agricultural workers in the agricultural sector. Lack of labor is one of the major obstacles in agriculture business. However, farmers commented that if they do agriculture business by themselves and they can gain income enough to take care their families, they will not change their occupation to others.

Then, the researcher proposed the concept of a small smart farm with less labor, time and fund by using simplified technology to help and support farming. The smart farm should be a household-based farming operation that will generate income for households on sufficiency economy basis. The team exchanged knowledge with the community and finally concluded that it should be done in "the smart farming by adopting the philosophy of the sufficiency economy".

The duck farm in alignment with the concept of the smart farming by adopting the philosophy of the sufficiency economy was considered to be the case study. The automatic duck farm system by using electricity from solar cell is a project which can be implemented to meet such needs of being smart farmers. Furthermore, this project is agricultural systems with various plants and animals in the same area. Each production activities contributes benefits to each other effectively that based on the principle of combining plants, animals and the environment. This project is integrated agricultural systems that will be successful by formulating, implementing, and focusing on each activity appropriately for physical, economic, social, labor, capital, land, production, and natural resources. Furthermore, this project focuses on utilizing the resources available in the area appropriately and maximizing benefit. This project will reduce the cost of purchasing energy for using in farms by producing electricity from solar panel system. Once the smart farm is in operation, only one labor can operate and maintain the farm. The expansion of the farm can be adjusted depend on area and environment.

The smart duck farming is not only build for a prototype but also disseminate knowledge to people who interested in farming. To help farmers adopt sustainable practices, it's vitally important that education help farmers make effective use of the science. In this study, the researcher will be responsible for bringing the knowledge of technology and farm management to farmers. The material and facilities are provided to become a community learning center which delivers knowledge to the community, other communities and interested parties. This project will be an example to see a practical smart farm which is suitable for Thai farmers. They can also be used to adjust ideas to fit the needs of each community.

As mentioned above, this study also explores the knowledge dissemination about the smart farming by adopting the philosophy of the sufficiency economy in duck farm prototype. The result from this study could be used to support smart farming 4. 0 and develop the policy to be feasible and suitable for Thai farmer situation.

1.2 Objectives

1.2.1 To apply the concept of the smart farming by adopting the philosophy of the sufficiency economy in duck farm prototype.

1.2.2 To distribute the knowledge or experiences from the practice of the smart farming by adopting the philosophy of the sufficiency economy in the community

1.2.3 To provide policy recommend for government to support a more sustainable, practical, and suitable practices of smart farming 4.0

1.3 Scope of the Study

1.3.1 The definition of smart farming used in this study is restricted to use appropriated technology that it is suitable and practical for farmers' ability to use, maintain and develop.

1.3.2 The sustainable, practical, and suitable practices of smart farming in this study is evaluate in three aspect, economics, environment, and society.

1.3.3 Latkrabang district is chosen to be the study area (as shown in figure 1.3) because most of the areas are green areas that are rural and agricultural lands. People who live in green areas is the target group to learn the smart farming by adopting the philosophy of the sufficiency economy. Yellow and orange areas are residential areas that people could apply the smart farm in this study as a supplementary career. In Latkrabang district, there are educational institute and agriculture center of government that farmers can approach knowledge easily. Moreover, the surrounding areas of Latkrabang district are agricultural areas, where knowledge can be disseminated easily to neighboring communities.

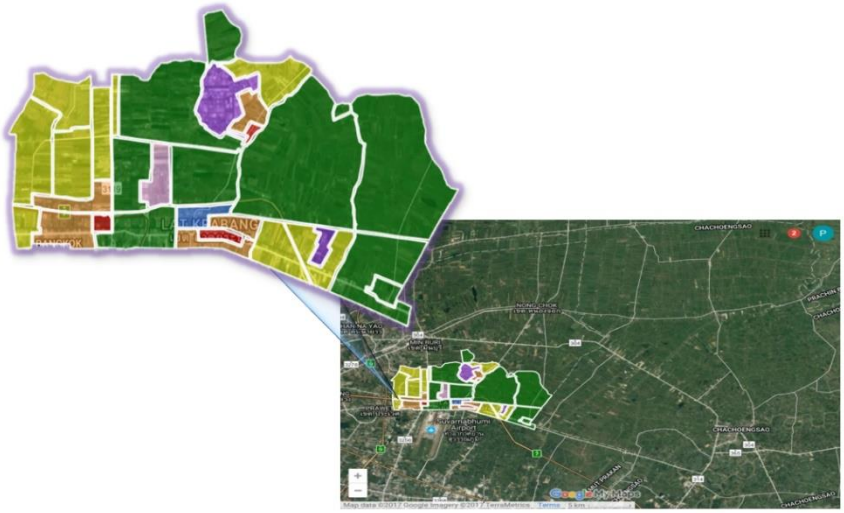


Figure 1.3 Location of the Pilot Test (Latkrabang)
Source: Google My Maps, 2017

1.3.4 The area of smart farming in this study was designed for 320 square meters (around 1 rai) because the research considered possibility of land tenure that most people are able to be own.

1.3.5 The period of time when the study was conducted starting from the preparation of outline, data gathering, and conduct of building, analysis and synthesis data was March 2017-April 2018.

1.3.6 The study of agricultural accounting encompasses several aspects from agricultural production to marketing, therefore, this study takes into account only the product after consumption in household.

CHAPTER 2
LITERATURE REVIEWER

In this chapter, the concept of smart farm, smart farming in response to Thailand 4.0 policy, agricultural policy in Thailand, the philosophy of sufficiency economy, the smart farming by adopting the philosophy of the sufficiency economy, and sustainable development are discussed.

2.1 Smart Farm

It is thought that smart farming could reduce production costs, increasing productivity and establishing standards for quality control by using machinery and technology to work in agriculture. Therefore, the propose of smart farming is increasing the quality and quantity of agricultural production. It is possible that smart farming will be future solution for Thai agriculture. According to the study of Banhazi, Lehr, Black, Crabtree, Schofield, Tscharke, & Berckmans (2012), they indicated that farm management with technologies could improve animal welfare, environmental of farm, economics stability of rural area, and also reduce pollution. Academic organizations should support knowledge to create technologies for smart farm in order to make the better life for farmer and agriculture sector (Banhazi et al., 2012).

Nowadays, the farmers have been facing with the lots of problem in agriculture, such as, inappropriate irrigation, pest, unpredicted weather, and many more. However, these problem could be solved by using Internet of Things, for example, Wi-Fi, NetSim simulator, emulator software, sensor technology to manage farming (Vinod & Sahadev, 2016). Moreover, Abi (2012) supported the idea that innovation is need for smart farming, such as, robotic, automatic machine, and intelligent software. These technologies were expected that will help reducing labour and costs in farming. In Ukraine, smart farm concept is also the basic trends of technological innovation (Yermak & Bugaenko, 2016).

DeLaval (2016) quoted “Smart Farming is about innovations that are decision tools, services, knowledge, and automation in order to support farm management”.The benefits of doing smart farm are more productivities, improved cost control, and farm profitability which lead to sustainable farming (DeLaval, 2016).

Cooperative is a factor that could enhance agricultural sector will be stronger. Agricultural families have been supported from cooperative. Cooperative seems play vital role in agricultural sector which lead to farm credit system, supplies, market, government support, educational institutes, research, and technical assistance. Many developed countries use cooperative for agricultural business activity and also organized in several ways (Cobia, 1989)

In Australia, The University of New England is a favorable educational institute which supported Australian farm by teaching and research on technology and

innovation, leading to smart farm. They claimed that sustainable manageable accessible rural technologies farm improved productivity, environmental sustainability, safety, workflow and social/business support. They indicated that educational institute contributed in creating knowledge to disseminate knowledge to farmers for sustainable agricultural development (The University of New England, 2017).

Michael and Gregory (2017) suggested their model for smart farm as shown in figure 2.1. Information, communication technologies, decision-support, and farm management tool are important things for making more efficient, and productive farming (Michael & Gregory, 2017).

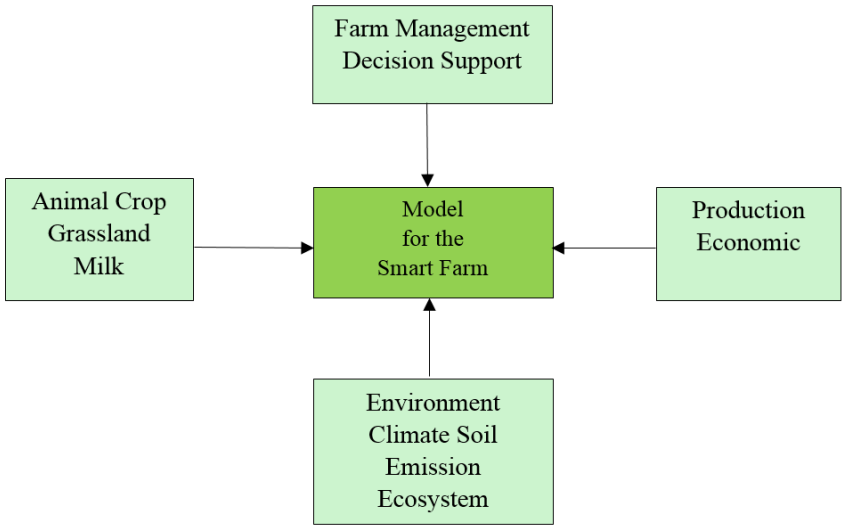


Figure 2.1 Smart Farm Model

Source: Michael & Gregory, 2017:2

It is interesting model to compare the possible way to do in Thailand for smart farm 4.0. Decision support tool seems the most important as basic to create production economic, and improve environment. The way to make the efficient decision support tool is government support in order to create agricultural research fund, smart farm promotion fund, monitoring, and consulting agencies. Technological cost seems to be a barrier for Thai farmer. In addition, most farmers are not also interested in incorporating technology because of investment cost. Technology for innovative farm is costly because Thailand cannot produce and develop its own technology and mostly advanced technology are imported from other countries. Material technology is costly because of currency and taxes on imported goods.

Drishti, Divyata, Rakhi, & Jimmy (2014) pointed at benefits of the concept of automation that making easier and faster work in farm and increasing efficiency. For example, implement automatic lighting system, auto-sprinkler system, in-farm temperature control and security for farm houses which as temperature and motion sensitive devices will only work when required. The automatic system conserves

energy effectively (Drishti et. al, 2014). Smart farming not only could improve productivity but also make environment better by reducing energy consumption.

Every farm has different needs which based on the size and type of operation. The smart farm concepts of monitoring and management are fundamental to keeping every one of these enterprises running smoothly (McDermott, 2016, p.19). The smart farm requires a great deal of technology by monitoring, and management technologies to enable control systems throughout the farming operation (McDermott, 2016).

In California, USA, there are agricultural education programs with approximately 8,000 students per year (Meadows, 2012). These programs have been supported funding by the Imperial Irrigation District, Imperial County Farm Bureau and local seed companies (Meadows, 2012). Agricultural education program could create smart farm by emphasizing hands-on experience of various activities, such as, harvesting and sampling vegetables, harvesting and eating winter crops to milking artificial cows and making butter, and also include hayrides and sing-alongs (Meadows, 2012).

Motivation could be used as a factor to push forward successful smart farm. According to the Smart Marketing Adds Rewards Today (SMART) was sponsored by Successful Farming magazine, they set the rewards, then more than 1,000 farmers from across the US took a part in contest to compete and win the prize. Reward can encourage farmers to develop their own farms (National contest awards smart farm marketers, 1993).

In Thailand, Department of Agricultural Extension (2017) developed projects which support knowledge dissemination to farmers. The farmers who participate in the knowledge dissemination project are expected to have farming knowledge, decision information, recognizing the quality of products, environmental and social responsibility, proud of being a farmer, and self-reliance. Moreover, Ministry of Agriculture and Cooperatives (2017) believed that knowledge, government service, and cooperative can create smart farm that lead to precision farm in the future. When Thai government launched Thailand 4.0 policy, smart farming is a part of the policy. The government encourages farmers to develop smart farm. The smart farm can be developed from various factors, knowledge dissemination, cooperative, technology, farm management, and financial support from government (Research Management and Quality Assurance Division, 2016).

Reviewing theory and practice of the smart farm concept can be concluded the significant factors to push on smart farm successfully, summarized in Table 2.1

Table 2.1 Conclusion of Factors Leading to Smart Farm

Sources	Countries	Factors									
		IOT	Robotic	Automation	Farm Management	Cooperative	Knowledge	Technologies	Innovation	Reward	Government Support
1. Vinod & Sahadev. (2016)	India	✓									
2. Abi (2012)	-		✓	✓				✓			
3. DeLaval (2016)	UK			✓	✓		✓				
4. Cobia (1989)	Europe					✓	✓	✓			✓
5. Banhazi et al. (2012)	Australia and UK						✓	✓			
6. Michael & Gregory(2017)	Ireland	✓			✓						
7. The University of New England (2017)	Australia							✓	✓		
8. Drishti, Divyata, Rakhi, & Jimmy (2014)	India			✓							
9.McDermott (2016)	US				✓			✓			
10. Yermak & Bugaenko (2016)	Ukraine							✓	✓		
11.Meadows (2012)	US						✓				
12. National contest awards smart farm marketers (1993)	US									✓	

Sources	Countries	Factors									
		IOT	**Robotic**	**Automation**	**Farm Management**	**Cooperative**	**Knowledge**	**Technologies**	**Innovation**	**Reward**	**Government Support**
13. Johnson & Monke (2017)	US										✓
14. European Commission (2017)	the European Union										✓
15. Department of Agricultural Extension (2017)	Thailand					✓	✓				
16. Research Management and Quality Assurance Division (2016)	Thailand				✓	✓	✓	✓			✓
17. Ministry of Agriculture and Cooperatives (2017)	Thailand						✓				✓
Total		**2**	**1**	**3**	**3**	**3**	**7**	**7**	**3**	**1**	**5**

From table 2.1, knowledge and technologies are the most significant factors for leading to the smart farm. Knowledge and technologies have been contributing to the need for smart farming (David, 1989; Banhazi et al., 2012; Meadows, 2012; Abi, 2012; DeLaval, 2016; McDermott, 2016; Research Management and Quality Assurance Division, 2016; Yermak & Bugaenko, 2016; Department of Agricultural Extension, 2017; Ministry of Agriculture and Cooperatives, 2017; The University of New England, 2017). To support farmers who gain knowledge and skills in modern agriculture will encourage them manage farm operations by using technology and innovation. Technologies to optimize the farming system, such as, mechanical harvesting, automatic system, and monitoring system could reduce cost of farming and solve labor shortage problem. Thus, farmer could build stronger relationship by sharing new knowledge among farmer's networks.

Support from government by policies, financial assistance, or investment for smart farming is what led to emergence of agricultural improvement (Cobia, 1989; Research Management and Quality Assurance Division, 2016; European Commission, 2017; Ministry of Agriculture and Cooperatives, 2017; Johnson & Monke, 2017). Although there were several factors to be considered smart farming encouragement, government support is an important factor that most farmers are interested. The enforcement from government by law, tax policy or government funding will support research and development in agriculture that will help many farmers are interested in smart farming. Moreover, the government support will encourage farmers achieve smart farming faster.

Automation, farm management, cooperative, and innovation were claimed that the smart farming could be developed by these factors (Cobia, 1989; Abi, 2012; Drishti et al, 2014; DeLaval, 2016; McDemott, 2016; Research Management and Quality Assurance Division, 2016; Yemak & Bugaenko, 2016; Department of Agricultural Extension, 2017; Michael &Gregory, 2017; The University of New England, 2017). Automation and innovation have started transforming the agriculture industry and helping farmers to improve their crops productivity and yield. Simple factors such as knowing the farm management and cooperative can lead to a profitable year.

The study of Vinod and Sahadev (2016) and Michael and Gregory (2017) suggested that IOT was a factor, leading to smart farming. IOT has been started using in farming to monitor the crop field, automate the systems in farm. However, the adoption of access to high-speed internet, mobile devices, and reliable, low-cost satellites (for imagery and positioning) by the manufacturer are keys to contribute IOT using in Thai agriculture.

Nowadays, robotic is one of the most modern technology in the agricultural sector. Abi (2012) supported that robotic will help reducing labor and cost and producing more agricultural productivity. Moreover, the high technologies, such as, AI or robotic will enhance the standard of agricultural products in the future.

There were few resources to claim about reward that it was a factor to contribute smart farm. National Contest Awards Smart Farm Marketers (1993) suggested that reward for farmers would motivate among agricultural communities to develop their capability. However, to understand characteristics of Thai farmer culture is needed to integrate element of smart reward for smart farmer.

2.2 Smart Farming in response to Thailand 4.0 Policy

Agriculture is a vital part for economic sectors in Thailand. Thailand has benefited from agriculture in many ways, such as, domestic consumption, and export. Increasing agricultural productivity results in increase of food and energy production for people's demand. Political regime, economic conditions have influenced on agricultural policy implementation in Thailand. Previously, Thai governments intervened in the agricultural market by controlling price, imposing taxes, or limiting quotas of agricultural export and imports. Shift in agricultural policy has occurred in the midst of political and economic transition and expansion of international trade.

Thai agricultural system of Thailand small household farmers in the past decades. However, the small household farmers have been facing many problems, including the loss of agricultural land. Agricultural promotion depended on agricultural chemistry that cause increasing of agricultural production costs and pollution. Furthermore, climate change is a problem for the agricultural sector in Thailand. The problem in Thai agricultural sector has been continuing and more serious crisis.

Therefore, government is an important mechanism by addressing policy or law to determine direction of agricultural improvement. From the studies of Raiprakobsub (2013) and Chuchat (2011) suggested the direction of agricultural policy for Thailand that should be, following:

1. To encourage integrated water management helps to relieve flood and drought and increase water efficiency. The cropping system need to be adjusted properly. The accelerated expansion of all irrigation areas also need to be implemented.

2. Agriculture in Southern and Northeastern should be solved and developed.

3. To develop cooperation with neighboring countries contributes linkages between trade partners in various countries.

4. Government should launch the policy on household debt suspension for farmers who have low income. Government should also organizing rehabilitation and career development plans for farmers.

5. The price of agricultural products should be raised by promoting and developing the agricultural risk insurance system about crop insurance systems due to natural disasters.

6. The government should create new generation of farmers who have technological knowledge of smart agricultural management.

7. The government should develop farmer's business institute by training the knowledge of corporate management and accessing to sources of funds fairly.

8. Agricultural learning center is channel for dissemination of agricultural knowledge.

9. The government should focus on promoting the use of appropriate technology, reducing agricultural production costs. The government should transfer knowledge from research to farmers on appropriate technology and the production system which suit for local conditions.

10. The government encourages farmers to develop quality and international standards of agricultural products in order to increase value of product.

11. The government should provide land for farmers who do not have land fairly and solve the problem of poverty. The farmer should be a stable occupation.

Evolution of agriculture in Thailand was divided into three eras before entering Thailand 4.0 model as follows;

- The first era of agriculture appeared in pattern of labor intensive system and low productivity.
- The second era of agriculture, synthetic pesticides, fertilizers and efficient machines were used in agricultural sector. The potential yield was increased dramatically, however, the pollution also increased because of agricultural chemical substances.
- The third era of agriculture was found that technology was a part of agricultural improvement to produce more productivity according to increase demand (Aeknarajindawat, 2016).

When Thai government launched Thailand 4.0 policy, smart farming 4.0 was a part of the policy. Thai agriculture in Thailand 4.0 era has been expected that information technology, such as, IOT, tracking system, monitoring, and remote sensing play vital roles. Sustainability, environmental consciousness, and safety solution were also considered in agriculture 4.0. After announcing Thailand 4.0 model, the government agencies determined policies and plans to develop agriculture which according to smart farming 4.0 in response to Thailand 4.0 model. Furthermore, the government emphasizes integrated work by exchanging and sharing information between agencies and farmer. The government officials are expected to have ability of technological using and innovative research. The agricultural products are increased value by processing and packaging. The government expects that farmer will be able to adopt innovation in agricultural sector effectively and farmers have to manage their agricultural products completely (Ministry of Agriculture and Cooperatives, 2017).

Since 2016 in agricultural reform, the goals of government were to reduce costs and increase the chance in agricultural products competitiveness. In 2017, the government focused intensely on raising standards for sustainable agriculture. The government created driving force of Thailand's agriculture under the philosophy of sufficiency economy and Thailand 4.0 model .The government focused on bringing technological innovation and knowledge to improve well-being of farmers. The government set the goals that farmers should increase income, decline debt, and proud being farmer. Until the year 2018, the government determines integrated plan for 15 important agricultural projects, following:

1. Water management
2. Large agricultural land plot
3. Learning center for agricultural improvement
4. Agrimap
5. To develop smart farmers
6. To develop farmer institution in the form of civil state
7. The agricultural bank

8. Organic agriculture
9. The new theory of agriculture
10. The fishery solution
11. The rice seed development center
12. The value added of agricultural products
13. The agricultural market
14. The development of agricultural products to the standard
15. The management of cooperative member debt of farmers

Moreover, the government forces smart agricultural curve plan in 2018 in order to achieve the goals by emphasizing human resources development of government officials and farmers. The government officials expected to be high-performing and expert in their works in order to disseminate technology and innovation to farmers. Then, farmers can adopt to the process of agricultural production and understand the smart farming 4.0 in response to Thailand 4.0 model (Ministry of Agriculture and Cooperatives, 2017). Department of Agricultural Extension (2017) has already planned to drive smart farmer project by disseminating knowledge. Firstly, farmers were screened qualification to categorize in existing smart farmer group and developing smart farmer group (The Office of Agricultural Economics, 2015). The study of The Office of Agricultural Economics (2015) showed that number of developing smart farmer group is higher than existing smart farmer group. Although, the government has planned to disseminate knowledge to farmers who have been chosen in smart farmer project, the government set the target of smart farmer production from disseminating knowledge are only 7,000 smart farmers (Research Management and Quality Assurance Division, 2016) or 0.12% of 5.91 million households in agricultural sector (National Statistical Office, 2014). The government should launch policy to develop smart farmer group by disseminating knowledge properly and widely by government agencies, research centers or educational institutions.

For smart farm 4.0 management, the government supports doing the large agricultural land plots that the large agricultural land plots are controlled by the government officer as field managers from various departments. Doing the large agricultural land plots requires advance technology while Thailand needs to import advanced technologies from other countries that it makes Thailand is facing trade deficit. It seems that endeavor of Thai government to do large-scale farming is following the same path of collective farm. Collective farm is organization of land and labor into large scale farming which had been organized by political control by state (Robert, 1982). Thai government tried to persuade farmers to do the large agricultural land plot which were controlled and managed by government officials. Moreover, the government claimed that this large-scale farming policy will help farmer to do more effective farming and income. They gave the reason of doing large-scale farming which were controlled and managed by government office that it will make the officers work and assist farmers easily. However, doing the large agricultural land plot is required a huge investment that most Thai farmers cannot afford to invest, probably. Blanchard & Shleifer (2001) stated that although collective farm has been operated in many countries during the 20th century, it has not been necessary to run by government agencies.

Thus, the reform of the Thai agricultural policy should aim to support small household farmers. The government should launch policy on equity of basic agricultural resources, especially the distribution of land holding. The government should encourage small household farmers to develop sustainable agriculture. Therefore, to reform of the agricultural system of the country has to adjust the relevant legislation, agricultural policy, and the working of government agencies. According to some case studies from other countries in the past showed that doing large-scale farming was not successful by government agencies control. In the Soviet Union era in 1928, the purposes of collective farm in Soviet Union were to increase the food supply for population, increase agricultural product for industry, and agricultural export (Stuart, 1982). However, the performance of Soviet agriculture by Soviet political leader, economist, and planner was failure because of poor farm management. Stuart (1982) noted that the education was important and could lead to positive change in Soviet collective agriculture in the early 1950s. The expansion of managerial authority and decision making tool were applied in farm management that made Soviet collective agriculture better gradually (Stuart, 1982). In some Africa countries, it is interesting to study about large-scale farming. The large-scale farming in Africa was in the form of collective farm which was under government control. After the French-Algerian war in Algerian, large-scale private farms were abandoned by their former European owners. Then, Algerian government took control these lands as state properties. They stipulated cooperative farm which consisted of worker and executive committee. The cooperative farm in each societies had to pay certain portions of the surplus of cultivation to government. This concept made bad situation and it became the idealistic collective farming policy of Algerian government that farmer was not motivate to do or collaborate. It showed that the government was not sufficient for running large-scale farming. Even in Tunisia, the policy of cooperative farm pattern was not also successful, while the individual farming seemed to be more suitable (Eberhard, 1974).

In Thailand, sustainable agricultural development in practice has been still very slow. In the reform of Thai agriculture should be analyzed the problem in the number of farmers, the expansion of agricultural area, and agricultural policy. Driving and implementing sustainable agriculture should focus on efficiency and effectiveness truly. Therefore, there are two issues about Thai agricultural policies that should be considered, following:

2.3 The Philosophy of Sufficient Economics and Smart Farm

King Rama 9 has drawn attention to the fact that the philosophy of sufficiency economy is a balance way of living. The philosophy of sufficiency economy focuses on three principles, moderation, reasonableness, and self-immunity (as shown in figure 2.2) (Mongsawad, 2010). The three principles are along with the conditions of moral and knowledge can be applied to any level of the society (Mongsawad, 2010).

