CHALLENGES AND OPPOTUNITIES OF SMART FARMING IMPLEMENTATION

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ABSTRACT

Smart farming is the concept of utilizing science and technology to apply in agriculture, which can improve the productivity and efficiency of the farm also reduce the cost. Most populations in Thailand involved with agriculture, which mostly runs the farm traditionally. Thai farmers rarely adopt the concept of smart farming. So this thematic paper studies the barriers that obstruct smart farming adoption and provide the recommendation to overcome those barriers

This thematic paper analyses the key stakeholder involve with smart farming implementation then collect data from each group of key stakeholders by using the semi-structured interview to identify the barriers and provide the recommendation.

This study reveals that the barriers that obstruct farmers on the implementation of smart farming are the capital investment concern and complexity of the smart farm system. So the proposed recommendations are to provide the farmer with special loan with specific detail requirement for implement the smart farming which include training and distribution the knowledge to other farmer and to design the smart farming system in the modular concept which expect to be easier to use and maintenance.

KEY WORDS: : smart farm/ innovation adoption/ agricultural technology

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CHAPTER I
INTRODUCTION

1.1 Introduction

Technological innovation is generally recognized as a vital component in business to catching-up with higher efficiency, higher productivity, and optimize production cost. Agriculture, in particular, its main product is food feeding to the global population. The agricultural field's innovation plays a crucial role in delivering agrarian products more efficient and productive. This agriculture development has to cat-up future food demand. The food demand will increase significantly to feed the global population in 2050; food production must increase by 70%, which implies that future increases must find climate-smart methods and inputs (Bogdanski, 2012).

Smart farming, also called digital agriculture(Liang et al., 2002) agriculture 4.0 (Klerkx and Rose, 2020) or data-driven farming (Eastwood et al., 2019), is one of technological innovation adoption in agricultural segment. It is an integration of the digital process. One of the most important global transformation processes(Rohleder and Krusken, 2016) and agrarian knowledge aim to increase the productivity and efficiency of the agricultural product, thereby contributing to sustainable development (EL Bilali and Allahyari, 2012). Smart farming relies on past, and real-time data collected through heterogeneous sources and aims at providing context- and situation-awareness throughout data analysis base on agricultural knowledge. The practical, specific and target-based solution is the outcome from implementing the smart farming

Thai Government has seen the importance of smart farming. The smart farming has been inserted in the 12th national economic and social development plan(2017-2021) and The twenty-year agricultural and cooperative strategy(2017-2036). With the goal “Thai farmers escape from the Middle-Income trap by having the average National Income per head of more than 13,000 US$ or 390,000 baht in the year 2036”(Thai Government,2017) throughout this goal there are 4 elements of development i.e., Farmers specialize in their professions. (Smart Farmer), Farmer

institutions have efficiency in management(Smart Agricultural Group), Quality of agricultural product serve customers need. (Smart Agricultural Product) and the Agricultural area and sector have potential. (Smart Area / Agriculture).Thus, the Thai Government has focus and pay attention to smart farming promotion and support among Thai farmers.

However, from general observation, the smart farming diffusion speed is quite slow among Thai farmers. Most Thai Farmer still operate their agricultural farm conventionally. This slow diffusion creates substantial opportunity loss on enhancing the productivity and efficiency of agricultural supply to capture the increasing demand for agricultural products (Bogdanski, 2012). Overall the slow diffusion of smart farming negatively impacts Thai Economic growth as it obstructs the potential of rising farmer income as 40% of farming households surveyed earned an annual income below the country's poverty line(Wisanu, 2018). The slow diffusion of smart farming obstructs the development of further associated innovation and technology, such as software, application, and intelligent accessory equipment. With the low number of users, it would not be economically satisfied. Thus, this study is conducted to identify barriers and its causal relationship to the implementation of smart farming with the analysis mainly based on the theory of diffusion of innovation. The research methodology is conducted via interview two groups of farmers who implement smart farming and have never implemented smart farming to contrast and identify the barriers of implementing smart farm. The interview result will be analysed and propose appropriate and effective ways of promoting smart farming.