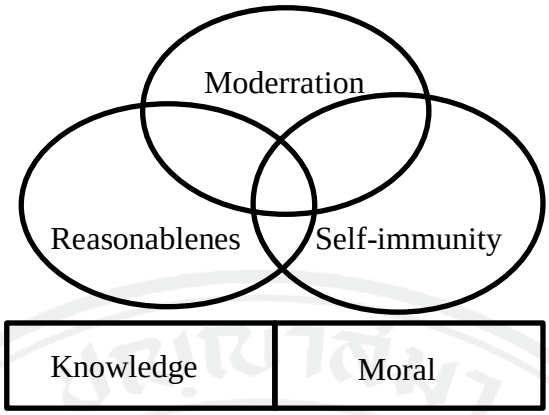


Figure 2.2 The Philosophy of Sufficiency Economy Framework
Source: Mongsawad, 2010: 129

The philosophy of sufficiency economy consists of balanced and sustainable development and ready for change in economic, environment, knowledge, and technology. Sufficient economy can lead to the goal of economic security. Thailand is an agricultural country, therefore, the economy of the country should focus on the agricultural economy and food security. This concept leads to the stability of the economy. Sufficient economy can be applied at all levels in society. It was not used in agriculture but also applied in financial sector, real estate sector, and international trade. The philosophy might be applied depending on the economic background of each individual and geo-social condition of the area. For doing small farms, King Bhumibol Adulyadej offers a model of small farm management called "New Theory Agriculture" based on Sufficiency Thinking. The "New Theory" which adopts the philosophy of "Sufficiency Economy" is considered a proper means to guide the people to rely on themselves so that they can secure in food and living. The New Theory Agriculture advises farmers to divide their plots into four sections under the 30:30:30:10 formula. Farmers should use 30% of land for a reservoir to ensure year-long water supply for farming, another 30% for rice fields, another 30% for vegetables, field crops, fruit trees, firewood, herbs, etc., and the remaining 10% for residence and livestock areas. After achieving food security, the second stage of the New Theory Agriculture advises farmers to organize and improve irrigation systems and farm productivity preferably as co-operatives. They should also share resources to provide welfare benefits to members. This basic model can be modified to suit different geographical conditions and farm sizes (Ministry of Foreign Affairs, 2007).

The philosophy of sufficiency economy is adopted with smart farm in this study. The smart farm in this study was considered on culture, environment, operational capabilities, and the feasibility of Thai farmers. Thailand is a small country, thus, Thai farmers do not need to use advanced technology to produce a large amount of product because overall people's consumption does not require a single product only. Agricultural land should be divided to produce appropriately and adequately that meet the diverse needs of domestic consumption. According to Whiteside (1998) mentioned that advanced technology is not always necessary for

smart farm. Some developing countries which do agriculture in rural need appropriate action at the technology, community, and policy and incentive level for achieving sustainable agriculture (Whiteside, 1998). Relf (2016) also pointed that smart farm is not only concern about technology but also think about what is right for farm's situation, then doing it to the best of your abilities. Smart decision will make farmers' business more robust (Relf, 2016) which consistent with the philosophy of sufficiency economy. Technology which is adapted in smallholder farming will be more success and benefit than large-scale farming. Because when doing large-scale farming, the state has not been able to favorable marketing and other supports (Whiteside, 1998).

Moderation from the philosophy of sufficiency economy to agricultural practice should consider on making the size of the farm at the farm level that the household can manage. Farmers can choose their own size and capability to invest by existing their own capital. Therefore, it is interesting to do smart farming in response to the need of household level in first step of agricultural development. According to a case study in Africa, the government turned to rather do smallholder farming system than concentrate on optimizing the yield of a single crop (Whiteside, 1998). African government supported to adapt appropriated technologies to a complex situation in agricultural household (Whiteside, 1998). Moreover, they encouraged smallholder farmer to do mixture of agriculture being grown in each field (Whiteside, 1998). However, service and policy which have to be define by government are important factor for reducing farmers' risk. Policy of technology approach is an efficient tool for smallholder farming development (Whiteside, 1998).

Thus, Sufficiency Economy with smart farm is suitable for Thai agricultural production without having to invest too much and using sufficient application of technology to increase productivity and the quality of the agricultural product in order to reduce labor and costs in the long term. This concept is the procedure to create self-immunity, moderation, and reasonableness which according to the philosophy of sufficiency economy.

The smart farm in this study is a concept that comes from the smart farm, integrated with the philosophy of sufficiency economy. Sufficiency economy with smart farm meets the suitable production for Thailand without the need to invest too much. The smart farm in this study applied technology to increase productivity and quality of production. Thus, the smart farm in this study will be a household-based farming operation that will generate income for households on sufficiency economy basis. The smart farm in this study indicates that farmer can do agricultural business to gain income from working to support their families. Creating a smart farm must incorporate factors that contribute to sustainable smart farming and extend it to be precision farming. Starting with the decision-making tools which based on the philosophy of sufficiency economy considered the ability to choose appropriated technology for farmers' ability to use or develop. The technology should be transferred and disseminated properly by government agencies, research centers or educational institutions for cooperating in agricultural development. When farmers can teach to each other that it means farmers have sufficient knowledge and ability to develop further.

The smart farming by adopting the philosophy of the sufficiency economy is a strategy for smart farm management which suit for Thai culture and environment. The smart farm in this study is able to support household-based farming operation that will generate income and save money, energy, time, resources, and create zero waste in the farm. The smart farm in this study uses technologies that it is easy to learn and maintain. There is no need to work in farm all the time in the smart farm in this study. Farmers can spend less time to work in the farm that it can reduce stress in animals. The people can also be farmer as a supplementary occupation by spending less time and labors to work in the farm. Moreover, the smart farm in this study is agricultural systems with many plants and animals in the same area. Each production activities contributes benefits to each other effectively that based on the principle of combining plants, animals and the environment. Waste which is generated from production on the farm can be recycled from one type of production to another one or several types of production in a fully integrated farm. Furthermore, the concept of the smart farm in this study focuses on utilizing the resources available in the area appropriately and maximizing benefit. For example, the cost of purchasing energy for use in farm has been reduced by using solar cell technology to produce electricity. Once a farm is in operation, only one labor can maintain the farm. The expansion of the farm can be adjusted depending on conditions.

In this study, the duck farm is a case study of the concept of the smart farming by adopting the philosophy of the sufficiency economy. The smart duck farm consists of automatic watering and drainage system. The watering system fill water in trough, then, the drainage system will clean waste in trough and drain water to vegetable plot automatically. According to Mason (2003) suggested that to be sustainable farming should maintain environmental resources locally, using them carefully and efficiently and re-using materials as much as possible. The concept of zero waste in the duck farm in alignment with the smart farming by adopting the philosophy of the sufficiency economy is to drain water from duck and fish farm which have high nutrients for vegetable plot. This concept can create environmentally friendly farming less pollution, and provide long-term savings (Mason, 2003).

(1) Creating appropriate agricultural policy for Thai environment

- Policies on agricultural land for small farmers and zoning for agricultural using seem interesting to review and practice seriously. Especially, irrigation areas where the government has invested a lot of budgets for agricultural purposes. However, many irrigation areas were permitted to use for other proposed.
- Policy on agricultural product's price insurance program need to be practiced seriously. The government should support the agricultural product's price explicitly because the agricultural product's price was an obstacle for growing up and more risky than other sectors. Thai farmers who may be forced to sell agricultural products in lower price than it should be in the market. To guarantee agricultural product's price helps farmer avoid the risk from unstable economy.
- Policy on financial supporting for smart farming need to be addressed by the government in form of loan and funding. Financial support from

government seems benefit, sharing with the financial institutions of government in the form of increasing customers in the loan.

- Policy on well-being of farmer should be implemented. Agricultural knowledge and 31technology should be disseminated to farmers seriously and equally. Any farmers can approach knowledge to develop agriculture in term of creating quality farming.

However, when Thai government conducts any policy on agriculture, they should consider on environment. The vital factors for smart farming in Thailand should be supported from government to launch policy and agricultural act to help and support farmer seriously.

(2) Participation of stakeholders

Everyone acknowledged the importance of stakeholder that participated in brainstorming - decision making - action. However, most government agencies just tried to "listen" the opinions of the relevant stakeholders only. Finally, decisions were made by government officials. Relevant stakeholder play a role only in interviewing, answering the questionnaire, and participating conference.

Actually, the farmers, consumers, and entrepreneur were the important interest groups. The government agencies should play the role of service provider. The researcher, academic, standard certification agencies were also the service providers to support farmers, consumers and agricultural entrepreneur. Thus, the government should focus on the need of stakeholders in the formulation of policies and measures to support sustainable agriculture.

Having accurate information about the agricultural situation with stakeholders and service providers is very important. The right decision making about targeting and direction policies should be on the accurate information and current database and knowledge from inside and outside the country. Weaknesses, strengths, potentiality, overseas situations, and the rules of foreign countries support Thailand to evaluate reality and other countries situations, correctly.

Table 2.2 Showing the Comparison between Smart Farm from Other Countries, Smart Farm 4.0 in Response to Thailand 4.0 Policy and the Smart Farming by Adopting the Philosophy of the Sufficiency Economy

Content	Smart Farm	Smart Farm 4.0 in Response to Thailand 4.0 Policy		The Smart Farming by Adopting the Philosophy of the Sufficiency Economy
		Pros	Cons	
1. Knowledge	There are agricultural education programs	There were plans for disseminating knowledge to qualified farmers	Limitation of the number of farmers participate in smart farmer project	Supporting disseminating knowledge for any farmers
2. Cooperative	To contribute the network of farmer community to share benefit	Government has a plan to create cooperative in each village	Focusing on the group, not an overview.	- Create network between farmer and seller. - The development of production-sharing group.
3. Technology	- Innovation - Internet of things - Robotic - Automatic machine - Intelligent software - Information and communication technologies	- Advanced technology	- Thailand cannot produce advanced technology - Import technology - Trade deficit.	Incorporating simple and economical feasible technology for household-based farming operation
4. Management	- Farm management - Decision tools - Service - Reward System - Government support	- Farm management - Doing the large agricultural land plots are controlled by government officer. - Financial support from government in form of loan - Service of agricultural data	- The difficulty and overlap in administrative functions from government. - Financial support - Benefit, sharing with the financial institutions of government - Idealistic policy	- Without management by government officer - Environmental management (zero waste) - Sufficient income

To be smart farmer, they can gradually start to do, it does not need to leave the thing for doing farming. For example, start with your existing capability to do the farm in the weekend or just in the evening as a part time job. Agriculture can be started anywhere at any time in the context of what it has area, time, fund, and knowledge.

Smart farm management adopting sufficiency economy can support Thai farmers implement smart farm easily. The establishment of basic and vocational training for the farmers in the household and secure and sustainable in the farm need to be concerned. Sufficiency Economy will provide basic and professional management for the farmer in household level in order to achieve stability and sustainable farming.

Table 2.3 Principle of the Philosophy of the Sufficiency Economy

The Philosophy of the Sufficiency Economy	Apply	Benefit
Moderation	Worth for investment Do not invest too much	No debt or less
Reasonableness	To understand ability and apply to create production activity	There is a strong self-reliance production structure.
Self-Immunity	There are various activities to do and give benefits to each others.	Saving, stability, and Sustainability

From table 2.3, the philosophy of the sufficiency economy with smart farm is based on the principle of being able to raise a basic level of consumption. This principle can be adopted to create a sufficiency business model for better well-being of farmer.

Table 2.4 the Philosophy of the Sufficiency Economy to Smart Farm

Sufficiency Economy	Apply to Smart Farm
Moderation	- Making the size of the farm at the farm level that the household can take care. Farmers can choose their own size and capacity to invest by their own capital. - Appropriate production size consistent with management capabilities without having to invest too much. - Not too greedy and do not focus on short-term profit. - To consider the ability in order to choose appropriated technology that it is suitable for farmers' ability to use or develop
Reasonableness	- Using sufficient application of technology to increase productivity and the quality of the output in order to reduce labor and costs in the long term - Technology is easy to learn and maintain - Focus on the risk diversification of farm productivity. - The farm can be adjusted the productivity.
Self-Immunity	- Farmers can bring their products from farm to households without having to buy them and do not have to rely on consumable goods in the market. - The smart farm in this study will be the way to save money, energy, time, resources, and create zero waste in the farm. The smart farm will show that farmer can do agricultural business and they gain income can support their family. - Main job and part time job - Serve the local and regional market before responding domestic and foreign markets, respectively.

The philosophy of the sufficiency economy consists of the three principles are along with the conditions of moral and knowledge. Moral and knowledge are vital role which can apply to the smart farming by focusing on honesty in farming and trading. The accumulated knowledge from doing farming will be disseminated to other farmers in order to develop agricultural knowledge and collaboration.

2.4 Sustainable Agriculture

Technological advancement and marketing mechanisms contribute to growth, production, consumption that negatively affect the environment, human life, animals and plants. Sustainable development is an idea to prevent the world from reaching the end. It is the use of natural resources and the environment to improve the quality of human life.

Sustainable development is "Our Common Future" published by the World Commission on Environment and Development (WCED, 1987 cited in Neil, 2007, p.208). Sustainable development principle has been accepted widely from many institutes or organizations (Neil, 2007).

Sustainable development principle also involves with the concept of sustainable consumption which concerns about equity issue (Neil, 2007). When everyone has equal access to resources, it does not load the rich. Equal access to resources could reduce resource price bump and exploitation because resources are the cost of production. If everyone is equally accessible, there are no resources will be used by specific people or resource price cheating.

Technology has been talked about leading sustainability of environment. However, technological development is not only thing for sustainability but social life, attitude, and value also preserve environment (Luke, 1994). Environmental attitude is fundamental to sustainability. Thus, it should start with ideas of human to conserve resources and environment in balance way, then, use technology to deal with the problem.

Sustainable development has confidence in the ability of science and technology to solve environmental problem by technologies. Human is expected to have the ability to control nature. The problems that arise always can be resolved late. But at times, this concept is contrary to the economic, social and political in taking advantage from the underprivileged people, poor, or farmers. Furthermore, this may cause damage to biodiversity and ecosystems.

Therefore, sustainability is the basic theory of natural resources using in production and consumption that affects the environment (Kuhlman & Farrington, 2010). Sustainability is whatever to do that it does not make next generation get in the trouble. Moreover, people in the future will live with quality of life. Actually, sustainability is to look at the next generations. Dyllick & Hockerts (2002) explained that sustainability can be implemented from economic, social and environmental development as figure 2.3.

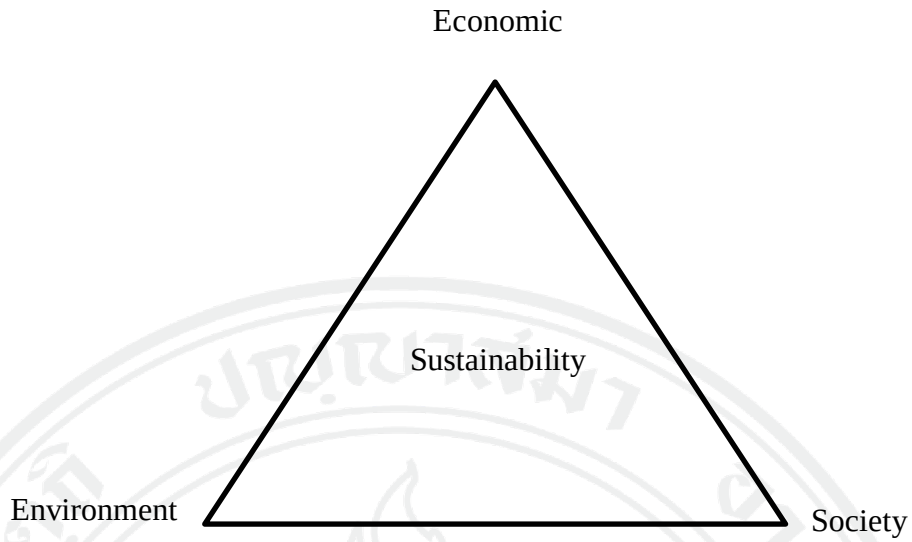


Figure 2.3 Three Dimension of Sustainability
Source: Dyllick & Hockerts (2002)

Sustainability to sustainable agriculture has been recognized by many countries around the world. The concept of sustainability is interesting to develop small household farming to sustainable agriculture. Sustainable agriculture help to solve the problem of poverty and reduce economic disparity between people in rural and urban. Sustainable agriculture conserve and restore environment in order to develop society. In fact, Thailand has recognized the importance of sustainable agriculture or organic agriculture for over 15 years. The goal of sustainable agriculture in Thailand was included in the National Economic and Social Development Plan No.8 (1997-2001) and the strategic plan for organic agriculture development (Chuchat, 2011).

Sustainable agriculture is a farming system that focuses on the balance of the ecosystem, good quality, sufficient for farmers and consumers, self-reliance, and including the important local community. The common principle of sustainable agriculture aims to produce food and the essential factors for living rather than producing to export. Thus, farmers do not have to run to the flow of the market. Sustainable agriculture is utilizing natural resources to maximize benefits without harming the environment, production systems, consumption and use of local resources. The product from sustainable farming will be safe from toxic residues. Sustainable agriculture allows family members to work together happily. Farmer families are able to live harmoniously with nature. Sustainable agriculture makes farming systems continue as long as possible without negative effects or problem on ecology, health, society and economy (Jitsanguan, 2000).

Sustainable agriculture is an agricultural system that cover the lifestyle of farmers. Production and management aim to achieve economic, social, environmental and ecological balance, leading to self-reliance and the improvement of the quality of

life of farmers and consumers. Sustainable agricultural systems contribute to the benefits of sustainable development in three dimensions as follows:

(i) Economic sustainability

- Food Security and Revenue
- Risk management
- Economies of Scale
- Value-added products and market expansion

(ii) Environmental sustainability

- Reducing the impact on the environment.
- Create biodiversity
- Restore the integrity of soil
- Effective water management
- Restore ecological balance

(iii) Social sustainability

- Reducing immigration
- Producer's hygiene
- Food safety
- Reducing dependency on external factors

Therefore, the smart farming by adopting the philosophy of the sufficiency economy is the way of sustainable agriculture that focused on well-being of farmer and local community. The smart farm in this study aims to produce sufficient food for families and communities fundamentally. The guidelines for sustainable agriculture are more clearly defined as follows:

1. To utilize and develop local wisdom combined with appropriate technologies for using in agricultural systems.

2. Encourage farmers to learn and develop agricultural knowledge and research.

3. To use resources from within local area and reduce resources from outside the area.

4. To pay attention of environmental care.

5. To avoid and reject the use of chemicals for agriculture.

6 To take advantage of biodiversity by creating the variety of agricultural production activities in the field and combine these activities to produce the most benefit together

7. To produce quality production for responding primary need of family and local community.

8. Allowing farmers and communities to develop themselves without external dominance.

Therefore, the smart farming by adopting the philosophy of the sufficiency economy is a way to achieve sustainability in three dimension of economic, environment, and society (as shown in figures 2.4 and 2.5)

The Smart Farming by Adopting the Philosophy of the Sufficiency Economy

Economic Sustainability	Environmental Sustainability	Social Sustainability
- Having income to take care family - Short-term in debt and reduce financial risk. - Create a stable income in order to expand the business. - Quality of agricultural output (Value added) - There are a variety of productivity which can compensate income each other.	- Create zero waste -Various creatures can support each other. - Effective water management.	- There is learning center of experiment and practice in agriculture. - Create a strong farmer society and reduce dependency from external factors - Create knowledge - Knowledge dissemination by farmer to farmer - Create a career for the local community. - Reduce immigration to the city.

Figure 2.4 the Smart Farming by Adopting the Philosophy of the Sufficiency Economy to Sustainability

Table 2.5 the Smart Farming by Adopting the Philosophy of the Sufficiency Economy and Creating Sustainable Agriculture

		Sufficiency Economy							
		Moderation		**Reasonableness**		**Self-Immunity**		**Moral and knowledge**	
Sustainability	**Economic**	Making the appropriated size of farm	Short-term in debt and reduce financial risk.	Using sufficient application of technology	-There are a variety of productivity which can compensate income each other. - Quality of agricultural output	Focus on responding to the need of household, local, and regional market before responding domestic and foreign markets, respectively.	Create a stable income in order to expand the business.	focusing on honesty in farming and trading	Quality of agricultural output
		Appropriate production size consistent with management capabilities without having to invest too much.	- Having income to take care family - Short-term in debt and reduce financial risk. - Create a stable income in order to expand the business	The farm can be adjusted the productivity	There are a variety of productivity which can compensate income each other.				
		Not too greedy and do not focus on short-term profit	Short-term in debt and reduce financial risk. - Create a stable income in order to expand the business						
	Environment			Using sufficient application of technology	-Create zero waste - Effective water management.			no chemical substance	Create zero-waste
				Focus on the risk diversification of farm productivity.	Various creatures can support each other.			environmental farm management	Eco-farmer
				The farm can be adjusted the productivity.	It creates symbiosis in the farm				
	Society			Technology is easy to learn and maintain	Knowledge dissemination by farmer to farmer	Main job and Part time job	- Create a career for the local community. - Reduce immigration to the city	focusing on honesty in farming and trading	Create a strong farmer society
								Knowledge dissemination to community	- There is learning center - Create a strong farmer society

The table 2.5 showed the relationship between the smart farming by adopting the philosophy of the sufficiency economy and sustainable agriculture creating. Sufficiency economy is easy to understand as it is based on three principals to create outcome of sustainable agriculture. Moderation is doing something, not too little or too much. Moderation also answers financial troubles by avoiding debt. According to moderation, making the appropriated things for farm consistents with management capabilities will affect sustainability in term of economic. Thus, farmers will have sufficient income to take care family and short-term in debt that reduce financial risk.

Reasonableness is decision making that should be made rationally with ethic and knowledge. Reasonableness is adopted with the smart farm in this study by considering using sufficient application of technology and focus on the risk diversification of farm productivity. To adopt reasonableness with smart farm in this study will affect sustainability in term of economic, environment, and society. Thus, the farmers will have variety of productivities which can compensate income each other, creating zero waste, effective water management, and quality of agricultural output. Then, knowledge dissemination by farmers to farmers will appear in local communities.

Self-immunity means developing the strength to cope with impact and changes from environment of future situations. Focusing on responding to the need of household, local, and regional market before responding domestic and foreign markets, respectively is a way that according to the principle of self-immunity. To adopt self-immunity with smart farm in this study will affect sustainability in term of economic and society. When, the outcomes will be creating career path of agricultural sector for the local communities and immigration to the city will decrease.

2.5 Related Research

Asia News Monitor (2017) reported that a smart farm project, which was initiated by the Southern Border Province Administration Center (SBPAC), has proven successful in helping farmers in Krong Pinang district of Yala province in Thailand as a supplement for their monthly incomes. The smart farm project has helped local people in Krong Pinang district earn extra income in addition to the money they make from working in rubber plantations.

Drishti, Divyata, Rakhi, & Jimmy (2014) introduced an efficient smart farm system. The living conditions of livestock were considered to design the smart farm, as well as reduce manual labor. Therefore, the smart farm consisted of automated light, temperature, humidity and sprinkler system. The animals were comfortable under automated control temperature and humidity system. The feeder control system times was installed for feeding animals in order to reduce the human labor in the process. All systems in the smart farm contributed convenience, energy efficiency, quality, and safety benefits properly.

The introduction of cloud computing and internet of things is the way for agricultural modernization and more popularity. The issues concerning agriculture could be solved by using technology as smart agriculture, for example, IoT (Fan, 2013). The data of automatic systems can be build massive data involved in agricultural production to control system in the real time (Fan, 2013; Ryu, Yun, Miao,

Ahn, Choi, & Kim, 2015; Nishant & Adil, 2016; Quang, Trong, Akihiko, Tam, Son, Mong, & Chau, 2017; Agrawal, Prieto, Ramos, & Corchado, 2016). Using an Intelligent System could effectively control the farm anywhere at any time, resulting in cost reduction, asset saving, and productive management (Jindarat & Wuttidittachotti, 2015)

The smart farm is not only provide convenience and also improve animal welfare and reduce greenhouse gas (GHG) emission and improve environmental performance of farm (Banhazi et al., 2012).

CHAPTER 3
METHODOLOGY

This research focuses on the assessment of the smart farming by adopting the philosophy of the sufficiency economy implementation. The research methods used mixed methods. IPO Model or input-process-output pattern was adapted for planning outline of exploring this project (Bushnell, 1990). IPO Model explored in terms of input, process, and output in order to approach and provide a framework for the smart farming by adopting the philosophy of the sufficiency economy analysis.

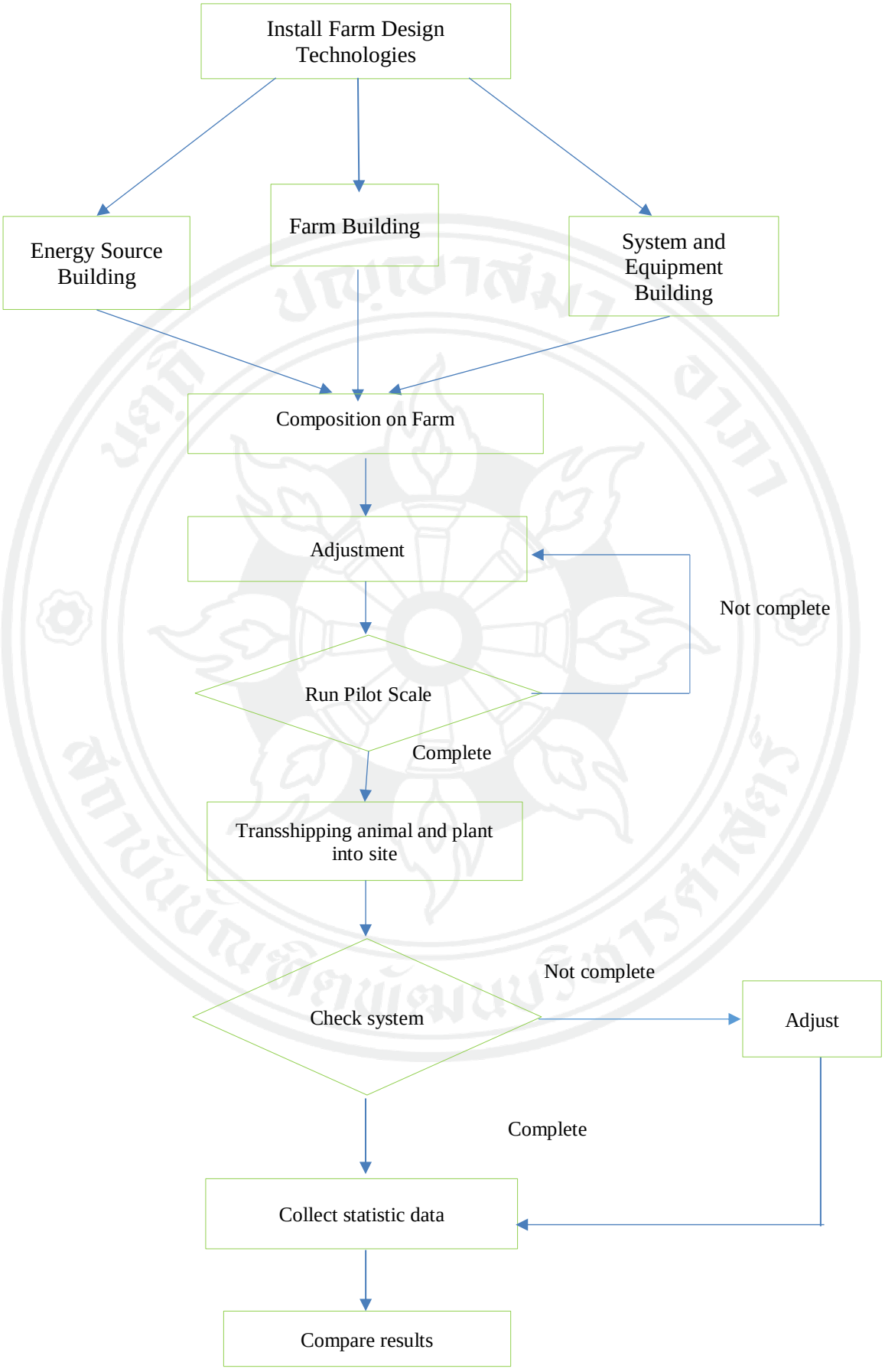
Moreover, impact was included in framework for the smart farming by adopting the philosophy of the sufficiency economy in this study analysis in order to understand effect's participant in the smart farming by adopting the philosophy of the sufficiency economy. The overview of the smart farming by adopting the philosophy of the sufficiency economy in this study analysis was shown in table 3.1

Table 3.1 The Research Methods to Analyze the Smart Farming by Adopting The Philosophy of The Sufficiency Economy

	Issues	**Tools**	**Participations**	**Data Analysis**
Input	To Design Knowledge and Technology	Semi-structured Interview	- Livestock and Agricultural Extension Officer - Livestock and Agricultural specialist - Livestock and Agricultural Extensionist	Descriptive Analysis
	Financial Analysis	- Break-even Point Analysis - NPV Analysis	-	- Break-even Point Analysis - NPV Analysis
process	Building	Materia Man Money	-	
output	The Smart Farm in This Study	- Observation - Semi-structured Interview	- Staff - Livestock and Agricultural Extension Officer - Livestock and Agricultural Specialist - Livestock and Agricultural Extensionist	- Flow Process Charts - Descriptive Analysis
	The Smart Farm in This Study Learning Center for Knowledge Dissemination	- Questionnaire - Semi-structured Interview	- Participants in the Project - Livestock and Agricultural Extension Officer - Livestock and Agricultural specialist - Livestock and Agricultural Extensionist	- Descriptive Statistics - Descriptive Analysis
	Quality of The Smart Farm's Products	Observation	- Catfish - Duck	Number and Weight of Fish and Duck
Impact	Awareness	- Questionnaire - Semi-structured Interview	- Participants in the Project	- Descriptive Statistics - Descriptive Analysis
	Environment	- Observation - Semi-structured Interview	Environmental Expert	Descriptive Analysis

3.1 The process of building and disseminating knowledge of the smart farming by adopting the philosophy of the sufficiency economy

The implementation of all part combined into a projects that will result in "the smart farming by adopting the philosophy of the sufficiency economy". The smart farming in this study can save cost, labor, and time, it is possible to raise more animals. With the limitation of space, animals can be raised in more numbers and less stress. This farm equipped with automatic duck feeder. The automatic door can be opened and closed automatically to expand space for duck walking. Automatic watering and drainage systems will drain water in trough to vegetable plot. Automatic feeding, aeration, and drainage systems of catfish pond also discharge water to vegetable plot. The size of vegetable plot depends on the quantity of water. This whole system are integrated to create zero waste in the farm. The process of building and disseminating knowledge of the smart farming in this study was shown in figure 3.1


Install Farm Design Technologies
Energy Source Building
Farm Building
System and Equipment Building
Composition on Farm
Adjustment
Not complete
Run Pilot Scale
Complete
Transshipping animal and plant into site
Not complete
Check system
Adjust
Complete
Collect statistic data
Compare results

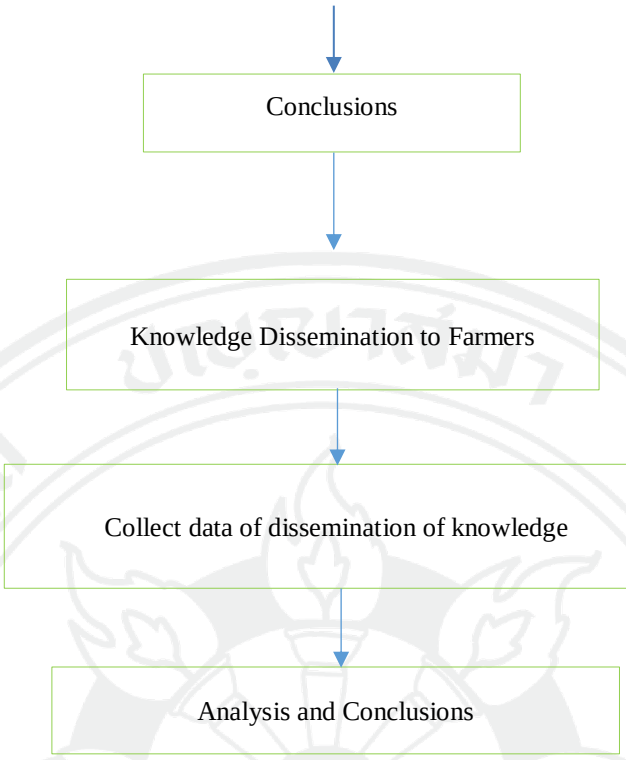


Figure 3.1 the Process of the Duck Farm System in Alignment with the Concept of the Smart Farming in This Study

From figure 3.1, the project provided the duck farm system by automatic controlling and using electricity from a solar cell in alignment with the smart farming by adopting the philosophy of the sufficiency economy as a learning center for community where farmers, interested parties, government and private organizations can learn from this learning center. This project also provides learning center to introduce knowledge and transferred this center as a source for further dissemination. In practically, when farmers learn and have knowledge, farmers can develop themselves as mentors to promote the learning in the form of farmer to farmer, then, successful projects are selected and support for extension and utilization by other communities.

3.2 Study Area

This study explores a case study of the automatic duck farm system in alignment with the concept of the smart farming by adopting the philosophy of the sufficiency economy in Latkrabang district. The following methodological approach answer this research by using a single case research design. In this research, the

automatic duck farm system by using electricity from a solar cell was selected to be a representative case in order to identify the smart farming by adopting the philosophy of the sufficiency economy for farmers.

3.3 This research applied mix methods to find the answers for each objective

3.3.1 To apply the concept of the smart farming by adopting the philosophy of the sufficiency economy in duck farm prototype.

3.3.1.1 Technology Need Assessment

Technology Need Assessment is a first method to access information for designing smart farm in this study. The objective of a technology needs assessment is to identify, evaluate and prioritize technological means for both mitigation and adaptation, in order to achieve sustainable development ends (United Nations Development Programme, 2010)

United Nations Development Programme (2010) suggested the key steps for conducting a technology needs assessment as follows:

Step 1 to concern the organizational and administrative process such as, their roles, responsibilities and work plan, including the involvement and participation of stakeholder groups required to implement a technology needs assessment.

Step 2 is related to identifying and deciding on development priorities.

Step 3 is associated with identifying and prioritizing (sub) sectors in terms of their contribution to mitigation and adaptation leading to sustainable development.

Step 4 to concerns identifying and prioritizing relevant technologies to achieve maximum development goals

Step 5 focuses on identifying activities that a country can undertake to accelerate the development and transfer of the technologies. These activities are characterized in terms of, e.g., resources required, timeline, risks, and required monitoring, reporting and verification activities. The activities provide input for the development of an overall technology strategy which either will be specific to the sector/ technology or will be common across sectors and technologies at the system or national level. The main outputs are a technology strategy and action plans to improve the whole system in the country concerned, including overcoming barriers in all parts of the system, as well as insight into the capacity needs in the country concerned for adoption of technologies

Firstly, the researcher has access to information in the agricultural community by interview. The interviewee were 20 household farmers. All participants were asked the main questions about “How was about work in agricultural sector?” It found that the farmer's working is relatively low profitable because there are no sufficient agricultural workers in the agricultural sector, therefore, lack of labor is one of the major obstacles in agriculture business. However, farmers commented that if they do agriculture business by themselves and

they can gain income enough to take care their families according to personal interview, they will not change their occupation to others. The researcher proposed the concept of a small smart farm with less labor, time and fund by using simplified technology to help and support. The team exchanged knowledge with the community and finally concluded that it should be done in "The smart farming by adopting the philosophy of the sufficiency economy in duck farm prototype".

From doing literature review, it could indicate that agriculture is the primary economic sector of Thailand. Therefore, agricultural sector in Thailand need technology to automate farm in order to increase efficiency. When the researcher access information from agricultural household-based farming by interviewing 20 household farmers, it found that a traditional farming requires lot of labors. Automation can proficiently moderate the amount of manual labor, and make farming easier and faster, leading to more agricultural growth. The smart farming by adopting the philosophy of the sufficiency economy are automated, which included auto-irrigation cycles, secure temperature controlled enclosures for livestock and farm products, and auto-feeding.

According to Community Organizations Development Institute (2015) reported land acquisition from the document of right issuing throughout Thailand that people have right of land holding less than 1 rai, accounting for 50.64% of the total. The research considered possibility of land tenure that most people are able to be own. Therefore, the smart farming by adopting the philosophy of the sufficiency economy in duck farm prototype was designed for 320 square meters (around 1 rai).

To develop technology need assessment of duck farm in alignment with the concept of the smart farming by adopting the philosophy of the sufficiency economy is measured by analyzing input about knowledge and technology design for the automatic duck farm system in alignment with the smart farming by adopting the philosophy of the sufficiency economy. Knowledge and technology was designed by considering on possibility of using technology, financial analysis, and proper knowledge. Generally, a traditional farming requires a lot of labor in agricultural household-based farming. Automation can proficiently moderate the amount of manual labor, and make farming easier and faster, leading to more agricultural growth. Therefore, the main idea of smart farming in this study is automatic system, which include auto-irrigation cycles, secure temperature controlled enclosures for livestock and farm products, and auto-feeding.

Experts' comment for farm and equipment design was indicated suitability of the smart farm. The participants in the interview process were conducted in this research who are specialize in livestock and agriculture. Therefore, the interviewees were a livestock and an agricultural specialist, a duck farmer, and a vegetable farmer. The semi-structure interview method was applied. During the interview process, the farm layout and equipment design of the smart farming in this study was showed and interviewees were asked how they thought about the design of the automatic duck farm in alignment with the concept of the smart farming by adopting the philosophy of the sufficiency economy. The interviewees indicated that

this was suitable for knowledge dissemination to farmer and worth investment. Interviewees suggested about plant which it should be vegetable because it is easy to sale. Otherwise, farmer should survey what are kind of vegetables needed for market. After the researcher obtains the affordable, and practical technologies from the experts, then the duck farm is designed in corporate with those technologies. After the researcher obtains the affordable, and practical technologies from the experts, then the duck farm was designed in corporate with these technologies.

3.3.1.2 Farm and Equipment Design

The overall area of the smart farm in this study is 320 square meters. For current agricultural alternatives, less land can make the land more efficient and productive. The smart farm in this study was designed by considering on maximize benefit for animal and environment in limited area. The smart farm in this study consists of 8 parts, as follows:

Part 1: Build an 8 meter x 6 meter farm to create a semi-open duck farm.
Part 2: Automatic duck feeder
Part 3: Automatic watering and drainage system.
Part 4: Automatic temperature and humidity control system
Part 5: Automatic open-close door system
Part 6: Power supply system by solar cell
Part 7: Automatic feeding, aeration, and drainage systems of catfish ponds
Overall, the design of duck farm management was shown in figure 3.2

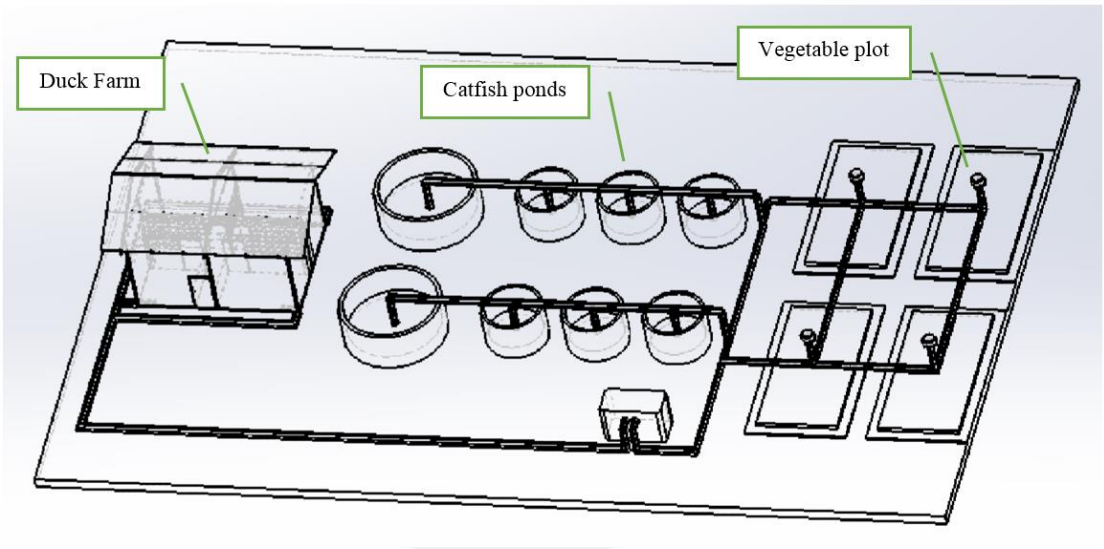


Figure 3.2 Overall of the Smart Farm in This Study

Part 1: Build an 8 meters x 6 meters farm to create a semi-open duck farm.

The duck farm area is divided into four sections (as shown in figure 3.3), three sections for breeder ducks. To divide area appropriately for duck living is good for breeding because there are not problem of male duck to fight each other to breed with female duck that it makes injury rate of male duck decrease. According to Mason (2003) advised that farm area should be subdivided to apply appropriate land care practices to sustain the condition of the land. Thus, the reasons of division duck farm

area were checking breeding ducks rate, breeding, breeders' lifespan, duck feeding rate, duck eggs rate. Another part was used for raising baby ducks that they had just out of eggs until one month year old. When baby ducks reach the age of one month, they will be moved from nursery section to the first generation ducks section.

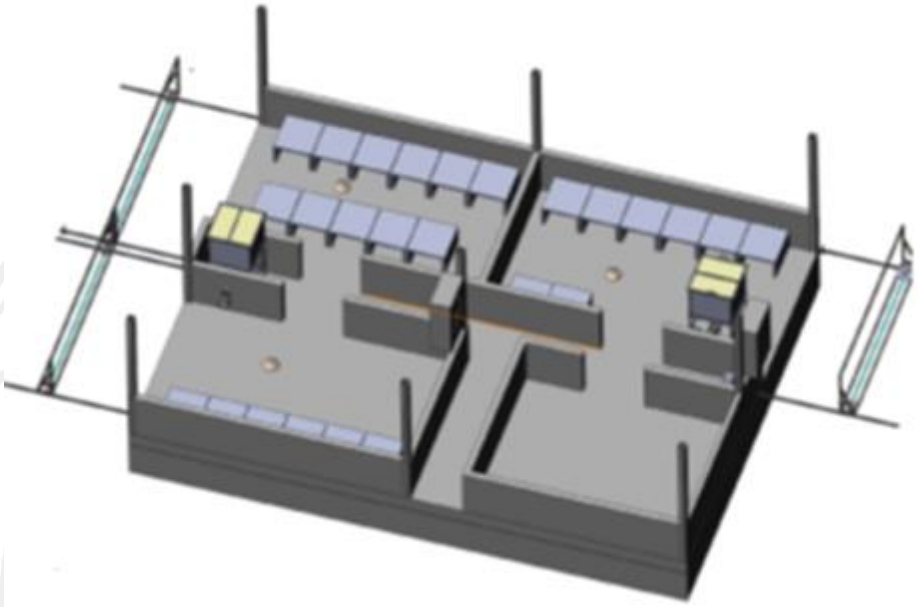


Figure 3.3 the Four Sections of Breeder Ducks and Baby Ducks

Part 2: Automatic duck feeder

Automatic duck feeder was design in 2 types. Type 1 was one way automatic duck feeder machines and type 2 is two way automatic duck feeder machines (as shown in figure 3.4 and 3.5). These design depend on location of setting in farm. The distributing systems consists of a screw set driven by the motor and also gears. The ends of each feeding line are food drive shaft that controls motors on and have to achieve automatic feeds delivery. Automatic duck feeders were set up feeding times as well as the amount of food. It ensures that ducks receive the proper amount of food at regular intervals, reducing wasted food and the duck feeder ventilates the food at precisely the correct doing time at 6.00 am and 6.00 pm.

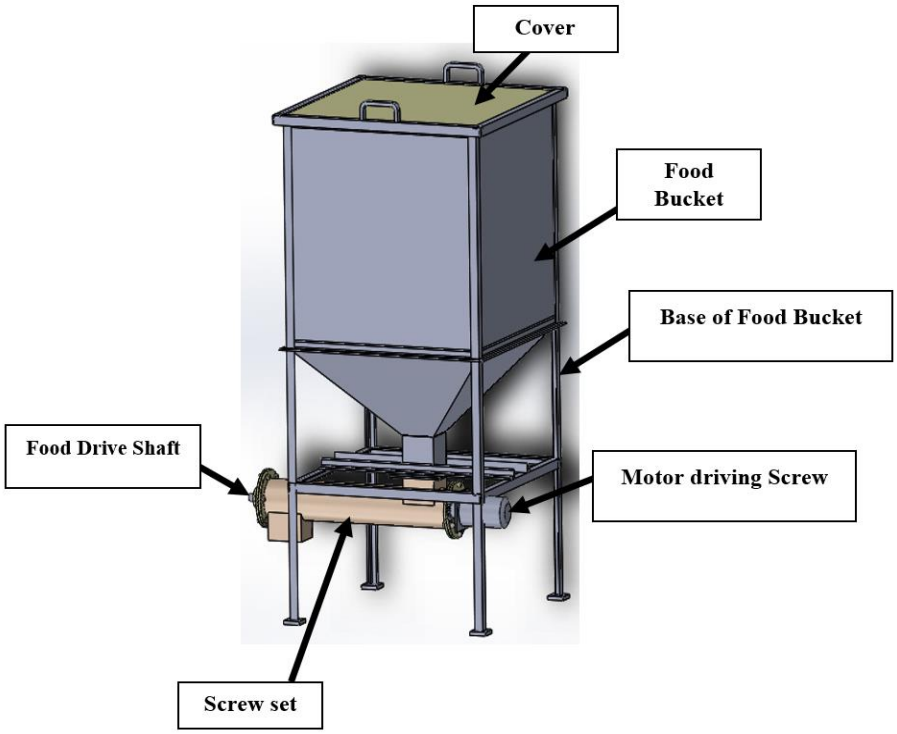


Figure 3.4 One Way Automatic Duck Feeder Machine

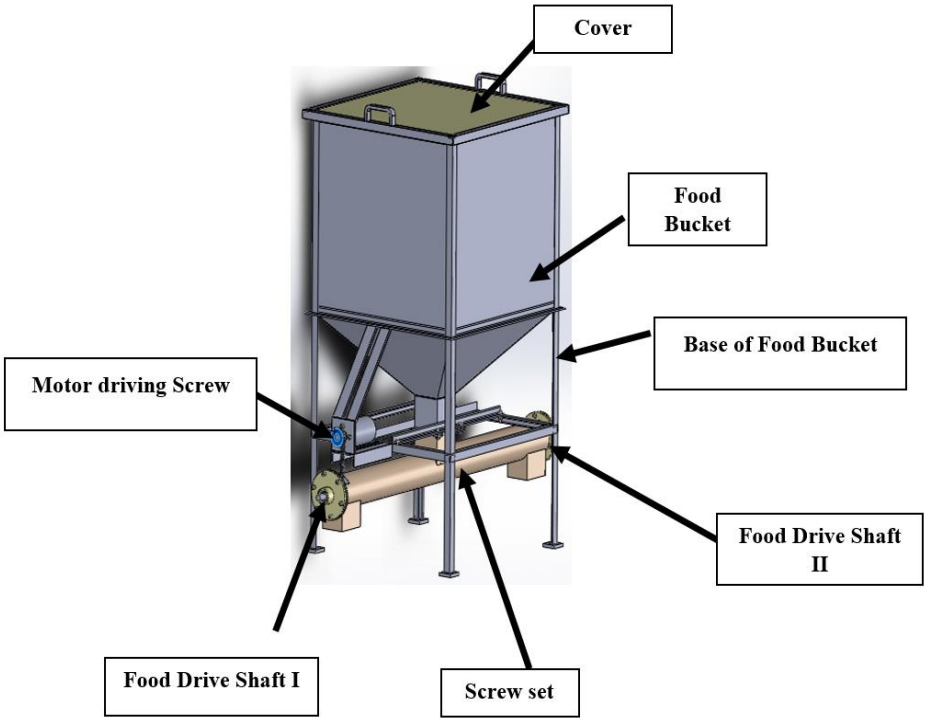


Figure 3.5 Two Way Automatic Duck Feeder Machine

Testing result of automatic duck feeder was measured by collecting data of the amount of food from automatic duck feeder machine as follows:

(1) The gravity of machine also take in consideration when it fill with full tank of pellets.

(2) This experiment will started with 1 second to 5 seconds of the one-way feeding of automatic duck feeder and 5 seconds to 25 seconds of the two-way feeding of automatic duck feeder.

(3) Then, recording the amount of food pellets taken until the food has drop all completely of the quantity pellets. The experiment is repeated with different 5 times period.

(4) The data of quantity pellets was collected to analyses the stable feeding and set the suitable time for feeding duck.

Part 3: Automatic watering and drainage system

The design of watering and drainage trough consist of inlet and outlet pipes for water flowing, water injection pipe to remove the waste out water trough. Float balls were installed to maintain the water level in the water trough. The design of watering and drainage trough was shown in figure 3.6.

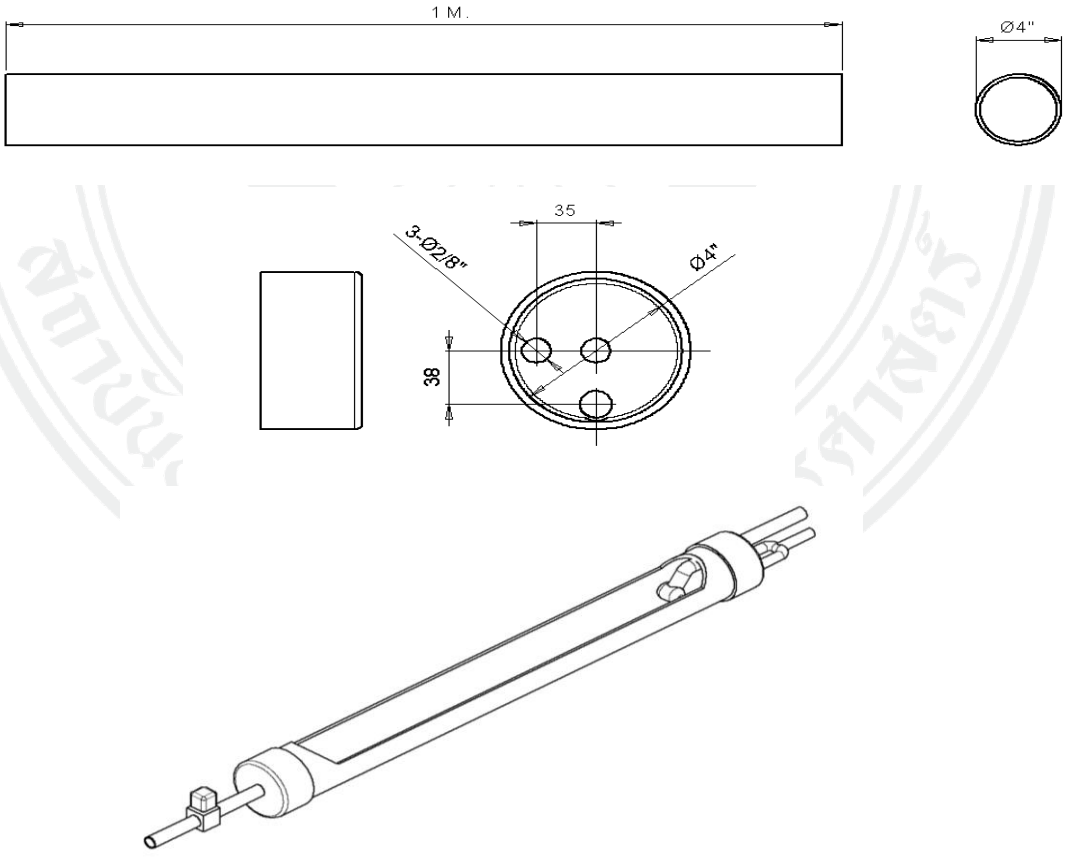


Figure 3.6 the Design of the Watering and Drainage Trough

When the first timer runs the motor water valves open, the water in the troughs run out for 30 seconds. After that, the second timer runs the pump, water injection pipe

will work for removing waste out of water trough for 8 seconds. then, the power is cut off by the second timer that make the water pump stops working and the first timer runs the motor water valves close. At the same time, the float balls that maintain the water level in the troughs falls to a minimum level that make the floating water valve opens, then, water is added to the troughs until water reaches the set level, then the valve is closed.