1.2 Research questions

1. Who is the key stakeholder involved in smart farming implementation.
2. What is the barrier of diffusion smart farming implementation.
3. What should be the recommendation to promote smart farming.

CHAPTER II
LITERATURE REVIEW

2.1 Diffusion of innovation(DOI)

From the literature review on "Detailed review of Roger's Diffusion of innovation theory and educational technology-related studies based on roger' theory " done by Ismail , 2006

The theory of diffusion of innovation was established by Everett Rogers in 1962. It originated in communication to explain how, over time, an idea or product gains momentum and diffuses through a specific population or social system. The outcome of this diffusion is that people, as part of a social system, adopt a new idea, behavior, or product. Adoption means that a person does something differently from what they had previously did (i.e., purchase or use a new product, acquire and perform a new behavior, etc.).

2.1.1 Innovation adoption

The adoption of a new idea, behavior, product or innovation happen differently among people in the social system .Some people has more ability to adopt the innovation than others. Researchers have found that people who adopt an innovation early have different characteristics than people who adopt an innovation later. When promoting an innovation to a target population, it is important to understand the characteristics of the target population that will help or hinder adoption of the innovation. There are five established adopter categories, and while the majority of the general population tends to fall in the middle categories, it is still necessary to understand the characteristics of the target population as different strategies used to appeal to the different adopter categories. Rogers ascribes different characteristics to each adopter category

Innovators, these are people who want to be the first to try the innovation. They are venturesome and interested in new ideas. These people are very willing to take risks, and are often the first to develop new ideas.

Early adopters, these are people who represent opinion leaders. They embrace leadership roles and change opportunities. They are aware of the need to change thus, they are very comfortable adopting new ideas. Strategies to appeal to this population include how-to manuals and information sheets on implementation. They do not need information to convince them to change.

Early majority, these people are rarely leaders, but they do adopt new ideas before the average person. That said, they typically need to see clear evidence that the innovation works before they are willing to adopt it. Strategies to appeal to this population include success stories and evidence of the effectiveness of innovation.

Late majority, these people are skeptical of change, and will only adopt an innovation after it has been tried by the majority. Strategies to appeal to this population include information on how many other people have tried the innovation and have adopted it successfully.

Laggards, these people are bound by tradition and very conservative. They are very skeptical of change and are the hardest group to bring on board. Strategies to appeal to this population include statistics, fear appeals, and pressure from people in the other adopter groups.

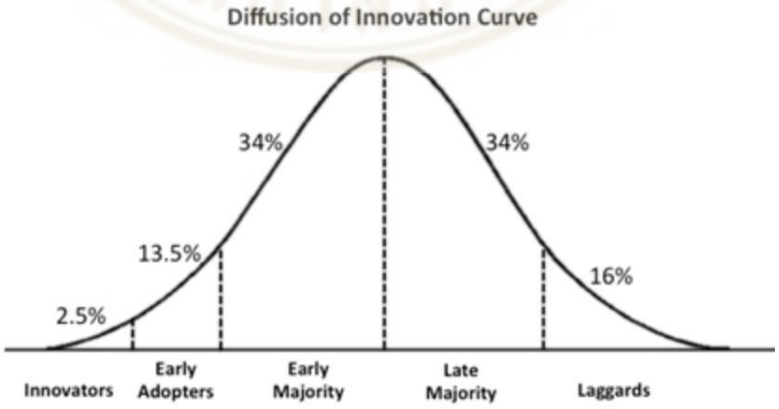

Figure 2.1 The innovation adoption curve

2.1.2 Innovation-decision process

According to Roger's Diffusion of innovation theory, he describes the innovation-decision process as information-seeking and information-processing activities. The decision maker(innovation adaptor) is motivated to reduce uncertainty about the advantage and disadvantage of an innovation. There are five steps involve in innovation-decision process which are knowledge , persuasion, decision, implementation and confirmation.

Knowledge, in this stage the decision maker learn the existence of innovation and seeks information about that particular innovation on what?, how? And why?. During this phase decision maker attempt to determine what is the innovation? , how and why does it work?.

Persuasion, in this stage, it will involve with the positive or negative toward the information. The individual is ascertaining the potential value of adopting an innovation, and further exploring its capabilities.

Decision, in this stage the decision maker decide either to adopt or reject the innovation. During this stage sometimes require a reference or the participation/input of a senior leader or experienced person.

Implementation, it is the process of transform the innovation into practice. There still have a certain degree of uncertainty toward the outcomes of the innovation and whether to keep it as opposed to reverting backward to old practices.

Confirmation, this is the final stage in the process which the individual seeking for supportive confirmation on his decision. In a formal project management methodology, the confirmation stage is simply an evaluation based on whether the criteria initially set up for the project has been met or not.

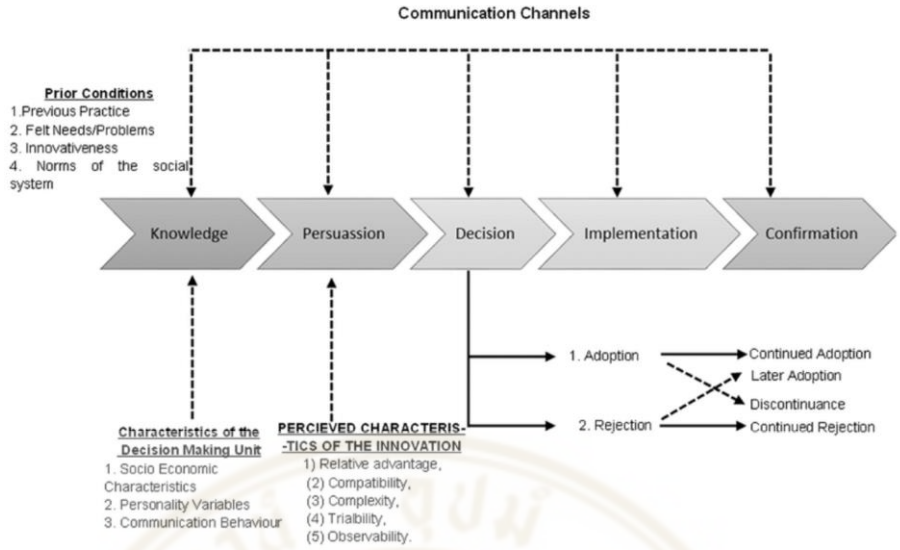

Figure 2.2 Innovation adoption process

2.1.3 Influence factors toward innovation adoption

The stages that a person adopts an innovation, the diffusion is accomplished. It includes awareness of the need for an innovation, decision to adopt (or reject) the innovation, initial use of the innovation to test it, and continued use of the innovation. There are five main factors that influence adoption of an innovation.

Relative Advantage, the degree to which an innovation is seen as better than the idea, program, or product it replaces.

Compatibility, how consistent the innovation is with the values, experiences, and needs of the potential adopters.

Complexity, how difficult the innovation is to understand and/or use.

Triability, the extent to which the innovation can be tested or experimented with before a commitment to adopt is made.

Observability, the extent to which the innovation provides obviously tangible results.

2.2 Smart farming innovation

From the literature review on “Internet of Thing in arable farming: Complementation, application, challenge and potential ” done by Andres et al , 2019.

Smart Farming is developed beyond the concept of precision agricultural which base its management on the scientific measurement, acquiring necessary data and process those data and integrated to agricultural knowledge in order to deliver effective and specific solution. Additionally smart farming usually incorporate intelligent service for applying and managing information and communication technology in farming allow transvers integration throughout the whole agricultural chain in regard to food safety and trackability (Sundmaeker et al, 2016). Internet of Thing (IOT) the crucial technology in smart farming it establishing the connection among the sensor , transmitter , processor and actuator. This connection add value to the obtained data through automatic processing.