Drainage and injection clean the troughs once time per a day at 5.00 pm. Automatic watering and drainage system can drained 15 liters of water that it will drain water from trough to vegetable plot.

Testing Result of automatic watering and drainage system was measured as follows:

(1) The pH of water for consuming is between 6.5-8.5 (Pollution Control Department, 2009)

(2) The standard value of water was measured as acidity- alkalinity by using the multi-parameter portable field instrument which can measure pH, temperature, dissolved oxygen, turbidity, conductivity, and salinity in water.

(3) The multi-parameter portable field instrument is designed with pH measurement by removing the pH electrode soaker bottle on the electrode before use as follows;

Step 1: Rinse the probe with de-ionized or distilled water before use in order to remove any impurities adhering on the probe. If the electrode is dehydrated, soak it for 30 minutes in KCI solution before taking the reading

Step 2: Press power on key

Step 3: Dip the electrode into the sample, the electrode into the sample, the electrode must be completely immersed into the sample. Stir the probe gently to create a homogenous sample and shorten the stabilizing time.

Step 4: Wait until the reading is stabilized.

(3) The troughs were collect data about pH every day in one month at 8 o'clock.

Part 4: Automatic temperature and humidity control system

This automatic temperature and humidity control system can cool and dry farm generating electronic devices by operating fans and lights when the temperature and humidity increase and decrease above the preset level. Its operation is fully automatic and turns off when the temperature returns normal. The position of fans and lights setting was shown in figure 3.7

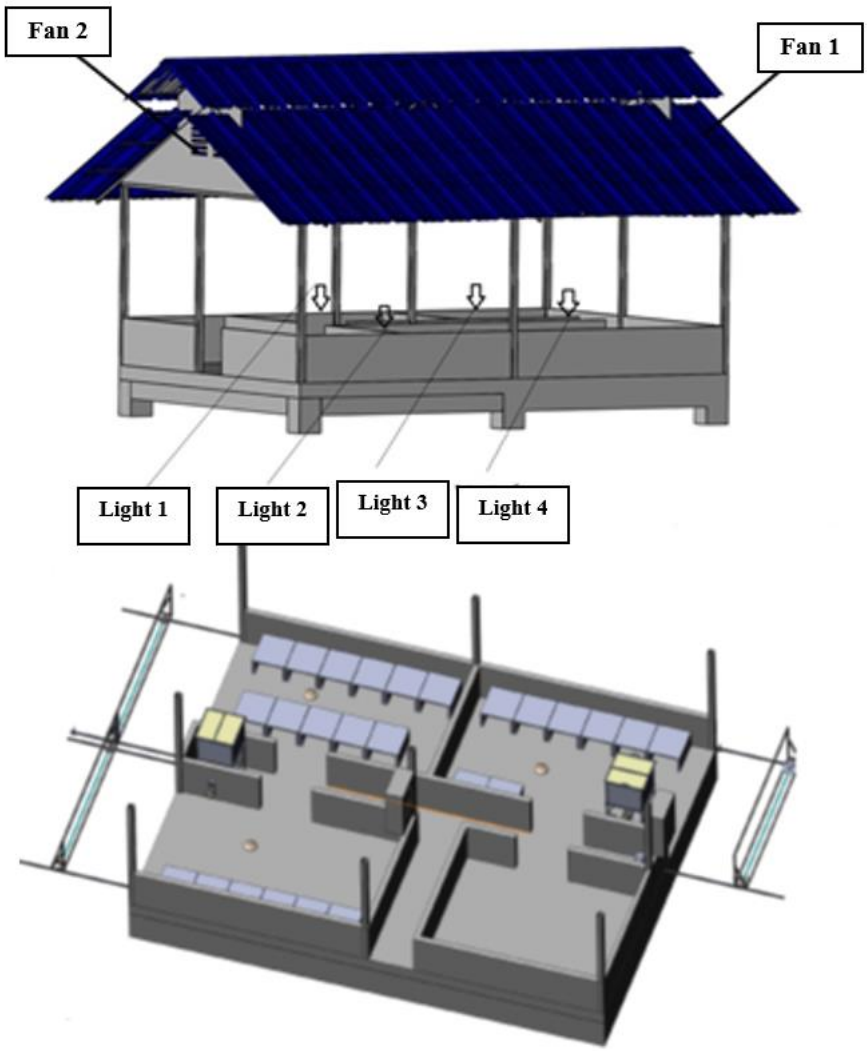


Figure 3.7 the Position of Fans and Lights Were Set In the Duck Farm

The temperature at 35-23 ºC is the suitable for adult duck while baby duck need temperature at 35-26 ºC (Department of Agricultural Extension, 2015). The relative humidity in duck farm should be around 65-75% (Department of Agricultural Extension, 2015). Controlled environment farm (temperature and humidity) are required for efficient production and high-quality of duck living. This farm uses equipment for automatic temperature and humidity control system to maintain the temperature and humidity at the required levels.

For adult ducks, when temperature is above 35 ºC and humidity is above 70 %, the fan will work automatically to make temperature in farm returns normal. When temperature is below 23 ºC, the lights will be on to make temperature in farm is warmer.

For baby ducks, when temperature is above 35 ºC and humidity is above 70 %, the fan will work automatically to make temperature in farm returns normal. When

temperature is below 26 ºC, the lights will be on to make temperature in farm is warmer.

The flowchart of fans and lights working process of automatic temperature and humidity control system was shown in figures 3.8 and 3.9

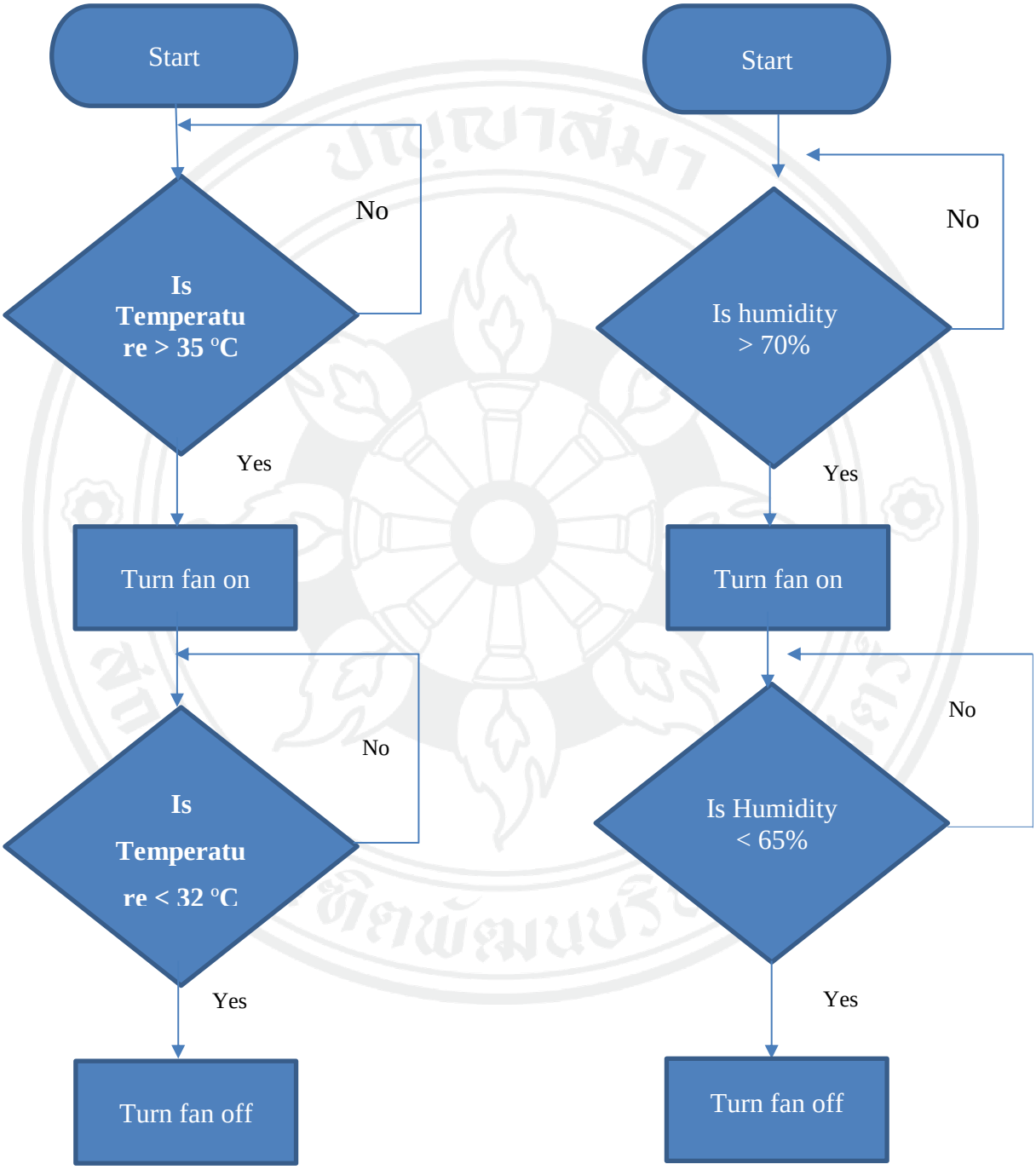


Figure 3.8 the Fans Working Process of Automatic Temperature and Humidity Control System

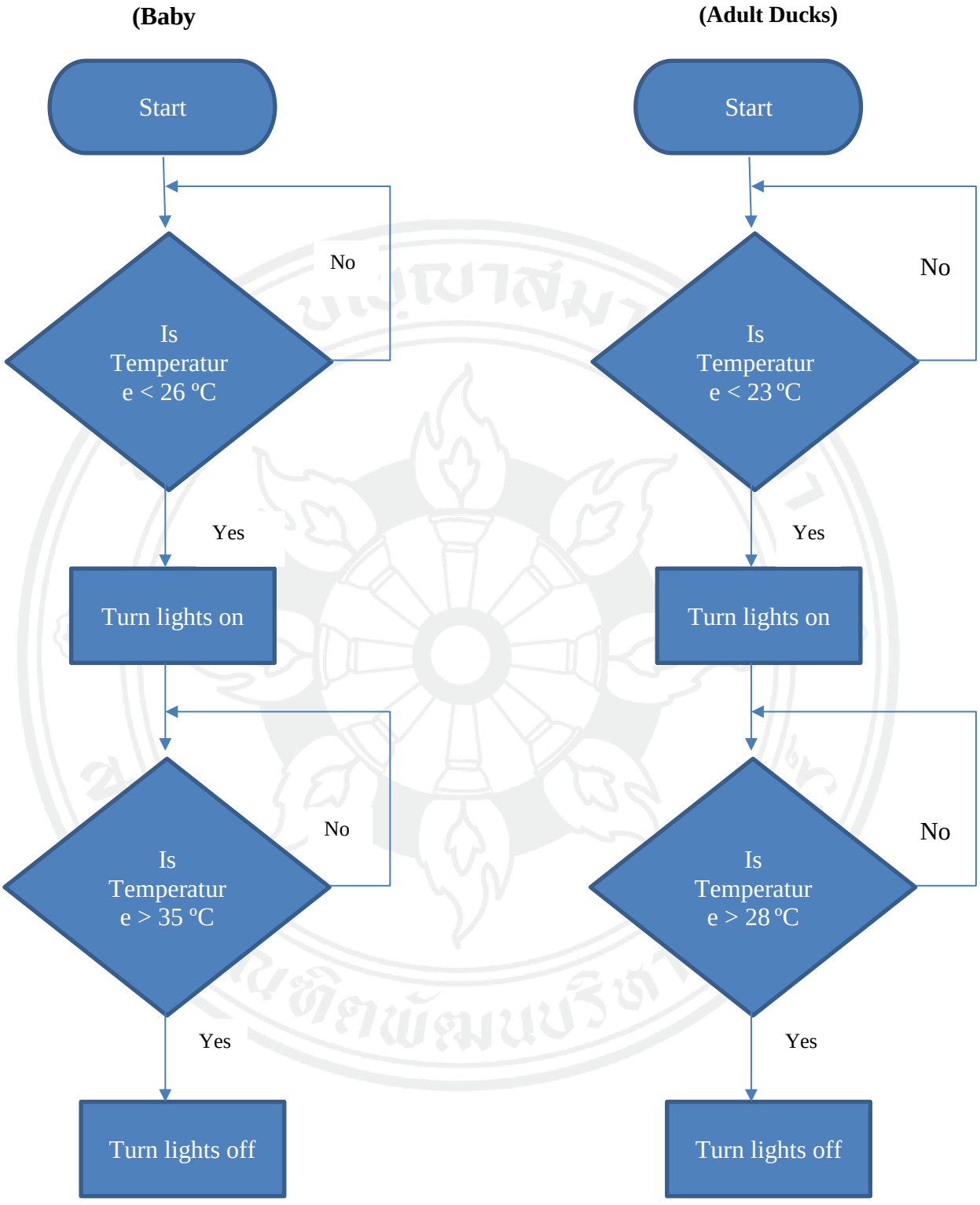


Figure 3.9 the Lights Working Process of Automatic Temperature and Humidity Control System for Adult and Baby Ducks

Using thermometer as follows;

(1) The thermometers were installed in the farm, at the fan, and at the warm bulb.

(2) The thermometer showed temperature in the farm that match the set temperature in order to indicate turning on and off of automatic temperature and humidity control system.

(3) The temperature in the smart farm was measured three times per day, 8.00 am, 1.00 pm, and 6.00 pm in a month. The data was analyzed as mean.

(4) The accuracy of thermometer is $\pm$1% of error.

Part 5: Automatic open-close door system

Automatic open-close door system was designed considering increase the area of ducks which make ducks' living is better by reducing stress in ducks. The automatic door open at 6.00 am and close at 6 pm. Automatic open-close door design was shown in figure 3.10

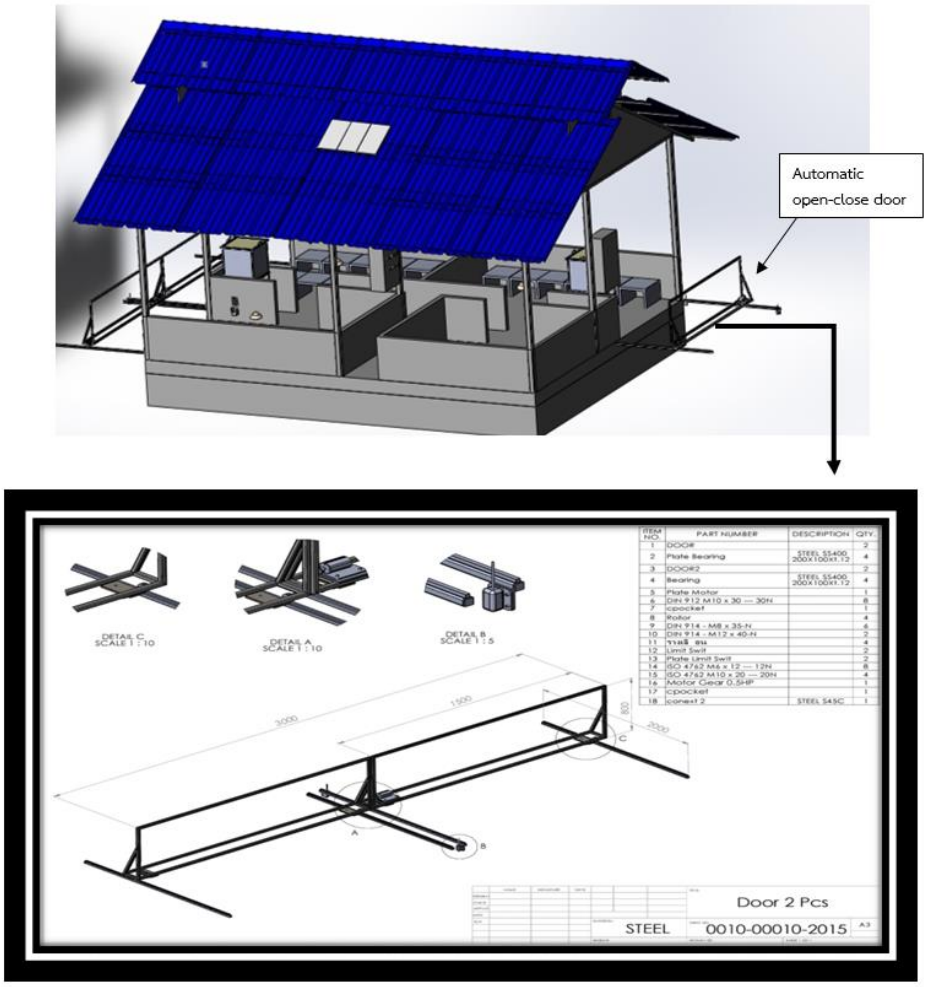


Figure 3.10 Automatic Open-Close Door Design

Part 6: Power supply system by solar cell

Most of the farms are located in outdoor area which solar energy should be used to maximize the value and benefit from nature. Thus, this duck farm used solar power which was the conversion of energy from sunlight into electricity to manage the automatic farming system.

The roof is the best location for solar panel installation. The solar panels generated DC electricity directly from sunlight. The inverter converts the DC electricity produced by the solar panels into AC electricity to be usable in the duck farm. The solar panels installation were shown in figure 3.11.

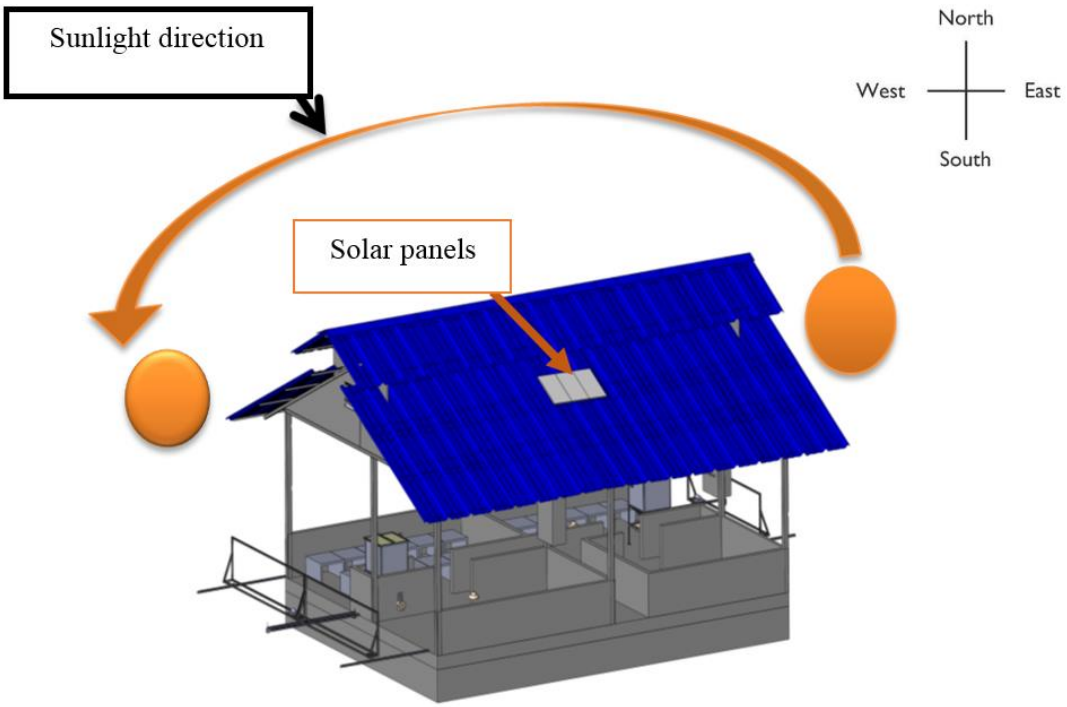


Figure 3.11 the Solar Panels Installation

Table 3.2 Calculating solar cells with equipment in the duck farm Size of solar panel = Energy using per day/ 5 hours(the amount of sunlight in a day, expectedly)

Equipment	**watt (W)**	**number (N)**	**hours (h)**	**Energy using per day WNh (Wh)**	**Size of solar panel $\frac{WNh}{5}$ (W)**
Warm light bulb	40	2	12	960	192
Light bulb	5	5	13	325	65
Automatic duck feeder 1	60	1	$1.11x10^{-3}$	0.0666	0.0133
Automatic duck feeder 2	60	1	$6.944x\ x10^{-3}$	0.416	0.0833
Gate motor 1	60	1	$7.77x\ x10^{-3}$	0.4662	0.09324
Gate motor 2	60	1	$4.16x\ x10^{-3}$	0.2496	0.04992
Water pump	200	1	0.25	50	10
Solenoid Valve	3	3	0.0207	0.186	0.03726
Automatic fish feeder	30	1	$1.11x10^{-3}$	0.0333	$7.3926x10^{-3}$
total	-	15		1336.417	267.28

From table 3.2, the total size of solar cell is 267.28 w, therefore, solar panel should be 330 w to ensure electricity using in the duck farm adequately. The size of solar cells and batteries should be increased to allow for the provision of spare power. The supply tools that control and convert the DC electricity produced by the solar panels into AC electricity to be usable in the duck farm are 1,100 watts inverter, 10 amps charge Controller, and 2 batteries of 12 volts, 135 Ah.

Part 7: Automatic feeding, aeration, and drainage systems of fish pond

The design of automatic feeding, aeration, and drainage systems of fishing pond was shown in figure 3.12.

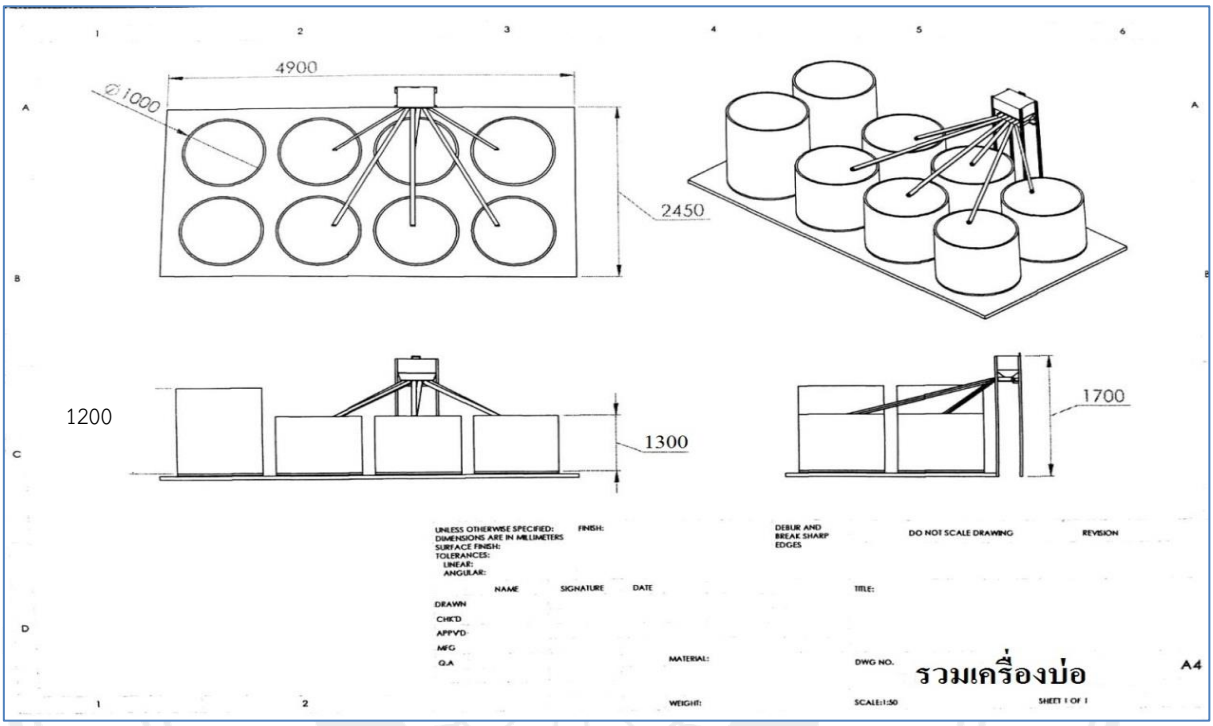


Figure 3.12 the Design of Automatic Feeding, Aeration, and Drainage Systems of Fishing Pond

From figure 3.12, two storage ponds were used to prepare water for six ponds for fishing. Automatic fish feeders will feed 2 times per a day at 7.00 am and 5.00 pm. The automatic drainage systems of fish pond will be drained 2 times per day at 8.00 am and 4.00 pm. The amount of drainage is 3/5 of the water in a pond. The amount of water drainage is 470 liters/ pond and total of six ponds are 2820 liters. The automatic drainage systems will discharge water by each pond around 5 minutes per pond. The automatic aeration operated 30 minutes, 2 times a day, at 12.00 am and 12.00 pm.

Testing result of automatic feeding, aeration, and drainage systems of fishing pond was measured by collecting data of food quantity from feeding catfish machine, the oxygen dissolved in water, and temperature in water as follows;

(1) Temperature of water in catfish ponds were measured by the multi-parameter portable field instrument. This meter is designed with an automatic temperature compensation feature. The probe was dipped into the sample and wait until the reading is stabilized. The temperature of water was collected from 6 ponds every day in 6 weeks. The data was analyzed as mean in order to compare with standard value of water.

(2) Oxygen dissolved of water in catfish ponds were also measured by the multi-parameter portable field instrument by following steps;

Step1: To remove the DO electrode protective cap on the electrode before use

Step2: Press the power on key that it might take a few minute to about 1 hour for the meter to have a stable D.O. reading in the air. The D.O. will be displayed on LCD with mg/l unit.

Step 3: The probe was dipped into the sample and making sure the electrode tips is totally immersed when you stir it, then wait until the reading is stabilized.

(3) The gravity of machine also take in consideration when it fill with full tank of pellets.

(4) This experiment will started with 1 second to 60 seconds of the feeding of automatic fish feeder.

(5) Then, recording the amount of food pellets taken until the food has drop all completely of the quantity pellets. The experiment is repeated with different 5 trial.

(6) The data of quantity pellets was collected to analyses the stable feeding and set the suitable time for feeding catfish that it depends on weight of catfish.

3.3.1.3 Working Process Evaluation

After system and technologies of the smart farming by adopting the philosophy of the sufficiency economy installed completely, the staff will be observed for farm working process by Flow Process Chart. Flow Process chart shows any particular movement of the operated process with symbols which determine by The American Society of Mechanical Engineers (ASME) as shown in figure 3.13.

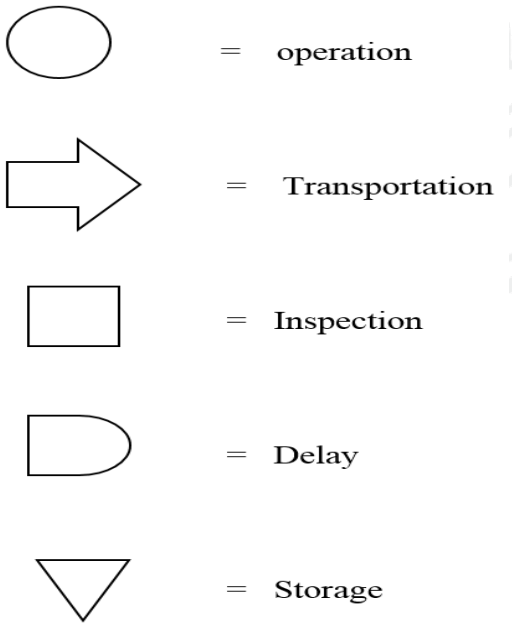


Figure 3.13 the Five Standard Symbols of Flow Process Chart Analysis by ASME

In this study, working process of the smart farming by adopting the philosophy of the sufficiency economy was described by Flow Process Chart in order to compare working time between the work processes in traditional farm and the smart farming by adopting the philosophy of the sufficiency economy.

3.3.1.4 Financial Analysis

After operating the farm for 2 month, number and weight of fish and duck is indicators for analyzing quality production of the smart farming by adopting the philosophy of the sufficiency economy's products. Environment in the smart farm was analyses by observation and semi-structured interview from experts in environment. Break-even point, payback period and NPV analysis was used for financial analysis. The three scenarios of selling productivity in the smart of this study were explained and compared the net benefit.

3.3.2 To distribute the knowledge or experiences from the practice of the smart farming by adopting the philosophy of the sufficiency economy in the community

3.3.2.1 Creating a "learning center" for the smart farming by adopting the philosophy of the sufficiency economy in Thailand

The smart farming by adopting the philosophy of the sufficiency economy learning center was created to provide a study visit and living classroom for participants to learn about smart duck farming. Current programming provides participants with skills in duck farming and technology for smart farm. Resources are also available for participants who are interested in this program. The staff of the learning center welcomes and is ready to respond to participants needs.

The program for this learning center was to educate participants about duck farming and technology for smart farm in the classroom and the participants visit the smart farm in the first and second day. The participants learned about farm equipment and technology, including automatic system, control system, and land management. Financial analysis of the smart farm was explained to consider on a worthwhile return on investment.

In the third day, the participants visit the smart farm by adopting the philosophy of the sufficiency economy learning center again to learn how participants' skills and knowledge can be applied in a variety of work environments. The mentor taught participants by providing educational smart duck farming on-location at the smart farming learning center. The detail of training program was showed in table 3.3.

Table 3.3 the Training Program of the Smart Farming by Adopting the Philosophy of the Sufficiency Economy Learning Center

Days	Training Method	Content	Hours
1st	Visit	- The participants were lead to visit the smart farm. - The mentor described story and inspiration of doing the smart farm. - Financial analysis of the smart farm	3 hrs.
	Lecture, Demonstration, and Practice	Operation of automatic feeder and watering for duck raising.	3 hrs.
2nd	Lecture, Demonstration, and Practice	- Operation of automatic feeding, aeration, and drainage systems of catfish pond. - Operation of automatic temperature and humidity control system.	6 hrs.
3rd	Lecture, Demonstration, and Practice	- Operation of automatic open-close door system - Operation of power supply system by solar cell	3 hrs.
	Group discussion	Question and Answer	3 hrs.
	Visit	Overall of the smart farm	3 hrs.

3.3.2.2 Data Collection

The smart farming by adopting the philosophy of the sufficiency economy learning center for knowledge dissemination is measured by the 30 participants' opinion and awareness in this study after finishing program of learning center in this study. Semi-structured interview and questionnaire are tools for collecting information from the participants. The information of participants' opinion was analyzed by descriptive statistics and content analysis method. The finding will answer effect of distribution the knowledge or experiences from the practice of the smart farming by adopting the philosophy of the sufficiency economy in the community.

3.3.2.3 Data Analysis

Quantitative analysis from questionnaire that ask about the participants' opinion and awareness in this study are measured by 4 point scales. The adjective is strongly agree, agree, disagree, and strongly disagree where 4 means strongly agree with the statement, and 1 means strongly agree with the statement.

Focus group averaged 30 minutes in length. During the interview process, permissions for tape-recording the interviews were asked for. In addition, in terms of ethical concerns, the interviewer clearly explained the aims of this research at the beginning of the in-depth interview process. Another important concern in the interviews was that the respondents were not compelled to answer the questions if they felt uncomfortable and also the personal information of respondents was to be kept confidential.

3.3.3 To provide policy recommend for government to support a more sustainable, practical, and suitable practices of smart farming 4.0

Evidences and findings from 3.3.1 and 3.3.2 was obtained policy-relevant data in order to create policy recommendation for government to support a more sustainable, practical, and suitable practices of smart farming 4.0.

CHAPTER 4

ANALYZING AND REPORTING TEST RESULTS

This chapter focuses on how data from operational tests of automatic machines and systems in the smart farming by adopting the philosophy of the sufficiency economy. In this chapter reports the analysis of operational test data. The vast majority focused on calculating means and percentages of measures of effectiveness and performance to compare aggregate means and percentages with target values derived from operational requirements or the performance of baseline systems.

4.1 Testing Result of Automatic Duck Feeder

Table 4.1 Experimental Results Showed That the Amount of Food from One Way Automatic Duck Feeder Machine

Time (second)	The amount of food (kg)					Mean	SD
	Trial						
	1	2	3	4	5		
1	0.32	0.31	0.39	0.35	0.39	0.35	0.03
2	0.43	0.42	0.47	0.47	0.45	0.45	0.02
3	0.52	0.52	0.59	0.55	0.56	0.55	0.03
4	0.64	0.69	0.56	0.65	0.65	0.64	0.04

From table 4.1, experimental results on the amount of feed which released from the one-way feeding of automatic duck feeder indicated that the feeder is stable and feed efficiently.

Table 4.2 the Amount of Food from Two Way Automatic Duck Feeder Machine

Time (second)	The amount of food from side 1 (kg)					Mean	SD	The amount of food from side 2 (kg)					Mean	SD
	Trial							**Trial**						
	1	2	3	4	5			1	2	3	4	5		
5	0.26	0.27	0.28	0.30	0.25	0.27	0.02	0.26	0.26	0.24	0.25	0.29	0.26	0.02
10	0.50	0.46	0.52	0.55	0.58	0.52	0.05	0.52	0.46	0.54	0.55	0.57	0.53	0.04
15	0.75	0.68	0.71	0.71	0.73	0.72	0.03	0.77	0.70	0.72	0.71	0.72	0.72	0.03
20	0.97	0.94	0.99	0.96	0.96	0.96	0.02	0.98	0.98	0.93	0.95	0.97	0.96	0.02
25	1.26	1.28	1.27	1.27	1.25	1.27	0.01	1.28	1.25	1.28	1.25	1.27	1.27	0.02

From table 4.2, experimental results on the amount of feed which released from the two-way feeding of automatic duck feeder indicated that the feeder is stable and feed efficiently.

4.2 Testing Result of Automatic Watering and Drainage System

In this study, the investigators collected information on automatic watering and drainage system. The pH value is indicated the acidity and alkalinity of the water.

Table 4.3 The pH of the Water for Consuming (Source: Pollution Control Department, 2009)

Parameter	Unit	pH
Acidity- Alkalinity	mg/L	6.5 - 8.5

Table 4.4 Water Acidity Data

Day	Trough 1	Trough 2	Trough 3	Day	Trough 1	Trough 2	Trough 3
	pH	pH	pH		pH	pH	pH
1	9.5	5.5	5.3	17	8.9	8.9	5.3
2	5.5	5.3	4.5	18	8.9	6.2	6.2
3	6.2	5.3	4.5	19	6.2	5.3	6.2
4	5.5	5.5	9.5	20	5.3	6.2	8.9
5	9.5	5.3	8.9	21	6.6	8.5	7.5
6	5.3	8.9	5.3	22	7.5	6.6	7.5
7	5.3	5.5	6.2	23	8.5	8.5	8.5
8	5.3	6.2	8.9	24	7.5	6.5	6.6
9	8.9	8.9	6.2	25	8.5	8.5	7.5
10	6.2	5.3	8.9	26	6.6	6.6	6.6
11	5.5	6.2	8.9	27	6.6	8.5	8.5
12	5.5	5.3	5.3	28	8.5	6.6	6.5
13	5.3	5.3	5.3	29	7.5	6.6	7.5
14	6.2	5.3	5.3	30	6.6	7.5	8.5
15	5.5	8.9	5.3	31	8.5	8.5	6.6
16	5.3	5.3	5.3				

Table 4.5 Quantities of Waste in Troughs

Days	Quantities of Waste in Trough 1		Quantities of Waste in Trough 2		Quantities of Waste in Trough 3	
	Before (g)	**After (g)**	**Before (g)**	**After (g)**	**Before (g)**	**After (g)**
1	300	35	350	40	300	40
2	300	41	400	38	300	44
3	350	40	350	45	400	32
4	300	44	300	40	300	40
5	350	33	320	40	370	40
6	323	45	360	39	360	40
7	400	40	325	38	340	40
8	321	40	400	42	350	40
9	325	38	390	38	341	40
10	369	44	300	32	400	40
11	350	10	322	9	345	11
12	400	8	300	10	300	10
13	350	11	350	10	300	10
14	310	10	400	13	400	10
15	335	10	300	10	300	10
16	300	7	300	10	300	10
17	350	10	350	11	300	8
18	325	10	325	10	300	10
19	300	10	300	10	300	10
20	312	10	364	12	300	10
21	300	0	400	0	425	0
22	350	0	300	0	300	0
23	441	0	335	0	300	0
24	300	0	300	0	320	0
25	400	0	450	0	450	0
26	300	0	322	0	330	0
27	300	0	421	0	300	0
28	300	0	332	0	350	0
29	400	0	400	0	353	0
30	332	0	300	0	300	0
31	300	0	300	0	300	0

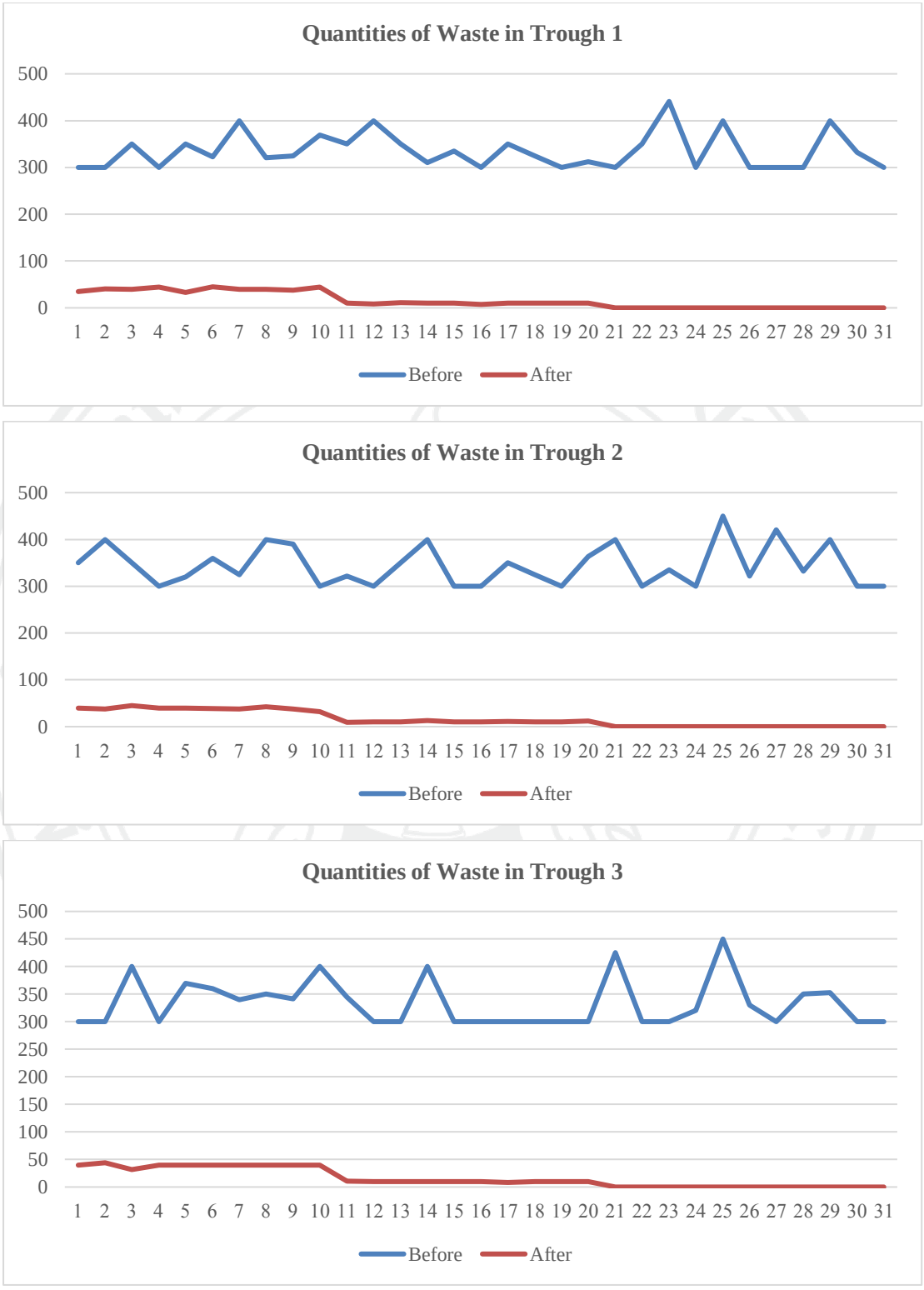


Figure 4.1 Comparison of quantities of waste in trough 1, 2, and 3

Table 4.4, 4.5 and figure 4.1 showed that quantities of waste in troughs were removed by water injection pipe. Data was collected by weighing the amount of waste (g) every day in a month. The process of water injection pipe improvement was as follows:

(1) During day 1-10, the small pipes were used for water injection to clean the trough. It made water dispersed. There were also waste scraps in the troughs.

(2) During the day 12-20, the small pipes were removed and then put water-injection pipe on both sides of trough. Watering and drainage trough worked more effectively but there is still a little waste left. Therefore, the standard value of water was measured as acidity- alkalinity that did not meet the water consumption criteria.

(3) During 21-31, the direction of the injection pipe was adjusted by making the water injection head is smaller in order to increase water pressure. The troughs could be cleaned effectively. Thus, during the day 21-31, troughs were cleaned that it made the standard value of water meets water consumption criteria.

4.3 Testing Results for Automatic Temperature Control System by Using the Warm Bulb

Table 4.6 Temperature of Automatic Temperature Control System for Adult Ducks

Days	Temperature measured setting control (°C)	Temperature measured in the farm (°C)	Temperature measured from 40W warm bulb (°C)	Error from sensor (%)
1	28°C	25°C	28°C	1%
2	28°C	24°C	27°C	1%
3	28°C	24°C	27°C	1%
4	28°C	25°C	28°C	1%
5	28°C	26.7°C	28°C	1%
6	28°C	26°C	28°C	1%
7	28°C	27°C	28°C	1%
8	28°C	27.2°C	28°C	1%
9	28°C	27.8°C	28°C	1%
10	28°C	26°C	28°C	1%
11	28°C	26.8°C	28°C	1%
12	28°C	27.1°C	28°C	1%
13	28°C	27°C	28°C	1%
14	28°C	26.2°C	28°C	1%
15	28°C	27°C	28°C	1%
16	28°C	27.5°C	28°C	1%
17	28°C	27.2°C	28°C	1%
18	28°C	27.7°C	28°C	1%
19	28°C	27.8°C	28°C	1%
20	28°C	28.1°C	N/A	1%
21	28°C	27.6°C	28°C	1%

Days	Temperature measured setting control (°C)	Temperature measured in the farm (°C)	Temperature measured from 40W warm bulb (°C)	Error from sensor (%)
22	28°C	27.4°C	28°C	1%
23	28°C	27.8°C	28°C	1%
24	28°C	27.3°C	28°C	1%
25	28°C	27.7°C	28°C	1%
26	28°C	25.7°C	27°C	1%
27	28°C	26.1°C	28°C	1%
28	28°C	26.5°C	28°C	1%
29	28°C	26.6°C	28°C	1%
30	28°C	27.1°C	28°C	1%
31	28°C	27.4°C	28°C	1%

From table 4.6, the temperature set control is between 35˚C - 23˚C. The test results of the temperature control system by using a 40 watt tube heat in 1-31 days indicated that warm bulb can increase the temperature to the desired temperature.

Table 4.7 Temperature of Automatic Temperature Control System for Baby Ducks

Days	Temperature measured setting control (°C)	Temperature measured in the farm (°C)	Temperature measured from 40W warm bulb (°C)	Error from sensor (%)
1	35°C	26.4°C	34.1°C	1%
2	35°C	27°C	34°C	1%
3	35°C	27°C	34.5°C	1%
4	35°C	28°C	34.9°C	1%
5	35°C	28.2°C	35°C	1%
6	35°C	27°C	34.2°C	1%
7	35°C	27.8°C	35°C	1%
8	35°C	27.9°C	35°C	1%
9	35°C	28°C	35°C	1%
10	35°C	28°C	35°C	1%
11	35°C	28.7°C	35°C	1%
12	35°C	28.7°C	35°C	1%
13	35°C	27°C	34.5°C	1%
14	35°C	28.3°C	35°C	1%
15	35°C	29.5°C	35°C	1%
16	35°C	29°C	35°C	1%
17	35°C	29.4°C	35°C	1%
18	35°C	28.4°C	35°C	1%
19	35°C	27°C	34.9°C	1%
20	35°C	27.3°C	35°C	1%
21	35°C	28.1°C	35°C	1%
22	35°C	28°C	35°C	1%
23	35°C	28.2°C	35°C	1%
24	35°C	29°C	35°C	1%
25	35°C	28.9°C	35°C	1%
26	35°C	29°C	35°C	1%

Days	Temperature measured setting control (°C)	Temperature measured in the farm (°C)	Temperature measured from 40W warm bulb (°C)	Error from sensor (%)
27	28°C	26.1°C	28°C	1%
28	28°C	26.5°C	28°C	1%
29	28°C	26.6°C	28°C	1%

From table 4.7, the set temperature is between 35˚C - 25˚C. The test results of the temperature control system by using a 40 watt tube heat in 1-30 days indicated that warm bulb can increase the temperature to the desired value.

4.4 Test Results for Automatic Temperature Control System by Using the Fan to Decrease Temperature

Table 4.8 Temperature of Automatic Temperature Control System

days	Temperature measured setting control (°C)	Temperature measured in the farm (°C)	Temperature measured from fan (°C)	Error from sensor (%)
1/3/2559	36°C	32°C	N/A	1%
2/3/2559	36°C	34°C	N/A	1%
3/3/2559	36°C	35°C	N/A	1%
4/3/2559	36°C	35.5°C	N/A	1%
5/3/2559	36°C	33°C	N/A	1%
6/3/2559	36°C	33.2°C	N/A	1%
7/3/2559	36°C	35°C	N/A	1%
8/3/2559	36°C	33°C	N/A	1%
9/3/2559	36°C	35°C	N/A	1%
10/3/2559	36°C	34.7°C	N/A	1%
11/3/2559	36°C	34°C	N/A	1%
12/3/2559	36°C	33°C	N/A	1%
13/3/2559	36°C	33.1°C	N/A	1%
14/3/2559	36°C	34°C	N/A	1%
15/3/2559	36°C	34.2°C	N/A	1%
16/3/2559	36°C	34.3°C	N/A	1%
17/3/2559	36°C	35.2°C	N/A	1%
18/3/2559	36°C	34.9°C	N/A	1%
19/3/2559	36°C	34.8°C	N/A	1%
20/3/2559	36°C	34.8°C	N/A	1%
21/3/2559	36°C	34.6°C	N/A	1%
22/3/2559	36°C	35.1°C	N/A	1%
23/3/2559	36°C	34.8°C	N/A	1%
24/3/2559	36°C	36.3°C	36°C	1%
25/3/2559	36°C	36°C	N/A	1%
26/3/2559	36°C	36.1°C	36°C	1%
27/3/2559	36°C	34°C	N/A	1%

days	Temperature measured setting control (°C)	Temperature measured in the farm (°C)	Temperature measured from fan (°C)	Error from sensor (%)
28/3/2559	36°C	34.2°C	N/A	1%
29/3/2559	36°C	34.1°C	N/A	1%
30/3/2559	36°C	33°C	N/A	1%
31/3/2559	36°C	33.7°C	N/A	1%

*N/A: Not Available

From table 4.8, the set temperature is between 36°C - 33°C. The test results of the temperature control system by using fans in 1-30 days indicated that fan can decrease the temperature to the desired temperature.

The temperature at which the fans start is at 36 °C. The temperature controller commands to switch on the fans that temperature can be decreased 2-3 °C.

The temperature at the warm bulb 40 watt -100 watts is 28 - 35 °C. The 40 watt bulb increased temperature 2-3 °C and the 100 watt bulb increased temperature 6-7 °C. The distance of the light to the floor was 30 cm that can increase the temperature in radius of 1 meter.

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4.5 Testing Result of Automatic Feeding, Aeration, and Drainage Systems of Catfish Pond

Table 4.9 the Oxygen Dissolved In Water When Turning On the Air Pump

weeks	pond 1	pond 2	pond 3	pond 4	pond 5	pond 6	default value	mean
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1	3.4	3.4	3.4	3	3	3	> **3**	3.2
2	3.4	3.4	3.4	3	3	3	> **3**	3.2
3	3.4	3.4	3.4	3	3	3	> **3**	3.2
4	3.4	3.4	3.4	3	3	3	> **3**	3.2
5	3.4	3.4	3.4	3	3	3	> **3**	3.2
6	3.4	3.4	3.4	3	3	3	> **3**	3.2
							average	3.2

From table 4.9, the average of oxygen dissolved in water was 3.2 mg/l. The result showed that the dissolved oxygen in the water is in the standard.