The benefit of implement smart farming could be presented through three categories which are timely effective management, cost-effective production and enhance management effort in the farm

Timely effective management , smart farming innovation help farmer reduce working time by replacing manpower with the automation system and another aspect smart farming enable the reduction of inherent environmental impact through the real time reaction to alarm function such as pest or disease detection.

Cost-effective production , by implementing smart farming it could reduce number of manpower and effectively control on the parameter that affect the growth of agricultural product result in higher quality and more consistent of the product which result in enhancing farmer wealthy.

Enhance managerial effort on the farm , remote accessing and real time monitoring which are parts of smart farming help farmers to spend less effort to control and monitor activities in their farm. Farmers can spent their available time to other higher value add activities.

2.3 The conceptual Frame work

To deep understand and explore factor that might be the barrier of diffusion smart farming implementation, as per the diffusion of innovation theory which explain on which element potentially being the barriers to the diffusion of innovation which are Relative advantage, Compatibility , Complexity, Trialability, and Observability and

in which step of innovation decision process that mission cause the reject of adoption an smart farming The interview will be conducted two group of farmers who implement the smart farming and another group who does not implement the smart farming. The contrast interview result will be analyzed and the propose the recommendation.

CHAPTER III
RESEARCH METHODOLOGY

This research is a qualitative study to identify the key stakeholder of smart farming implementation, explore a deep understanding on the barriers that obstruct the diffusion of smart farming innovation base on The theory of diffusion of innovation through the five basic attributes i.e., relative advantage, compatibility, complexity, trialability, and observability. Then propose the solution to improve the diffusion of smart farming among farmers.

The researcher selected the qualitative study as would like to understand the in-depth information from the key stakeholders to understand their aspect of barriers toward the implementation of smart farming. The qualitative study in this research was conducted through the semi-structured interview. It can reveal the insight of their concern, which they can communicate during the interview. Also, most of the farmers live in rural areas where the communication may be able to reach them properly, and they are not familiar with the formal survey so they may get lost or in doubt to answer the questionnaire correctly, which may lead to the incorrect conclusion. The interview

Five steps in sequence could order the step of this research. Firstly, conducting the key stakeholder's analysis to identify who is involved with implementing smart farming based on the component that the farmer who wants smart farming system would like to have before implementation. The assumption was set as they may need the following support aspect i.e., fund, knowledge, example, and product. The stakeholder analysis provided the role of those key stakeholders, the interest of key stakeholders on smart farming implementation, and their concern toward the implementation of smart farming.

Secondly, the researcher generates the interview questions, which has corresponding with the five essential characteristics of an innovation for each group of key stakeholders. The interview is designed to collect the data using the semi-structured script. There are five questions that directly or indirectly five basic characteristics an

innovation for each group; however, during the interview, the ongoing interviewer can pick the interesting issue that the interviewee expresses to ask further questions to capture more in-depth detail.

Thirdly, the researcher conducts the interview one-on-one, face-to-face, or telephone-based on the interviewee's availability. The number of interviewees will be 3-10 persons per group of key stakeholders. The interview is recorded and transcript.

Fourthly, for data analysis, this research uses content analysis to group the content in the same categories or have a relationship with each other. Then, analyze that information based on the five basic characters of innovation and innovation decision-making process and synthesize the result to answer the research questions. Then conducts a conclusion of the result.

Fifthly, based on the conclusion of the previous step, this information will be used as a direction to improve the diffusion of innovation. The synthesis will conduct base on the conclusion, the theory of diffusion of innovation corresponding with the insight of the answer from the interview. Then propose the driver to promote smart farming.