Table 4.10 the Average Temperature of the Water in 6 Catfish Ponds Before and After Drainage

weeks	Temperature of the water before drainage (°C)	Temperature of the water after drainage (°C)	Different Average (°C)
1	28.3	26.7	1.6
2	28.3	26.7	1.6
3	28.3	26.7	1.6
4	29.3	27.7	1.6
5	29.3	27.7	1.6
6	29.3	27.7	1.6

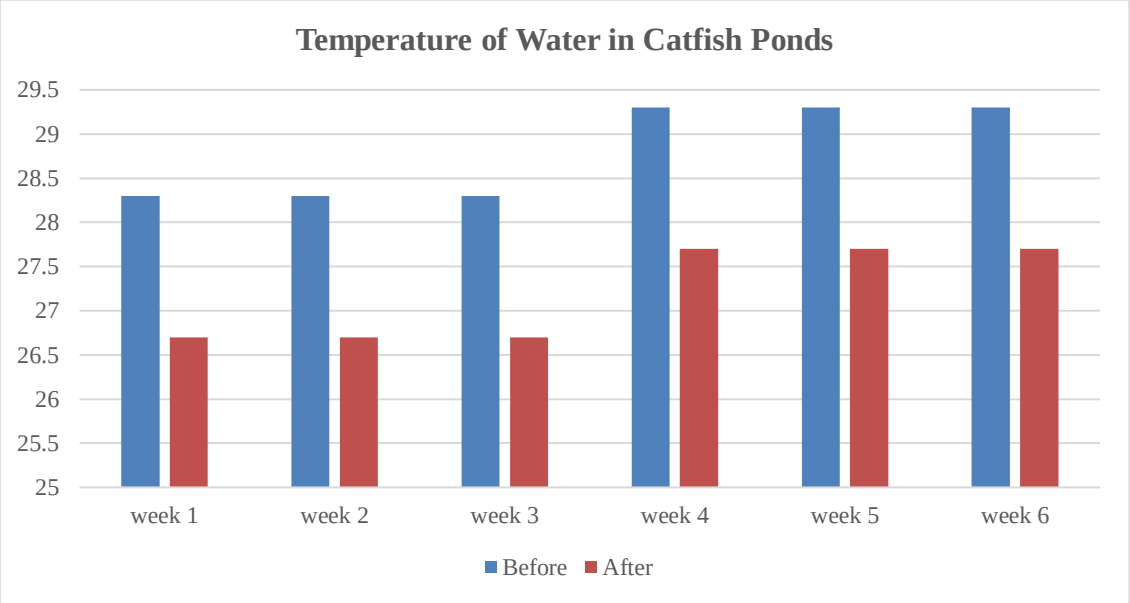

Figure 4.2 Comparison of Average Temperature of the Water in 6 Catfish Ponds Before and After Drainage

The table 4.10 and figure 4.2 showed that the average temperature of water in 6 catfish ponds before drainage was 28.3 ˚C and the average temperature of water after drainage was 26.7 ˚C in week 1. The average temperature of water before drainage was 29.3 ˚C and the average temperature of water after drainage was 27.7 ˚C in week 6. The different average of temperature between before and after drainage was 1.6 ˚C. It showed that to drain water from catfish pond could decrease and control temperature of water for raising catfish farm in the standard condition.

Table 4.11 Food Quantity from Automatic Feeding Catfish Machine

Time (sec.)	Food Quantity					Average weight (g)
	Trial 1 weight (g)	Trial 2 weight (g)	Trial 3 weight (g)	Trial 4 weight (g)	Trials 5 weight (g)	
1	2.55	2.55	2.55	2.55	2.55	2.55
2	4.55	4.55	4.55	4.55	4.55	4.55
3	6.55	6.55	6.55	6.55	6.55	6.55
4	9.55	9.55	9.55	9.55	9.55	9.55
5	13.55	13.55	13.55	13.55	13.55	13.55
6	18.55	18.55	18.55	18.55	18.55	18.55
7	24.55	24.55	24.55	24.55	24.55	24.55
8	31.55	31.55	31.55	31.55	31.55	31.55
9	39.55	39.55	39.55	39.55	39.55	39.55
10	48.55	48.55	48.55	48.55	48.55	48.55
11	57.55	57.55	57.55	57.55	57.55	57.55
12	66.55	66.55	66.55	66.55	66.55	66.55
13	75.55	75.55	75.55	75.55	75.55	75.55
14	84.55	84.55	84.55	84.55	84.55	84.55
15	93.55	93.55	93.55	93.55	93.55	93.55
16	102.55	102.55	102.55	102.55	102.55	102.55
17	111.55	111.55	111.55	111.55	111.55	111.55
18	120.55	120.55	120.55	120.55	120.55	120.55
19	129.55	129.55	129.55	129.55	129.55	129.55
20	138.55	138.55	138.55	138.55	138.55	138.55
21	147.55	147.55	147.55	147.55	147.55	147.55
22	156.55	156.55	156.55	156.55	156.55	156.55
23	165.55	165.55	165.55	165.55	165.55	165.55
24	174.55	174.55	174.55	174.55	174.55	174.55
25	183.55	183.55	183.55	183.55	183.55	183.55
26	192.55	192.55	192.55	192.55	192.55	192.55
27	201.55	201.55	201.55	201.55	201.55	201.55
28	210.55	210.55	210.55	210.55	210.55	210.55
29	219.55	219.55	219.55	219.55	219.55	219.55
30	228.55	228.55	228.55	228.55	228.55	228.55
31	237.55	237.55	237.55	237.55	237.55	237.55
32	246.55	246.55	246.55	246.55	246.55	246.55
33	255.55	255.55	255.55	255.55	255.55	255.55
34	264.55	264.55	264.55	264.55	264.55	264.55
35	273.55	273.55	273.55	273.55	273.55	273.55
36	282.55	282.55	282.55	282.55	282.55	282.55
37	291.55	291.55	291.55	291.55	291.55	291.55
38	300.55	300.55	300.55	300.55	300.55	300.55
39	309.55	309.55	309.55	309.55	309.55	309.55
40	318.55	318.55	318.55	318.55	318.55	318.55
41	327.55	327.55	327.55	327.55	327.55	327.55
42	336.55	336.55	336.55	336.55	336.55	336.55
43	345.55	345.55	345.55	345.55	345.55	345.55
44	354.55	354.55	354.55	354.55	354.55	354.55
45	363.55	363.55	363.55	363.55	363.55	363.55
46	372.55	372.55	372.55	372.55	372.55	372.55

Time (sec.)	Food Quantity					Average weight (g)
	Trial 1 weight (g)	Trial 2 weight (g)	Trial 3 weight (g)	Trial 4 weight (g)	Trials 5 weight (g)	
47	381.55	381.55	381.55	381.55	381.55	381.55
48	390.55	390.55	390.55	390.55	390.55	390.55
49	399.55	399.55	399.55	399.55	399.55	399.55
50	408.55	408.55	408.55	408.55	408.55	408.55
51	417.55	417.55	417.55	417.55	417.55	417.55
52	426.55	426.55	426.55	426.55	426.55	426.55
53	435.55	435.55	435.55	435.55	435.55	435.55
54	444.55	444.55	444.55	444.55	444.55	444.55
55	453.55	453.55	453.55	453.55	453.55	453.55
56	462.55	462.55	462.55	462.55	462.55	462.55
57	471.55	471.55	471.55	471.55	471.55	471.55
58	480.55	480.55	480.55	480.55	480.55	480.55
59	489.55	489.55	489.55	489.55	489.55	489.55
60	498.55	498.55	498.55	498.55	498.55	498.55

From table 4.11, checking average weight of food 5 trials found that the amount of food was weigh at 2.55 grams in the first second of 1 - 5 times. It indicated that the feeder is stable and feed effectively. The amount of food was weigh at 498.55 grams in the 60th second of 1 - 5 times. The working time of feeding machine to release amount of food can be adjusted that depended on the weight of the fish.

T**able 4.12** Amount of Food for Feeding Catfish

Weeks	Weight of catfish (g)	Feeding percentage	The right amount of food (g)/a pond	The amount of food left out of the feeding machine (g)	The working time of the feeding machine (sec)
1	15.90	7%	105.74	106.5	10
2	30.85	4%	117.23	120.55	18
3	37.78	6%	215.35	219.55	29
4	46.00	5%	218.5	219.55	29
5	62.55	4%	237.69	237.55	31
6	75.12	5%	356.82	363.55	45

From table 4.12 showed that the amount of appropriated food was similar to the amount of food left out of the feeding machine. It indicated that the feeding in the right amount for the weight of the fish is clear to specify the time duration of the feeder.

CHAPTER 5
RESULTS

This chapter describes the analysis of data followed by discussion of the research findings. The findings relate to the research objective that guided the study. Data were analyzed to explore the concept of the smart farm by adopting the philosophy of the sufficiency economy in the duck farm prototype. Information from participants in the knowledge dissemination of the smart farm by adopting the philosophy of the sufficiency economy was analyzed to describe about effective the smart farming by adopting the philosophy of the sufficiency economy learning center and awareness to do the smart farming by adopting the philosophy of the sufficiency economy. Gathering information were analyzed to suggest policy recommendation for government to support a more sustainable, practical, and suitable practices of smart farming 4.0

5.1 To apply the concept of the smart farming by adopting the philosophy of the sufficiency economy in duck farm prototype.

Experts' comments for farm and equipment design was indicated suitability of the smart farm in this study. The 4 interviewees who are a livestock and an agricultural specialist, a duck farmer, and a vegetable farmer indicated that this farm design was suitable for knowledge dissemination to farmer and worth investment. Interviewees suggested about plant which it should be vegetable because it is easy to sale. Otherwise, farmer should survey what kind of vegetables needed for market. The livestock and agricultural specialist suggested that catfish is high demand and simply to raise. After the researcher obtains the affordable, and practical technologies from the experts, then the duck farm was designed in corporate with those technologies.

From experts' suggestion, the smart farm by adopting the philosophy of the sufficiency economy was improved. The smart farm in this study is the duck and catfish farming which is the economical animal that is the market demand in the community. Moreover, the duck and catfish was simple to raise. Kale, morning glory, and lettuce should be grown on the farm because of the market demand in the local community.

From experts' comments to practice, the technologies were installed in the study area which were developed from opinion of expert in livestock and agriculture. The smart farm by adopting the philosophy of the sufficiency economy design plays an important role in the overall production and health of duck, catfish, and vegetable. A good designed farm with all types of facilities, higher production, maximum profit and good health were considered.

5.1.1 The results of working process analysis

Automatic duck and fish feeding systems are properly installed in the correct position for operation in the farm. Thus, working on the smart farming could reduce labors and time which compared to the general operation in the farm without automatic support. Working Process in the smart farming by adopting the philosophy of the sufficiency economy in this study was analyzed by the Flow Process Charts in order to show operation detail of working in the farm. The Flow Process Charts of the smart farming by adopting the philosophy of the sufficiency economy which explained working process on feeding and watering in the farm by using automatic system and machine was shown in figures 5.1. The symbols of Flow Process Charts in order to show operation detail of working in the farm were explained as follows:

In the duck farm  = the position of food storage for ducks

 = the direction to deliver food to the position of feeding for ducks

 = operation of feeding for ducks

 = inspection of feeding for ducks

 = the position of water storage for ducks

 = the direction to deliver water to the position of watering for ducks

 = operation of watering for ducks

 = inspection of watering for ducks

In the catfish farm  = the position of food storage for catfish

 = the direction to deliver food to the position of feeding for catfish

 = operation of feeding for catfish

 = inspection of feeding for catfish

 = the position of water storage for catfish ponds

 = the direction to drain water to catfish ponds

 = operation of drainage for catfish ponds

 = inspection of drainage for catfish ponds

 = the position of water storage for vegetable plots

 = the direction to drain water to vegetable plots

 = operation of pouring for vegetable plots

 = inspection of pouring for vegetable plots

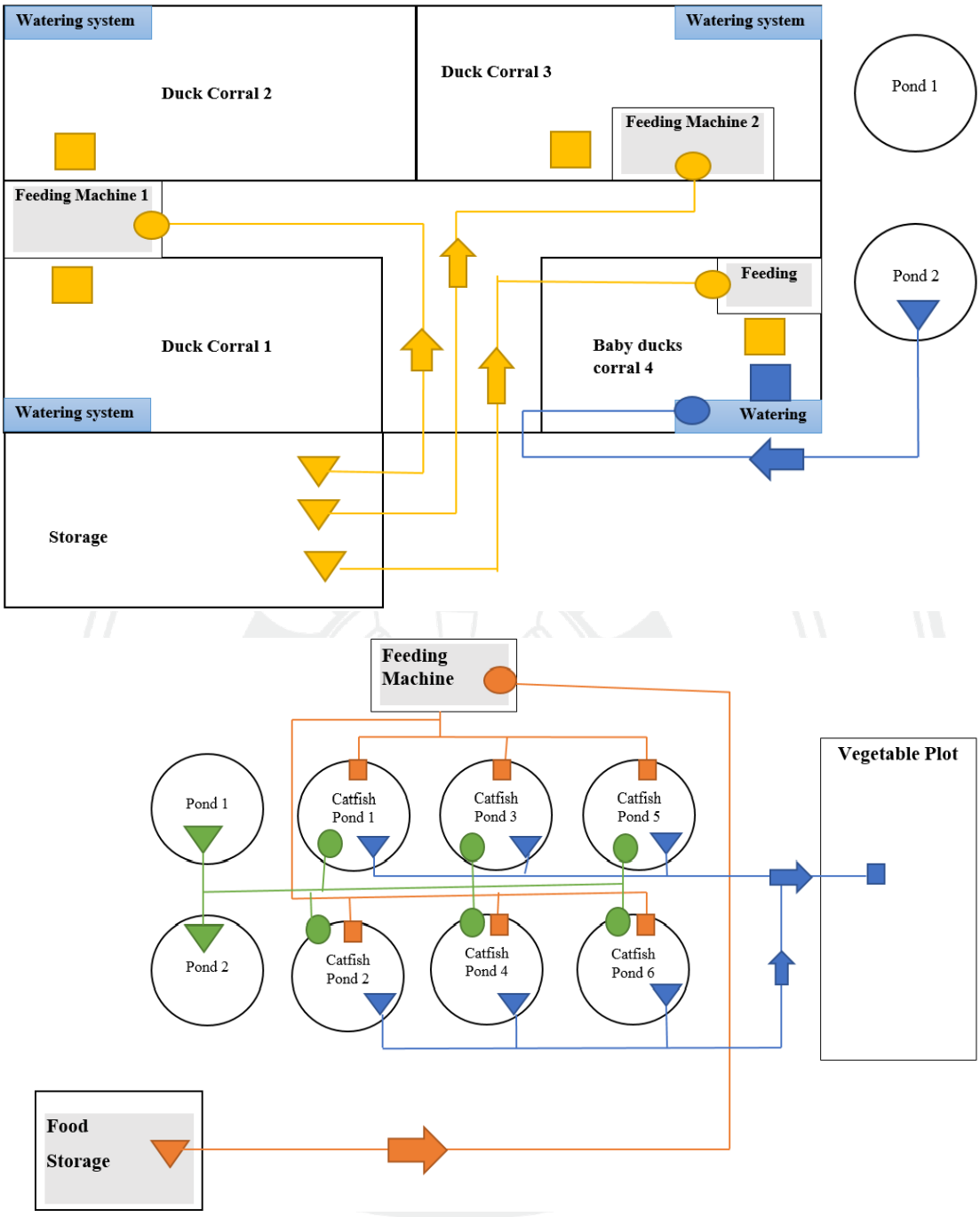

Figure 5.1 the Flow Process Charts of the Smart Farming by Adopting the Philosophy of the Sufficiency Economy

The Flow Process Charts of traditional farm which explained working process on feeding and watering in the farm by without using automatic system and machine was shown in figure 5.2.

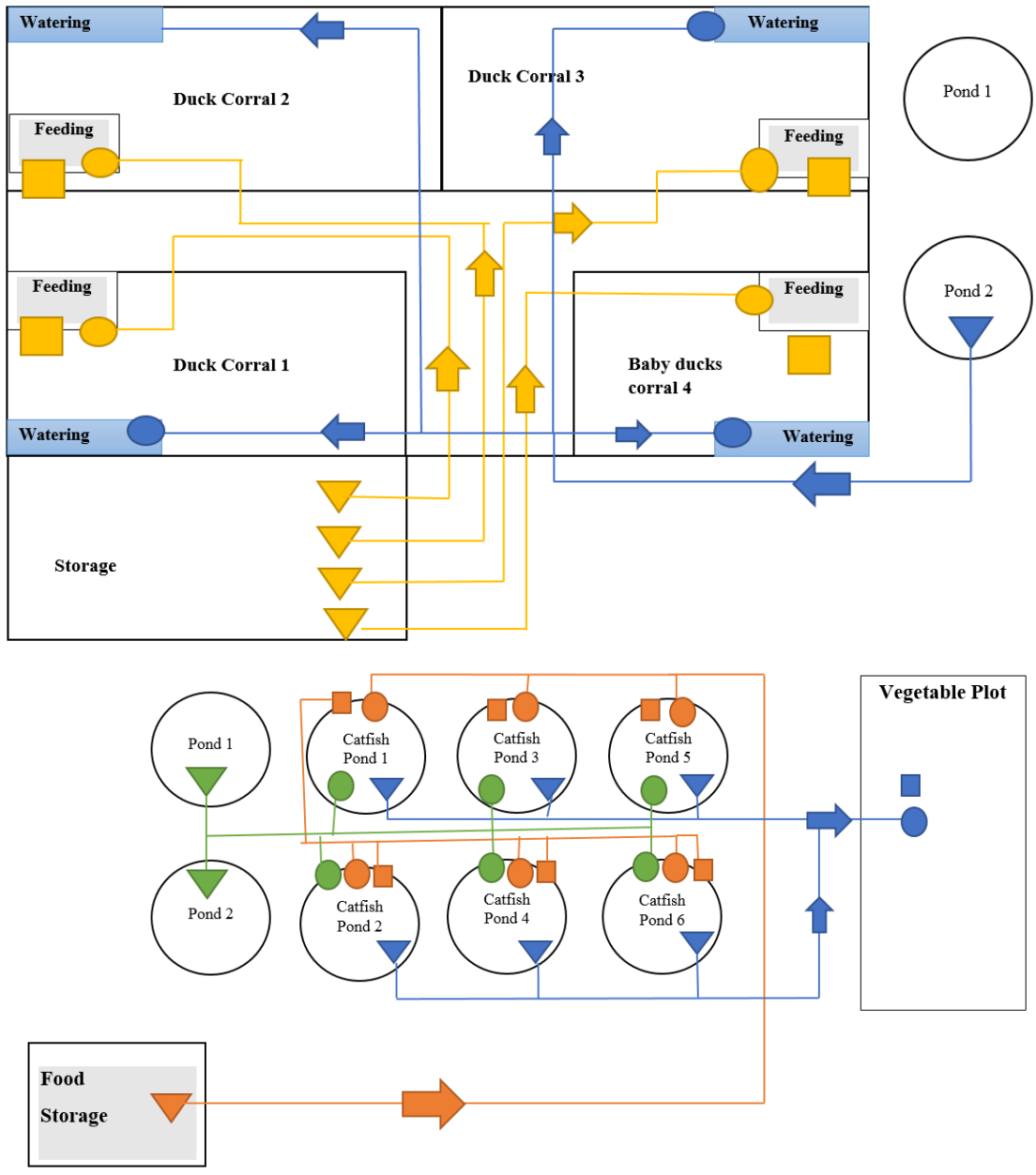

Figure 5.2 the Flow Process Charts of Traditional Farm

From figures 5.1 and 5.2, the smart farming in this study showed that the potential of benefit of automatic system and machine could reduce time and labor to work in farm. Movement and work activities in the smart farm in this study is less than traditional farm obviously.

When working time of multiple activities between the smart farm in this study and traditional farm were compared in one week, the result was found that, it took just fifty minutes to feed in the smart farm in this study for a week. On the other hand, traditional farms, which do not have automatic feeding systems, labors are required to feed ducks for 700 minutes or 11 hours and 20 minutes per a week. Thus, feeding in the smart farm took less time than traditional farms. Furthermore, watering activity took just thirty-five minutes for watering duck in the smart farm in this study for a week. While traditional farms which do not have automatic watering systems, it took 560 minutes or 9 hours and 20 minutes per a week for watering duck. Thus, watering in the smart farm also took less time than traditional farms. The result of comparison feeding and watering activity time as shown in tables 5.1 and 5.2

Table 5.1 Comparison Time for Feeding Activity between the Smart Farming by Adopting the Philosophy of the Sufficiency Economy and Traditional Farm in One Week

The Smart Farm		**Traditional Farm**	
Activities	**Time (min.)**	**Activities**	**Time (min.)**
Fill food into feeding machine 1 for duck	5	feeding at duck corral 1	10 x 7 days = 70
Fill food into feeding machine 2 for duck	5	feeding at duck corral 2	10 x 7 days = 70
Fill food for baby duck	5 x 7 days = 35	feeding at duck corral 3	10 x 7 days = 70
Fill food into feeding machine for cat fish	5	feeding at baby duck corral 4	10 x 7 days = 70
		Feeding catfish for pond 1	10 x 7 days = 70
		Feeding catfish for pond 2	10 x 7 days = 70
		Feeding catfish for pond 3	10 x 7 days = 70
		Feeding catfish for pond 4	10 x 7 days = 70
		Feeding catfish for pond 5	10 x 7 days = 70
		Feeding catfish for pond 6	10 x 7 days = 70
total	50	total	700 (11 hrs. and 20 mins.)

Table 5.2 Comparison Time for Watering Activity between the Smart Farming by Adopting the Philosophy of the Sufficiency Economy and Traditional Farm in One Week

The Smart Farm		**Traditional Farm**	
Activities	**Time (min.)**	**Activities**	**Time (min.)**
watering for baby duck	5 x 7 days = 35	watering at duck corral 1	20 x 7 days = 140
		watering at duck corral 2	20 x 7 days = 140
		watering at duck corral 3	20 x 7 days = 140
		watering at baby duck corral 4	20 x 7 days = 140
total	35	total	560 (9 hrs. and 20 mins.)

5.1.2 Productivity of the smart farming in this study

The expectation of the smart farming by adopting the philosophy of the sufficiency economy is no need to work in farm all the time by using automatic system and innovative equipment. In addition, farmer can spend less time to work in the farm that it can reduce stress and disturb in animals which results in healthy growth and production. Thus, the result of number and weight of duck and catfish in the smart farm in this study represents a boost to efficiency, by improving healthy growth and quality of product.

Table 5.3 Weight of Duck (kg)

Date	**Age (weeks)**	**Number of trials**										**Mean**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
3/Oct/2017	1-2	0.11	0.12	0.10	0.12	0.11	0.18	0.10	0.12	0.12	0.16	0.12
16/Oct/2017	3-4	0.26	0.20	0.20	0.30	0.30	0.22	0.21	0.21	0.21	0.23	0.23
1/Nov/2017	5-6	0.90	0.90	0.80	0.91	1.00	0.90	0.90	0.90	0.80	1.00	0.90
15/Nov/2017	7-8	1.90	2.50	2.30	2.63	2.68	2.40	2.30	2.41	2.32	2.49	2.39
4/Dec/2017	9-10	3.00	3.50	3.10	3.00	3.20	3.00	2.70	3.40	3.60	3.40	3.19

Table 5.4 Comparison between Weight of Duck from Smart Farm and Department of Livestock Development, District 9 (2011)

weeks	**smart farm (kg)**	**Department of Livestock Development, District 9 (kg)**	**Difference value**	
			kg	**Percentage**
1-6	1.74	1.20	0.54	31.03%
7-10	3.19	2.10	1.09	34.17%

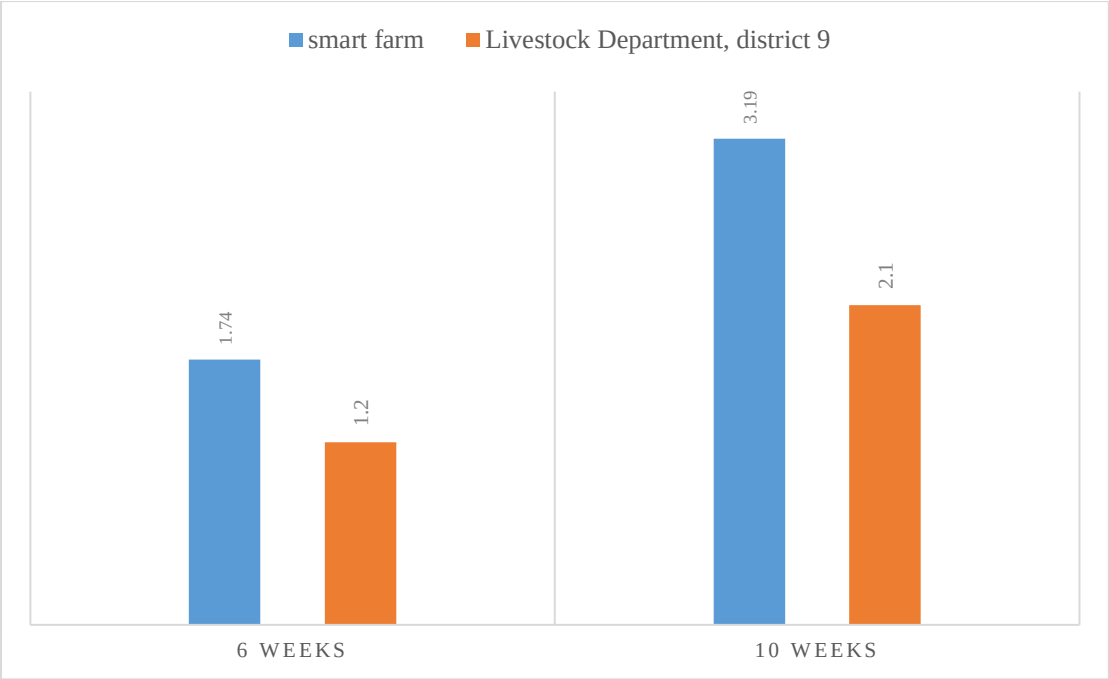

Figure 5.3 Comparison between Weight of Duck from Smart Farm and Department of Livestock Development, District 9 (2011)

From tables 5.3-5.4 and figure 5.3 showed that the weight of ducks from the smart farm in this study was heavier than the standard (Livestock Development, district 9, 2011) in 6 weeks around 3.03%. In 10 weeks the weight of ducks from the smart farm in this study was also heavier than the standard (Livestock Development, district 9, 2011) around 34.17%.

Table 5.5 the Growth of Catfish in Weight (g) and Length (cm)

weeks	Pond 1		Pond 2		Pond 3		Pond 4		Pond 5		Pond 6		Mean	
	W/g	L/cm	W/g	L/cm	W/g	L/cm	W/g	L/cm	W/g	L/cm	W/g	L/cm	W/g	L/cm
1	15.90	5.00	15.90	5.00	15.90	5.00	15.90	5.00	15.90	5.00	15.90	5.00	15.90	5.00
2	30.20	9.50	31.10	9.80	32.20	9.50	30.00	9.50	30.50	9.20	31.10	9.50	30.85	9.50
3	38.00	13.60	36.95	13.50	37.50	13.00	36.70	13.80	39.00	14.00	38.50	14.00	37.78	13.65
4	46.10	18.80	45.00	19.50	47.00	19.70	45.10	18.50	47.00	17.90	45.80	19.50	46.00	18.98
5	65.00	23.50	62.20	22.50	62.80	23.30	62.20	23.40	61.10	24.80	62.00	24.70	62.55	23.70
6	77.90	26.50	74.40	25.80	75.00	25.80	74.90	26.20	71.20	27.50	77.30	27.20	75.12	26.50

From table 5.5, the average weight and length of the catfish in the first week were 15.90 g. and 5 cm. Then 6 weeks later, the average weight and length were 75.12 g. and 26.50 cm. it showed that the growth of the catfish increased 59.22 g in weight and the length increased by 21.5 cm in 6 weeks.

Table 5.6 Comparison of Catfish Growth

weeks	The average weight of catfish (Fisheries Research and Development Center, 2013)	The average weight of catfish in the smart farm	Difference value (g)
2	31.00	30.85	- 0.15
4	46.05	46.00	- 0.05
6	76.05	75.12	- 0.93

From Table 5.6, the average weight of catfish in the smart farm was slightly lower than the standard of the average weight of catfish (Fisheries Research and Development Center, 2013). It showed that the growth of the catfish is normal. While information of feeding catfish from Fisheries Research and Development Center (2013) can feed 50 catfish/m^2, the smart farm can feed 95 catfish/m^2

Furthermore, the smart farming by adopting the philosophy of the sufficiency economy allowed duck eggs were hatched naturally. The incubation period was lasts from 21 to 31 days. Ducks are very good setters, capable of hatching 28-30 duck eggs/ a female duck. The nest box should be located in a clean dry shelter, bedded with suitable litter. The incubation rate of smart farm was shown in table 5.7

Table 5.7 the Incubation Rate per a Week

Date	Incubation Rate (Baby Ducks)
7 NOV 2017	152
14 NOV 2017	149
21 NOV 2017	158
28 NOV 2017	153
5 DEC 2017	152
12 DEC 2017	155
19 DEC 2017	160
26 DEC 2017	158
Average	**155**

5.1.3 Financial Analysis

The smart farm by adopting the philosophy of the sufficiency economy aims to show that farmer can do agricultural business and they gain income can support their family. From financial analysis, it showed in three scenario that it indicated the smart farming in this study was worth for investment and did not invest too much. Operation cost was the cost of duck and baby feed that can be categorized, as follow:

(1) The cost of baby duck feed (aged of 1-3 weeks) is 430 baht/bag (30 kg/bag)

(2) The cost of baby duck feed (aged of 4-6 weeks) is 340 baht/bag (30 kg/bag)

(3) The cost of duck feed is 270 baht/bag (30 kg/bag)

The results of financial analysis of the smart farm in this study were shown, as follows:Initial cost

Table 5.8 Initial Cost for Building Farm and Automatic System and Machine

List	Cost
Farm construction	200,000
Drainage and watering system (included 4 troughs)	15,000
Automatic duck feeder system(included 2 feeding machines)	25,000
Automatic temperature and humidity control system (including light bulbs and fans)	5,400
Automatic open-close door system(included 3 feeding machines)	6,600
Automatic feeding, aeration, and drainage systems of 6 catfish ponds	18,000
Power supply system by solar cell	26,900
Duck (3 male + 27 female)	9,600
total	306,500

Table 5.8 reveal that initial cost for building farm and automatic system and machine installation was 306,500 bath. The initial cost was calculated in break-even point analysis of three scenarios of selling duck.

Scenario I: Operation Cost and income approximately (In case of selling average 155 baby ducks/ week only)

When considering in case of selling average 155 baby ducks/ week only, the benefit per month would be 18,600 baht approximately at 2nd month and the operation cost per month would be 2,800 baht. Thus, the net benefit per month was 15,800 baht. When considering about initial and operation cost, selling baby ducks would break-even point in 21st month (shown in table 5.9).

Table 5.9 Expense and Receipt of the Smart Farming by Adopting the Philosophy of the Sufficiency Economy *(In case of selling average 155 baby ducks/ week only)*

Month	Initial investment	Operation cost	benefit	Net benefit
0	*306,500	0	0	-306,500
1	0	**1,080	0	-307,580
2	0	***2800	18,600	-291,780
3	0	2800	18,600	-275,980
4	0	2800	18,600	-260,180
5	0	2800	18,600	-244,380
6	0	2800	18,600	-228,580
7	0	2800	18,600	-212,780
8	0	2800	18,600	-196,980
9	0	2800	18,600	-181,180
10	0	2800	18,600	-165,380
11	0	2800	18,600	-149,580
12	0	2800	18,600	-133,780
13	0	2800	18,600	-117,980
14	0	2800	18,600	-102,180
15	0	2800	18,600	-86,380
16	0	2800	18,600	-70,580
17	0	2800	18,600	-54,780
18	0	2800	18,600	-38,980
19	0	2800	18,600	-23,180
20	0	2800	18,600	-7,380
21	0	2800	18,600	8,420
22	0	2800	18,600	24,220
23	0	2800	18,600	40,020
24	0	2800	18,600	55,820
25	0	2800	18,600	71,620
26	0	2800	18,600	87,420
27	0	2800	18,600	103,220
28	0	2800	18,600	119,020

* Initial cost

** The cost of duck feed (270 baht x 4 bags = 1,080 baht)

*** The cost of duck feed (270 baht x 4 bags = 1,080 baht) and baby duck feed (430 baht x 4 bags = 1,720 baht) are 2,800 baht

Scenario II: Operation Cost and income approximately (In case of selling ducks/week only)

When considering in case of selling average 155 ducks/ week only, the net benefit per month would be 111,977 baht. Considering about initial and operation cost, selling baby ducks would break-even point in 7th month (shown in table 5.10).

Table 5.10 Expense and Receipt of the Smart Farming by Adopting the Philosophy of the Sufficiency Economy *(In case of selling 155 ducks/week only)*

Month	Initial investment	Operation cost	benefit	Net benefit
0	*306,500	0	0	-306,500
1	0	**1,080	0	-307,580
2	0	***2800	0	-310,380
3	0	****4160	0	-314,540
4	0	****4160	0	-318,700
5	0	*****16580	128,557	-206,723
6	0	16580	128,557	-94,746
7	0	16580	128,557	17,231
8	0	16580	128,557	129,208
9	0	16580	128,557	241,185
10	0	16580	128,557	353,162
11	0	16580	128,557	465,139
12	0	16580	128,557	577,116
13	0	16580	128,557	689,093
14	0	16580	128,557	801,070
15	0	16580	128,557	913,047
16	0	16580	128,557	1,025,024
17	0	16580	128,557	1,137,001
18	0	16580	128,557	1,248,978
19	0	16580	128,557	1,360,955
20	0	16580	128,557	1,472,932

* Initial cost

** The cost of duck feed (270 baht x 4 bags = 1,080 baht)

*** The cost of duck feed (270 baht x 4 bags = 1,080 baht) and baby duck feed (430 baht x 4 bags = 1,720 baht) are 2,800 baht

**** The cost of duck feed (270 baht x 4 bags = 1,080 baht), baby duck (aged of 4-6 weeks) feed (340 baht x 4 bags = 1,360 baht), and baby duck (aged of 1-3 weeks) feed (430 baht x 4 bags = 1,720 baht) are 4,160 baht

***** The cost of duck feed (270 baht x 50 bags = 13,500 baht), baby duck (aged of 4-6 weeks) feed (340 baht x 4 bags = 1,360 baht), and baby duck (aged of 1-3 weeks) feed (430 baht x 4 bags = 1,720 baht) are 16,580 baht

Scenario III: Operation Cost and income approximately (In case of selling 50% ducks and 50% baby duck/week)

When considering in case of selling average 77 ducks and 78 baby ducks/ week, the benefit per month would be 9,360 baht in 2th - 4th month and 25,326 after 5th month. Considering about initial and operation cost, selling baby ducks would break-even point in 21st month (shown in table 5.11).

Table 5.11 Expense and Receipt of the Smart Farming by Adopting the Philosophy of the Sufficiency Economy *(In case of selling 50% ducks and 50% baby duck/week)*

Month	Initial investment	Operation cost	benefit	Net benefit
0	*306,500	0	0	-306,500
1	0	**1,080	0	-307,580
2	0	***2800	9,360	-301,020
3	0	****4160	9,360	-295,820
4	0	****4160	9,360	-290,620
5	0	*****8480	25,326	-273,774
6	0	8480	25,326	-256,928
7	0	8480	25,326	-240,082
8	0	8480	25,326	-223,236
9	0	8480	25,326	-206,390
10	0	8480	25,326	-189,544
11	0	8480	25,326	-172,698
12	0	8480	25,326	-155,852
13	0	8480	25,326	-139,006
14	0	8480	25,326	-122,160
15	0	8480	25,326	-105,314
16	0	8480	25,326	-88,468
17	0	8480	25,326	-71,622
18	0	8480	25,326	-54,776
19	0	8480	25,326	-37,930
20	0	8480	25,326	-21,084
21	0	8480	25,326	-4,238
22	0	8480	25,326	12,608
23	0	8480	25,326	29,454
24	0	8480	25,326	46,300

* Initial cost

** The cost of duck feed (270 baht x 4 bags = 1,080 baht)

*** The cost of duck feed (270 baht x 4 bags = 1,080 baht) and baby duck feed (430 baht x 4 bags = 1,720 baht) are 2,800 baht

**** The cost of duck feed (270 baht x 4 bags = 1,080 baht), baby duck (aged of 4-6 weeks) feed (340 baht x 4 bags = 1,360 baht), and baby duck (aged of 1-3 weeks) feed (430 baht x 4 bags = 1,720 baht) are 4,160 baht

***** The cost of duck feed (270 baht x 50 bags = 13,500 baht), baby duck (aged of 4-6 weeks) feed

(340 baht x 4 bags = 1,360 baht), and baby duck (aged of 1-3 weeks) feed (430 baht x 4 bags = 1,720 baht)
are 16,580 baht

Optional income

Optional income was from selling catfish. The catfish were harvested at the weight of 75 grams and the age of about 1 and a half months. When considering in case of selling catfish, the average income of 6 weeks would be 2,139 baht and the profit was 437 baht. Thus, selling catfish would break-even point in 27th week (shown in table 5.12).

Table 5.12 Expense and Receipt of Smart Farm from Selling Catfish of 6 Ponds

Weeks	Operation cost	benefit	Net benefit
1	634	0	-634
2	178	0	-812
3	178	0	-990
4	178	0	-1,168
5	178	0	-1,346
6	178	0	-1,524
7	178	2,139	437
8	634	0	-197
9	178	0	-375
10	178	0	-553
11	178	0	-731
12	178	0	-909
13	178	0	-1,087
14	178	2,139	874
15	634	0	240
16	178	0	62
17	178	0	-116
18	178	0	-294
19	178	0	-472
20	178	0	-650
21	178	2,139	1,311
22	634	0	677
23	178	0	499
24	178	0	321
25	178	0	143
26	178	0	-35
27	178	0	-213
28	178	2,139	1,748
29	634	0	1,114
30	178	0	936
31	178	0	758
32	178	0	580
33	178	0	402
34	178	0	224
35	178	2,139	2,185

From tables 5.9-5.12, the best scenario was the case of selling ducks only that the net benefit was 111,977 baht per month. While the worst scenario was the case of selling baby ducks only that the net benefit per month was 15,800 baht. The break-even point analysis showed that in case of duck only selling gave the most profit and reach the break-even point will come fastest. Moreover, there was also optional income from raising catfish.

In conclusion, initial investment and annual net benefit from selling ducks and catfish were calculated to analyze NPV of the smart farming in this study. NPV was analyzed worthiness of the smart farming in this study. The best scenario of selling ducks and catfish were considered. The useful life of the smart farm in this study is 10 years. After 10 years it will have no salvage value. The smart farm in this study wants a 15% of interest to return on all investments (shown in table 5.13).

Table 5.13 NPV Analysis of the Smart Farming

Year	Initial Investment	Operating Costs (Duck)	Operating Costs (Catfish)	Benefit of Duck Selling	Benefit Catfish	Net Benefit	*PV of Net Benefit
0	-306,500					-306500	-306500
1		-144,840	-13,082	577,116	874	420068	365277
2		-198,960	-13,082	1,343,724	874	1132556	856375
3		-198,960	-13,082	1,343,724	874	1132556	744674
4		-198,960	-13,082	1,343,724	874	1132556	647543
5		-198,960	-13082	1,343,724	874	1132556	563080
6		-198,960	-13082	1,343,724	874	1132556	489635
7		-198,960	-13082	1,343,724	874	1132556	425770
8		-198,960	-13082	1,343,724	874	1132556	370235
9		-198,960	-13082	1,343,724	874	1132556	321943
10		-198,960	-13082	1,343,724	874	1132556	279951
NPV							4,757,982

$$* PV\ of\ Net\ Benefit = \frac{Net\ Benefit}{(1 + i\%)^n}$$

From table 5.13, the smart farming by adopting the philosophy of the sufficiency economy should be purchased because the net present value is positive (4,757,982-306,500 = 4,451,482 baht). Having a positive net present value means the smart farming in this study promises a rate of return that is higher than the minimum rate of return required by management.

The result of benefit of the smart farming in this study indicated that only about one rai (1,600 m^2) of agricultural land can generate income for supporting the family, and there is still another money to accumulate for the expansion of the farm business in the future.

The expectation of this study will lead farmer to do the smart farming by adopting the philosophy of the sufficiency economy for sustainability. The smart farm in this study aims produce sufficient food for families and communities fundamentally. From sufficiency economy to design the smart farming is the way to

achieve sustainability in agriculture that focused on the well-being of farmer and local community.

5.1.4 The Break-Even Cost for the smart farm in this study, using solar energy system

5.1.4.1 Gross cost of solar panel system

The net cost of installing solar energy system on the smart farm in this study was dependent on the size of the system and the equipment that makes up that system (see in chapter 3) which showed in table 5.14.

Table 5.14 the Net Cost of Installing Solar Energy System

Equipment	Number	cost
Inverter	1	7500
Solar panel	2	12200
Wires and peripherals	1	1700
Battery	2	3000
Charger	1	2500
Total		26900

5.1.4.2 Average monthly electricity use

The amount of electricity that the smart farm in this study consuming monthly was 40.10 kilowatt-hour (Energy using per day × 30 days). The smart farm in this study was categorized in small business, where the price of electricity currently sits at about 3.0874 baht per kilowatt-hour. The electricity price per month, including service charge and vat was around 494.58 baht (Provincial Electricity Authority, 2017).

5.1.4.3 To break even with solar panels

Using solar energy to produce electricity could reduce electricity cost around 494.58 baht per month. While, the net cost of installing solar energy system on the smart farm in this study was 26,900 baht. Therefore, to install solar panel system would break-even point in 4^{th} year approximately (26,900/494.58 = 54.38 months).

However, the smart farm in this study needed to pay just 494.58 baht per month for electricity bill that it was not expensive when compare with net benefit. Although, to install solar panel system would break-even point in 4^{th} year approximately, the maintenance cost need to be paid every year for battery changing, maintenance fee, and depreciation.

5.1.4.4 To compare electricity cost between the smart farm using solar panel and traditional farm

Solar panel system was designed to produce electricity for controlling automatic system in the smart farm. Actually, electricity bill did not need to pay when solar panel system was installed in the farm. However, the maintenance cost was considered instead of electricity bill. From table 5.15, it showed that farmers will pay the average cost around 11,680 baht/year in 5 years, if they use solar panel

system to produce electricity. The maintenance cost was changing equipment about solar panel system. In fifth year, the total cost of the smart farm that used solar panel system was 58,400 baht while the traditional farm need to pay around 36,675 baht for electricity bill and electric wire maintenance.

Table 5.15 Comparing Electricity Cost between the Smart Farm Using Solar Panel and Traditional Farm

Year	Maintenance List	Cost (baht)	
		The Smart Farm	Traditional Farm
1	Solar panel system installation	26,900	-
	Electrical Equipment	5,000	5,000
	Electricity bill	-	5,934.96
	Total	31,900	10,934.96
2	Battery replacement	3,000	-
	Wire maintenance	500	500
	Electricity bill	-	5,934.96
	Total	3,500	6,434.96
3	Battery replacement	3,000	-
	Wire maintenance	500	500
	Charger replacement	2,500	-
	Electricity bill	-	5,934.96
	Total	6,000	6,434.96
4	Battery replacement	3,000	-
	Wire maintenance	500	500
	Electricity bill	-	5,934.96
	Total	3,500	6,434.96
5	Battery replacement	3,000	-
	Inverter replacement	7,500	-
	Charger replacement	2,500	-
	Wire maintenance	500	500
	Electricity bill	-	5,934.96
	Total	13,500	6,434.96
Total cost from 1st to 5th year		58,400	36,674.8

Therefore, the smart farm in this study is located in electrical access area, it does not need to install solar panel system. However, to install solar panel system is suitable for the smart farm that located in electricity inaccessibility area.

5.2 To distribute the knowledge or experiences from the practice of the hybrid of Thailand smart farm in the community

Data from 36 participants' opinion toward the smart farming by adopting the philosophy of the sufficiency economy learning center was evaluated with the 7 items, measured on a 4 point Likert type scale where 4 means strongly agree with the statement, and 1 means strongly agree with the statement. Table 5.15 summarized the

descriptive statistics of participants' opinion toward the hybrid of Thailand smart farm learning center.

Table 5.16 Descriptive Statistics of Participants' Opinion toward the Smart Farming by Adopting the Philosophy of the Sufficiency Economy Learning Center

The smart farm 4.5 learning center (output)	Mean	SD
1. This program addresses my needs.	3.56	0.61
2. The mentor had strong experience and explained it in a way I could understand.	3.36	0.80
3. The mentor was approachable and open to my questions.	3.31	0.82
4. The mentor are qualified and enthusiastic.	3.61	0.64
5. I am satisfied with the quality of smart farm 4.5	2.97	0.51
6. I would recommend the smart farm 4.5 Learning Center to my friends.	3.50	0.65
7. I feel more confident about my ability to succeed	3.39	0.77
Total	3.39	0.69

Table 5.16 reveals that the overall means is 3.39, which indicates a positive attitude on average.

From the results of the interviews, we found that all learners enjoy knowledge dissemination of the smart farm by adopting the philosophy of the sufficiency economy as a learning center. All participants were asked the main questions about "what do you think about the smart farm by adopting the philosophy of the sufficiency economy" and "Is the farm suitable for being the smart farm by adopting the philosophy of the sufficiency economy learning center?" Most of participant commented in the same way that technology for continuous agricultural development is not easy for farmers, therefore, having a learning center will help farmers understand technology and can be the model for other farmers. Moreover, livestock and agricultural extension officer suggested that this learning center has a mission to develop Thai farmers become a smart farmer. Some participant expressed more opinion that the strong support for this learning center will drive Thailand 4.0 of government are real and powerful. The learning center could support to train the skills and practice of a professional farmer and to disseminate knowledge for the public widely.

To sum up, all of them strongly agree that:

(1) The smart farming by adopting the philosophy of the sufficiency economy learning center helped participants to learn;

(2) The smart farming by adopting the philosophy of the sufficiency economy learning center gave participants good suggestions on their problems;

(3) The smart farming by adopting the philosophy of the sufficiency economy learning center is trustworthy;

(4) They never had a time that they felt uncomfortable;

(5) There is a possibility that the participants to benefit from each other and inspire competition among them;

(6) The smart farming by adopting the philosophy of the sufficiency economy learning center can provide necessary skills in the smart farm through practice.

The results of both the surveys and the interviews revealed that the participants' need of educational agricultural program will definitely increase

The smart farming by adopting the philosophy of the sufficiency economy as a learning center in this study aims to be responsible for delivers knowledge to the community. This project will be an example to show a practical smart farm which is suitable for Thai farmers and encourage people to be interested in agriculture. Participants in the smart farming by adopting the philosophy of the sufficiency economy as a learning center was also evaluate about awareness of the smart farming by adopting the philosophy of the sufficiency economy.

Awareness from 36 participants toward the smart farming by adopting the philosophy of the sufficiency economy was evaluated with the 13 items, measured on a 4 point Likert type scale where 4 means strongly agree with the statement, and 1 means strongly agree with the statement. Table 5.16 summarized the descriptive statistics of participants' awareness toward the smart farming by adopting the philosophy of the sufficiency economy learning center.

Table 5.17 Awareness of the Smart Farming by Adopting the Philosophy of the Sufficiency Economy

Awareness	Mean	SD
1. The smart farm in this study can make well-being better	3.28	0.74
2. The smart farm in this study can be a supplementary career	3.33	0.72
3. Doing The smart farm in this study, you can earn income to take care your family	3.22	0.59
4. Agriculture at household level is the best way for Thai farmer	3.53	0.56
5. The smart farm in this study can reduce waste of time and labor	3.14	0.42
6. The smart farm in this study is easy to do and maintain	3.64	0.59
7. The smart farm in this study can be environmental friendly	3.64	0.64
8. I will Analysis and planning farm	3.42	0.69
9. I am doing Agriculture at household level	3.22	0.76
10. I am doing agricultural mix systems with many plants and animals in the same area	3.14	0.59
11. I have a self-sufficient lifestyle	3.14	0.59
12. I will co-operate and support the smart farm in this study for community activities	3.44	0.65
13. I will transfer knowledge to others	3.22	0.72
Total	3.34	0.64

Table 5.17 reveals that the overall means is 3.34, which indicates a positive attitude on average.

From the results of the interviews, Interviewer persuaded participants talk about their decision making to do the smart farming by adopting the philosophy of the sufficiency economy. All participants were asked the main questions about “What do you think about doing the smart farming by adopting the philosophy of the sufficiency economy” and “Do you want to do the smart farming by adopting the philosophy of the sufficiency economy? and Why?” Most of participant indicated that the use of technology in agriculture and widely disseminated will increase farm's productivity and improve quality of life. Some farmer said “we are free to live and do not have to worry about the farming too much because technology was used to make farming is easier and more comfortable”. A farmer said that “ I think that making the smart farming by adopting the philosophy of the sufficiency economy is not difficult and this farm can be adapted to our existing abilities” . Mostly indicated that initial investment to do the smart farming by adopting the philosophy of the sufficiency economy was not too much. Some participant said “I think it does not to need spending a lot of money on investment, but the farm need to plan layout and install the system satisfactory” and “the smart farming by adopting the philosophy of the sufficiency economy is not difficult to use and maintain that anyone in family whether children, adults or elderly can use and maintain”. As point of participant’s view showed that participants desired to do the smart farming by adopting the philosophy of the sufficiency economy because it takes less time than traditional farming. As some participant said “I am a farmer who can do smart farm, coupled with doing rice

field". When interviewer ask environmental expert about environment in the smart farm, they gave opinion that the smart farming in this study is clear and little smell which create well-being of animal. The environment in the smart farming in this study is better than the traditional farm which farmer usually do. The environmental expert said "the use of waste in the farm will be beneficial that it will lead to zero waste principle and it is not wasteful in the use of resources". Moreover, they indicated that this knowledge should be disseminated to the local people for their sustainability in agriculture and it should be the model for other communities.

After a month from the smart farming by adopting the philosophy of the sufficiency economy learning, there was a participant who bring the knowledge of the smart farming by adopting the philosophy of the sufficiency economy to practice in his home, Mahasarakam province. His farm consisted of automatic feeding and watering system. The automatic systems were modified to suit the existing material in the area and his budget. His story about delivery the smart farming by adopting the philosophy of the sufficiency economy to practice was interesting. Kaset Thammachat magazine interviewed him about the smart farm in his practice, adapted from the smart farm in this study.

5.3 To provide policy recommend for government to support a more sustainable, practical, and suitable practices of smart farming 4.0

As discussed above, policy instruments are based on the direct regulatory approach. Taking the results of this study into account as well as farmers' well-being, the smart farming by adopting the philosophy of the sufficiency economy to the practice and general developments of Thai agriculture. I make the following policy recommendations for a sustainable agriculture:

• Create incentives for the farmers to adopt best management practices at smallholder farm level. Thai farmers must be convinced that there is many problems to be addressed. To learn about alternative management practices, adopt the practices implement sustainable agriculture successfully. The benefit of doing smart farm should be publicized to people widely. The government officials who involve with agricultural sector should service information to allow people understand benefit in doing smart farm seriously. Although, the government sectors have promoted doing smart farm by meeting with communities, seminar, community forum, or website, changing the concept or traditional lifestyle of a farmer with just words or text is hard possible. It is necessary to have learning center for agricultural prototype by collaboration between farmer and government sectors in order to educate the agricultural practice. For instance, when a farmer performs a sample center, it is profitable. The government should have the supported measures, such as, tax measures, rewards, and the return is a percentage of the profit that the farmer receives from the sample center.