CHAPTER IV
RESULT AND DATA ANALYSIS

4.1 Key stakeholder analysis on smart farming implementation

As per the planned methodology, the first step of this research is to conducting stakeholder analysis base on the process of implement a smart farming from zero to successfully. The result of key stakeholder , their roles , their interest and their concern

Table 4.1 Stakeholder analysis of smart farming implementation

Key Stakeholders	**Role in smart farming implementation**	**Stakeholder 's interest**	**Key concern toward smart farming implementation**
Fund Provider	Provide fund to framers for smart farming implementation	Interest from the loan	Farmer unable to pay back the loan and interest.
Knowledge Influencer	Provide knowledge of smart farming	Fulfil their career description	Knowledge or communication may not attractive by farmers
Smart farming technology provider	Provide consultancy and Provide equipment and construction	Consultant fee and price of product sell	Farmers may decide not to implement smart farming
Farmer who already implement smart farming	Being a role model and example for farmer who not yet implement smart farm yet.	Reputation of success	No.(This group have already implemented smart farming)
Farmer who not yet implement smart farming	Making decision whether or not to implement smart farming.	Productivity and efficiency improvement	The expected outcome of implement smart farming and the learning curve of smart farming

From the analysis, found that there are five key stakeholders involving with the process of smart farming implementation, which are Fund provider, Knowledge influencer, Smart farming technology provider, Farmers who already implement smart farming, and Farmer who not yet implement smart agriculture.

Fund providers play the role of providing financial support to the farmers who would like to implement smart farming, but they do not have sufficient money to start smart agriculture. The example of this stakeholder is the bank, which supports by the government, such as Bank of Agricultural and Cooperative(BAAC). BAAC has one of the tools that Thai government use to drive the twenty-year agricultural and cooperative strategy(2017-2036) by providing a fund to the farmer who interests in smart farming with special interest rate.

Knowledge influencers are the person in an academic institute or research institute who knows about smart farming and diffuse the smart farming knowledge to the farmer though several of channels such as training class, research publishing, online knowledge sharing. These people play an important role in making the farmer aware of the new technology and its benefit toward their current work.

Smart farming technology providers are the company who can provide the technical support both hardware and software to the farmers who want to implement the smart farming. Without this stakeholder, the smart farming would be just a concept or dream for farmers. This group of stakeholders has the highest interest to the smart farming implementation because they can gain direct benefit from selling the equipment, software, and charging the consultancy fee.

The farmers who already implement smart farming play the role of role models for farmers who want to start smart farming. The farmers who want to start smart farming generally will go to visit and discuss with this group of stakeholders to see the actual result of smart farming and collect information for making decisions on whether or not to implement smart farms at their own farm. This group of stakeholder can play the same role as knowledge influencer since some of them can diffuse the knowledge of smart farming among the farmer's network however the knowledge spread from this group are generally the actual result and operational practice on smart farming which differ from knowledge influencer which their diffused knowledge mainly focused on the academic expertise.

The farmers who not yet implement smart farming, this group of farmers plays an essential role in smart farming implementation. They have to make decisions on whether to continue their farming in the traditional way or change to implement smart farming.

4.2 Fund provider

The researcher conducted a semi-structured interview with Bank of Agricultural and Cooperative's manager and loan officer. The interview result reveals that as BAAC is a government bank to promote the intelligent farming as per the twenty-year agricultural and cooperative strategy(2017-2036) by providing financial support with the special interest rate for the farmer who asks for the fund to implement smart farming or extend the value-added process to the existing agricultural product. The criteria to approve the loan to smart agriculture quite the same as general agricultural loan which the bank have to strictly consider through 4 elements, i.e., financial, accounting, marketing, and management aspect.

According to the interview, the result found interesting aspects which are most of the loaner for smart farming is the new generation their age is approximately less than 35 years old. Notable quote.

"More than half of our customers who interest to get the loan for smart farming is the young generation and their family originally the farmers who still doing the farm in the traditional way (BAAC Manager)"

The young generation aware of the gap in their existing traditional auricular farm and believes that this gap can be closed by implementing technology because they dare to come to the bank to ask for the loan for their ideas. While the old generation who have worked traditionally for a long time, but they overlook the gap in their work or do not believe that it can be improved.

The initiative of need the loan for smart farming is mostly come from seeing closed people or people in the same community did and they success by increasing the productivity on their farm or reduce the cost of production so the farmers would like to do it in the same way. Notable quote.