• Support local research on the smart farm with sufficiency economy and sustainability of best management practices. Alternative practices new to an area need to be locally field tested so that farmers can see the sustainable agriculture benefits first-hand. Research funding at the local level should be supported by

government. The government should increase funding in collaborative research between researchers from educational institutes and people in local communities. The research process will use the results, weighted criteria and indicators discussed in the workshop as inputs in modeling tool and prioritization of agricultural development. The workshop information will be supplemented with primary data, scientific literature, and expert knowledge to analyze the costs and benefits of each smart agriculture option to generate different investment. The result from research process provides valuable information for selecting the most appropriate practices or approach to invest in agriculture according to national context, environmental and socio-economic challenges as well as serve as a model to replicate in other regions of the country.

• Design an effective information and education program for farmers in the rural communities to enhance public education and contribute to more effective smart farm management in the future. The development of the existent agricultural knowledge system would prove a useful educational tool. The education programs must both educate them about smart farm with sufficiency economy, furthermore, the education programs recognizing the ways in which their farming practices contribute to the sustainable agriculture. At the local level, governments should promote agricultural education in schools, local communities, and through civic organizations. The agricultural learning center should not cost for training program. Therefore, the agricultural learning center should be supported from government in funding, resource, and experienced staff seriously. Public media can access to people easily, therefore, agricultural knowledge was disseminated widely via public media. For example, government should provide funding for television programs about agriculture production. Moreover, the government should provide funding for educational institutes that provide education program for farmers.

• Making available financial assistance helps farmers to provide an incentive to try something new. Agricultural finance is strategically important for eradicating extreme poverty and boosting shared prosperity. However, government policies from the past to the present do not solve long-term problems but it solves the problem at that time in the era of each government, the guaranteed price of rice for pledged crops, or rice subsidy scheme, for example. The government should also launch policy about finance strategies and enhancing access to suitable financial services to farmers, particularly smallholders. The agricultural Small and Medium Enterprises (SMEs) is a way to increase agricultural productivity and income. Government should also provide technical assistance to reform and build capacity of public financial institutions, to focus on financial cooperatives, given the importance of financial assistance and financial services to smallholder farmers, rural, and households. For example, the government supports loan program with low interest rate or no interest for smallholder farmers. The long term loan is an interesting policy that the government should support in order to reduce the debt burden of farmers.

• To establish transparent farm management policies identify the full economic, environmental and social costs and benefits in agriculture, and any associated transfers between farmers and consumers. In the past, the government promoted inappropriate agricultural knowledge. The government did not think long term effects from inappropriate agricultural encouragement. For example, when

rubber price rose, the government encouraged farmers to grow rubber. Then, when farmers grew more rubber, the overproduction of rubber happened in the market that made rubber prices decreased sharply. The government was obliged to subsidize rubber by people's tax to support farmers who grew rubber. Moreover, government should establish the center to purchase agricultural products in order to add value in agricultural production. The objective of the center to purchase agricultural products is create standard of the processed agricultural products for consumption in country and export. The example of progress of the center to purchase agricultural products was shown in figure 5.4

Figure 5.4 the Progress of the Center to Purchase Duck

At all levels, government influence on agriculture is often the center of debate. Government policies must balance the costs and benefits to farmers, consumers, the environment, government budgets, and competing interests.

CHAPTER 6
DISCUSSION

6.1 To improve human capability and social well-being as an overall

When comparison of multiple activities between the smart farming by adopting the philosophy of the sufficiency economy and traditional farm, the smart farming in this study takes less time in working on farm than traditional farms. Living on a farm has so much working where to take lots of the time to work on. Therefore, the automation system was used to manage the farm in order to make farmers work less time on the farm and more comfortable. People can be farmer as part-time job. For example, hobby farming in the concept of smart farming by adopting the philosophy of the sufficiency economy was applied to smaller operations run by families are part-time farmers. When automated work in the farm every day, people was request to spend just one day a week to take care of the farm and maintain automatic farm system. The automated system is designed for everyone in the family, whether they are children or the elderly, everyone can work on farming in the concept of smart farming in this study. In addition, the use of technology will reduce farmers' costs in the long term.

The knowledge about duck and catfish farming with automatic system from this study increases productivity in the smart farm. Number and weight of duck of the smart farming by adopting the philosophy of the sufficiency economy is higher than standard of Livestock Development, district 9 (2011). Because of the automatic use of the farm, people do not have to go to the farm for a long time to disturb animals. It also reduces the rate of infection from humans to animals and create well-being animal in farm. Automatic system improves the quality of animals and better reproduction. Baby duck is not shocked by external disturbances, resulting in a good growth rate. The high feed conversion ratio has a positive effect on the growth of ducks. Moreover, two factors that contribute to the quality of farm environment are temperature and humidity. The smart farm in this study was installed well-designed automatic temperature and humidity control system which can help ducks effortlessly maintain. The environment is suitable for ducks living needs. The automatic temperature and humidity control system is necessary in any situation that requires a certain temperature to be maintained. The automatic temperature and humidity control system helps farmer to avoid the problems that come with incorrect temperature and humidity levels such as disease. When environment in farm is suitable for animal living, ducks will have the large structure and very weight.

6.2 Economical feasibility

The social and environmental challenges of the twenty-first century, agriculture must find new ways to improve and adapt to conditions. The technologies seem related to agriculture. The smart farming by adopting the philosophy of the sufficiency economy represents alternative farm technology development. The potential benefits exhibited by the smart farm in this study are reducing cost, maintaining control over design and use, sustainable reuse, zero waste and recycling of materials. Currently, the knowledge of the smart farming by adopting the philosophy of the sufficiency economy is considered on possibility of using technology, cost of technology, and proper knowledge.

A break-even analysis determine the number of product units that need to be sold for a business to be profitable knowing the price and the cost of the product. Thus, financial analysis of smart farming by adopting the philosophy of the sufficiency economy business found that in case of selling 155 ducks/week only would break-even point in 7^{th} month. This case is the most profitable to work on duck farming. The average income per month would be 111,977 baht. Financial analysis of the smart farm in this study showed benefit and worthiness. Farmers can rely on themselves from doing the smart farm in this study. The financial analysis results showed that income from doing the smart farm in this study can support farmer families. Small farming increase their family income that will be much more than the earnings from office job.

The smart farming by adopting the philosophy of the sufficiency economy is a strategy for smart farm management by incorporating simple and economical feasible technology that is suitable for Thai culture and environment. The smart farm in this study use technology that it is easy to learn and maintain. Equipment for the smart farm can buy from hardware store generally. The smart farm in this study use technology that it is not too expensive to invest.

From sufficiency economy to smart farm, moderation is applied to smart farm with the concept of not too greedy and do not focus on short-term profit. The farmers can make the size of the farm that they can take care. Farmers should choose their own size and capacity to invest by their own capital. Moreover, Farmers should consider their ability to choose appropriate technology in farming.

6.3 Environmentally Friendly

The smart farming by adopting the philosophy of the sufficiency economy is to pay attention to environmental care. The automatic drainage systems will discharge water by each pond around 5 minutes per a pond. The automatic aeration operates 30 minutes, twice times a day, at 12.00 am and 12 pm. The amount of water drainage is 470 liters/ a pond and total of six ponds are 2820 liters which flow to pour vegetable plot. It showed that this farm is effective water management.

Straw and chaff from flooring the duck farm and duck dung can mixed as duck manure that is a valuable fertilizer for farming operation. Duck manure supply

needed nutrients for vegetable growth. Duck manure not only supply many nutrients for crop production, but they are also valuable sources of organic matter.

Environment in the smart farm is clear and little smell which create well-being of animal. The use of waste in the farm will be beneficial that it will lead to zero waste principle and it is not wasteful in the use of resources.

The government should support Thai farmers and consumers are starting to feel the pull of sustainable agriculture, organic farming, and organic food. The government should put its weight into environmentally-friendly agriculture. The fertilizer control policy, plus a bill for promoting proper treatment and utilization of animal manure should pushed by government.

The government were required to draw up their own plans to introduce sustainable agricultural production methods suited to the unique characteristics of local communities. Farmers who comply with the environmental friendly farming can now be certified as "Eco-Farmers," indicating that they are producers working to enrich their soil and reduce the use of chemical fertilizers and agrochemicals. The government should support a financial support system and preferential taxation measures, such as extension of loan payback periods

The government promotes sustainable agriculture for farmers to learn sustainable agriculture technologies and techniques, and labeling of environment-friendly produce to attract more support from distributors and consumers.

To sum up, the smart farming by adopting the philosophy of the sufficiency economy will lead to sustainability in every aspects, as shown in figure 6.1.

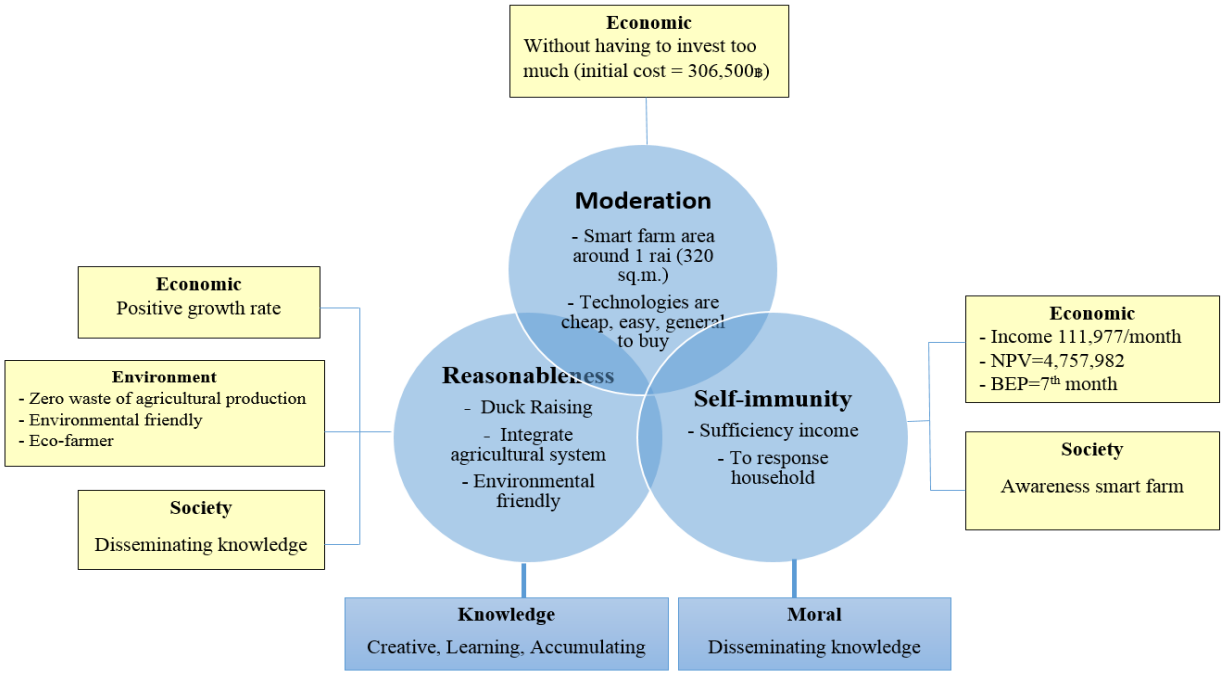

Figure 6.1 Conclusion of the Smart Farming by Adopting the Philosophy of the Sufficiency Economy Leads to Sustainability

The smart farming by adopting the philosophy of the sufficiency economy is a concept which can be applied to sustainable agriculture. This concept can be used to develop household level in agricultural communities. This concept can create job for the local people to reduce poverty and social disparity, and creating well-being to local people. When the household level is strong, it will create cooperation among households in community network development. This cooperation will create the strong foundation for further agricultural development.

BIBLIOGRAPHY

Abi, G. (2012). Smart farming. *Engineering & Technology, 7*(6), 38 – 40, DOI: 10.1049/et.2012.0601

Aeknarajindawat, N. (2017). Good Governance in Local Government Administration: Keystone for Thailand in Transition to Thailand 4.0 Development Scheme. *International Journal of Management and Applied Science (IJMAS), 3*(1), 47-50.

Agrawal, H., Prieto, J., Ramos, C., Corchado, J.M. (2016). *Smart feeding in farming through IoT in silos*. In: Corchado Rodriguez

Asia News Monitor. (2017). *Thailand: Smart farm project along highways in the deep south.* Retrieved from https://search.proquest.com/docview/1883236130?accountid=44809

Asia News Monitor. (2017). *Thailand: Smart farm project proves successful in Yala.* Retrieved from https://search.proquest.com/docview/1891907102?accountid=44809

Banhazi, T. M. and Lehr, H. and Black, J. L. and Crabtree, H. and Schofield, P. and Tscharke, M. and Berckmans, D. (2012). Precision livestock farming: an international review of scientific and commercial aspects. *International Journal of Agricultural and Biological Engineering, 5* (3), 1-9.

Blanchard, O. & Shleifer, A. (2001). Federalism with and without Political Centralization: China Versus Russia. *IMF Economic Review, 48*(1), 171–179

Bushnell, D.S. (1990). Input, Process, Output: A Model for Evaluating Training. *Training and Development, 44*(3), 41-43

Chuchat, C. (2554). *Agricultural Policy*. Bangkok: Agricultural Land Reform Office.

Cobia, D. W. (1989). *Cooperatives in Agriculture*. New Jersey: Prentice-hall, Inc.

Collis, J., & Hussey, R. (2009). *Business research: A practical guide for undergraduate & postgraduate students*. Basingstoke, Hampshire [UK: Palgrave Macmillan.

Community Development Institute. (2015). *Resolving Land and Housing Issues by Local Communities in The Project to Support the Problem of Land, Food and Rural Housing in 2015.* Bangkok: Community Development Institute, Ministry of Social Development and Human Security.

DeLaval. (2016). *Unlock your dairy farm future now*. Retrieved May 30, 2017, from http://www.delaval.co.uk/-/Dairy-knowledge-and-advice/Smart-Farming/

Department of Agricultural Extension. (2015). *Duck Raising.* Retrieved from http://ag-ebook.lib.ku.ac.th/ebooks/2011/2011-002-0276/index.html#/1/

Department of Agricultural Extension. (2017). *Driven Smart farmer (การขับเคลื่อน smart farmer).* Retrieved May 30, 2017, from http://chiangyuen.mahasarakham.doae.go.th/5.Smart-Farmer.pdf

Department of Agricultural Extension. (2017). *Agricultural Population(ประชากรภาคเกษตร).* Retrieved May 30, 2017, from http://www.agriinfo.doae.go.th/

Department of Livestock Development, District 9. (2013). *Duck Farming*. Retrieved October 30, 2017, from http://region9.dld.go.th/index.php?option=com_content&view=article&id=86:2011-02-08-19-21-26&catid=50:2011-02-01-22-54-48&Itemid=78

Drishti, K., Divyata, S., Rakhi, R., & Jimmy, M. (2014). Smart Farm: Extending Automation to the Farm Level. *International Journal of Scientific & Technology Research, 3*(7):109-113.

Dyllick, T. & Hockerts, K. (2002). Beyond the Business Case for Corporate Sustainability. *Business Strategy and the Environment, 11*, 130-141, DOI:10.1002/bse.323

Eberhard, D. (1974). *Operational Efficiency of Agricultural Cooperative in Developing Countries.* Rome: Food and Agriculture Organization of the United Nation.

Eisenhardt, K. M. (1989). Building Theories from Case Study Research. *The Academy of Management Review, 14*(4): 532-550

European Commission. (2017). *CAP at a glance.* Retrieved June 13, 2017, from https://ec.europa.eu/agriculture/cap-overview_en

Fairchild, M. (2003). Skilled Specialization: *A Study in the Metal trades Part 1 The Nature and Measurement if Skill*. London: Routledge.

Fan, T. K. (2013). Smart Agriculture Based on Cloud Computing and IOT. *Journal of Convergence Information Technology, 8*(2). doi: 10.4156/jcit.vol8.issue2.26

Fisheries Research and Development Center. (2013). *Catfish Farming*. Retrieved October 30, 2017, from http://www.fisheries.go.th/if-suratthani/1planile.htm

Freshwater Fisheries Research and Development Center. (2017). *Catfish Raising*. Retrieved from http://www.fisheries.go.th/ifkorat/index.php?option=com_content&view=article&id=26:2009-09-09-08-36-02&catid=1:2009-08-04-06-15-39&Itemid=51

Jitsanguan, T. (2000). *Sustainable Agriculture Development: An Analysis of Economic and Social Factors*. The 1st National Seminar on Agriculture in Bangkok, 15-17 November 2000.

Jintana, A. (2013). *Business Finance (Capital Budgeting)*. Bangkok: Triple Education.Kuhlman, T. & Farrington, J. (2010). What is Sustainability? *Sustainability, 2,* 3436-3448, doi:10.3390/su2113436

Kunawongkrit., A. (2017). *Sufficiency Agriculture or Agro-Industry*. Retrieved June 13, 2017, from http://www.cusar.chula.ac.th/index.php/article/15-2013-03-11-08-57-53

Ministry of Foreign Affairs. (2007). *Sufficiency Economy Philosophy: Thailand's Path towards Sustainable Development Goals.* Bangkok: Office of the National Economic and Social Development Board

Google My Maps. (2017). *ร่างผังเมืองรวมกรุงเทพมหานคร (ปรับปรุงครั้งที่ 3) เขตลาดกระบัง.* <https://www.google.com/maps/d/viewer?mid=1jujBDhuG1bnQVKdynfY9tCdXRL4&hl=en_US&ll=13.780254092373466%2C100.92347929043478&z=11 > [Viewed 7 June 2017].

Jamlong, P. (2007). *Environmental Project Management*. Bangkok: Thippanate Publishing.

Jindarat, S. & Wuttidittachotti, P. (2015). Smart farm monitoring using Raspberry Pi and Arduino. *International Conference on Computer, Communications, and Control Technology (I4CT)*, Kuching, pp. 284-288.doi: 10.1109/I4CT.2015.7219582

Johnson, R., & Monke, J. (2017). *What Is the Farm Bill*? Retrieved June 13, 2017, https://fas.org/sgp/crs/misc/RS22131.pdf

Joseph, S. W, Harry, P. H., & Kathryn, E. N. (2010). *Handbook of Practical Program Evaluation.* San Francisco: Jossey-Bass.

Kaewmard, N. & Saiyod, S. (2014). Sensor data collection and irrigation control on vegetable crop using smart phone and wireless sensor networks for smart farm. *IEEE Conference on Wireless Sensors (ICWiSE)*, Subang, 2014, pp. 106-112.

Land Development Department. (2017). *The survey of land use types in the year 2015/2016*. Retrieved June 13, 2017, from http://www1.ldd.go.th/WEB_OLP/result/luse_result58-59.htm

Luke, M. (1994). *Ecology and Society an Introduction.* Cambridge: Blackwell.

Malhotra, N. K., & Birks, D. F. (2007). *Marketing research: an applied approach* (3rd European ed). Prentice Hall/Financial Times, Harlow

Mason, J. (2003). *Sustainable Agriculture*. Collingwood, Vic: CSIRO Publishing.

Meadows, R. (2012). Research news sidebar: Farm Smart offers hands-on experience, insight into where food comes from. *California Agriculture*, *66*(4).

McDermott, K. (2016). How smart farm technology is transforming agriculture. *Rural Telecommunications, 35*(4), 17-20. Retrieved from https://search.proquest.com/docview/1806994286?accountid=44809

McRobie, G. (1981). *Small is possible.* New York: Harper & Row

Michael, J. O'Grady & Gregory, M.P. O'Hare. (2017). Modelling the Smart Farm. *Information Processing in Agriculture*. DOI**:** 10.1016/j.inpa.2017.05.001

Ministry of Agriculture and Cooperatives. (2017). Smart Farmer and Smart Officer Retrieved June 30, 2017, http://www.thaismartfarmer.net/

Ministry of Agriculture and Cooperatives. (2017). *Agriculture Minister urges all agencies to in 2018 and delivered 15 hosted agencies, according to key policies under the budget of more than 55 billion, aimed solving agricultural problems in inappropriate areas go together with agriculture 4.0.* Retrieved October 30, 2017, from https://www.moac.go.th/news-preview-391691791819

Mongsawad, P. (2010). The Philosophy of The Sufficiency Economy: A Contribution to The Theory of Development. *Asia-Pacific Development Journal*, 123-143.

National contest awards smart farm marketers. (1993). *AgriMarketing, 31*(3), 71. Retrieved from https://search.proquest.com/docview/214013286?accountid=44809

National Statistical Office. (2014). *The agricultural census throughout the kingdom in 2013.* Bangkok: National Statistical Office.

National Statistical Office. (2014). *2013 Agricultural Census Whole Kingdom*. Retrieved June 30, 2017, from http://popcensus.nso.go.th/web/kaset/

National Statistical Office. (2017). *Summary of the Labor Survey in 2017*. Retrieved June 30, 2017, from http://www.nso.go.th/sites/2014

Neil, C. (2007). *The Politics of the Environment*. Cambridge University press: New York

Nishant, K. V., & Adil, U. (2016). Internet of Things (IoT): A relief for Indian farmers. *2016 IEEE Global Humanitarian Technology Conference (GHTC)*, Seattle, WA, 2016, pp. 831-835.

Phikulthong, K., Suparat, J., & Phithoon, P. (2003). *A Study of Farmers' Views on Income Stability of the Philosophy of Sufficiency Economy.* Bangkok: Ministry of Social Development and Human Security

Pollution Control Department. (2009). *Water Quality Standards*. Retrieved October 30, 2017, from http://www.pcd.go.th/info_serv/reg_std_water01.html

Provincial Electricity Authority. (2017). *Electricity Pricing System.* Retrieved March 3, 2018, from https://www.pea.co.th/webapplications/CheckRate/checkrate.html

Quang Tran Minh, Trong Nhan Phan, Akihiko Takahashi, Tam Thai Thanh, Son Nguyen Duy, Mong Nguyen Thanh, Chau Nguyen Hong. (2017). *A Cost-effective Smart Farming System with Knowledge Base*. SoICT 2017 Proceedings of the Eighth International Symposium on Information and Communication Technology Pages 309-316

Raiprakobsub, T. (2013). *Political System, Economy, Trade Liberalization with Agricultural Policy in Southeast Asia*. Bangkok: Faculty of Public Administration National Institute of Development Administration

Relf, T. (2016). Think smart to find the best plan for your farm. *Farmers Weekly, 166*(11), 3. Retrieved from https://search.proquest.com/docview/1841109374?accountid=44809

Research Management and Quality Assurance Division. (2016). *Thailand 4.0 Models Drive Thailand to Prosperity, Wealth and Sustainability*. Retrieved June 13, 2017, www.libarts.up.ac.th/v2/img/Thailand-4.0.pdf

Ryu, M., Yun, J., Miao, T., Ahn, I. Y., Choi, S.C., Kim, J. (2015). *Design and Implementation of a Connected Farm for Smart Farming System*. In: SENSORS, 2015 IEEE, 1–4 doi: 10.1109/ICSENS.2015.7370624

Stuart, R. C. (1982). *The Collective Farm in Soviet Agriculture.* Canada: D.C. Heath and Company.

Somphot, K., & Wisakha, P. (2007). Analysis of Business Management and Environmental Management in Sufficiency Economy by Using Input-Output Table Model, Principles of Mass Balance, and Industrial Ecology. *NIDA Development Journal, 47*(3), 141-165.

Sophon Chomchan. (2014). *Thailand's Agricultural Policy Dynamics: History From Past to Present.* Bangkok: The Thailand Research Fund

Thailand Board of Investment. (2017). Thailand 4.0 Means Opportunity Thailand. *Thailand Investment review, 27*(1):3-4.

The Chaipattana Foundation. (2017). *Philosophy of Sufficiency Economy.* Retrieved June 13, 2017,http://www.chaipat.or.th/chaipat_english/index.php?option=com_content&view=article&id=4103&Itemid=293

The Government Public Relations Department. (2017). *Intelligent SMEs and Smart Agriculture in Response to Thailand 4.0 Policy*. Retrieved May 30, 2017, from http://thailand.prd.go.th/ewt_news.php?nid=4731&filename=index

The Office of Agricultural Economics. (1992). *Agriculture in Thailand*. Bangkok: The Office of Agricultural Economics

The Office of Agricultural Economics. (2015). *Preparation of Smart Farmer with access to "Thailand 4.0"*. Retrieved May 30, 2017, from http://www.oae.go.th/ewt_news.php?nid=23177&filename=index

The Office of Agricultural Economics. (2017). *Agricultural statistics of Thailand in 2017*. Bangkok: Information Technology & Communication Center, Department of Agricultural Extension.

The University of New England. (2017). *About the SMART Farm*. Retrieved May 30, 2017, from http://www.une.edu.au/research/research-centres-institutes/smart-farm/about-the-smart- farm

United Nations Development Programme. (2010). *Handbook for Conducting Technology Needs Assessment for Climate Change*. New York: UNDP

Vinod, S. & Sahadev, R. (2016). Advance Agro Farm Design with Smart Farming, Irrigation and Rain Water Harvesting Using Internet of Things. International *Journal of Advanced Engineering and Management, 1* (1), 33 – 45

Whiteside, M. (1998). *Living Farm Encouraging Sustainable Smallholder Agriculture in Southern Africa.* London: Earthscan Publication Ltd.

Yermak, S. O., & Bugaenko, O. V. (2016). *Implementation of Innovative Development Strategy of a Dairy Enterprise Based on A Smart Farm Concept. Aktual'Ni Problemy Ekonomiky = Actual Problems in Economics*, (186), 138-146. Retrieved from https://search.proquest.com/docview/1857278113?accountid=44809

Yin, R. K. (2009). *Case study research: Design and methods* (4th Ed.). Thousand Oaks, CA: Sage.

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