"Most of farmers who interest to get the loan in the smart farming told me that they have seen their friend or people in their community has done this smart farming or apply technology into their farm and they success so they would like to do so(BAAC Manager) "

By seeing the actual success of implement smart farming from people in the same area are the critical factor that the farmer could use to deciding whether or not to process starting smart farming. According to Roger's theory of diffusion of innovation, this point align with one of the influential factors toward innovation adoption, which is observability. The farmers will have more confidence from seeing the real success of smart farming in their community than receive information from other channels.

4.3 Knowledge influencer

The researcher conducted a semi-structured interview with one of the university lectures and two academic institution researchers. They have their work on spreading out the knowledge of smart farming into farmers groups.

From the interview, three knowledge influencers, most of the farmers who interest in smart farming are contact-farming farmers and young generation farmers.

"There are three groups of farmers who interest in smart farming i.e. contact-farming farmers around 75%, new generation farmer around 20% and wealthy person who want to avoid land tax around 5% (University lecturer)"

Most of the farmer who interests in smart farming is contact-farming farmers. This group of farmers has contact with the factory to deliver a quality product with a written qualification. Hence, the farmer needs to merchandise their product to achieve and sustain the quality; otherwise, their product price will significantly deduct its price. So, in this case, smart farming plays a crucial role in quality improvement and consistently maintains the quality of the product. The written qualification creates the need for smart agriculture, this point aligns with one of the influences of innovation adoption factor as per Roger's theory of innovation diffusion which is the relative advantage so if there is no qualification requirement, the need for smart farming will not aware and meet. The qualification of agricultural products could be one of the tools that initiate the relative advantage throughout contact-farming or other relation; the farmers

need to find the way to meet the industry or manufacturer qualification, then they can decide easily to implement smart farming

4.4 Smart farming technology provider

The researcher conducted a semi-structured interview with three business owners who are the technology provider for agriculture. Two of them are the technology provider for shrimp farms, while another one is the automatically watering boat manufacturer.

The concern toward the implementation of smart farming is the capital investment since the technology for smart farming is quite expensive and requires big upfront payment and farmers may not believe in the outcome..

"There are some cases that the farmers who interest in my product decide to reject after I inform him on the product price (automatically watering boat manufacturer)"

According to the result, it could be implied that the farmer has insufficient capital to invest in this equipment. Hence, they decide to reject the product; however, it could be meant that the farmers do not believe strongly enough to invest in this equipment because, in fact, the farmer can get the loan from the bank, but they decide not to go on this way. So the confidant on the result of smart farming has more importance their capital investment needed to implement smart farming because the insufficient capital can be dissolved by an agricultural financial loan which supports by the government through BAAC.

The proper use of technology will impact on the result. So the competence of the user is important as well since the incorrectly use will lead to an unsuccessful result and eventually demotivate farmers to implement the smart farming or event implement but not a success so the farms will have bad impression on smart farming and widespread their bad impression to other farmers.

"There are some cases that the farmer decide to reject my product after free trial period because they receive bad output after I investigate the result actually cause from their worker not follow the procedure (Shrimp farm technology provider#01)"

The involved influence factor of innovation adoption, as per Roger's theory of innovation diffusion are trialability and complexity. In this case, the technology provides try to offer their product to the farmers for the trail with the certain period before deciding on whether or not to purchase the technology this offer create the trialability which is one of the influence factors toward the innovation adoption it could be an opportunity to use the technology and getting the result during this trial period they can realize the usefulness of the technology on productivity improvement. However, the complexity of the technology needs to be dissolved as the worker who is the user may not clearly understand and not follow the procedure case the result turn out not as good as it could be.

4.5 Farmers who already implement smart farming

The researcher conducted a semi-structured interview with four farmers who already implement smart farming. Two of them are the owner of smart pig farm, one of them is a banana farmer which utilizing the automatically watering boat, and another one is a shrimp farm owner.

The need to implement the smart farm from the interview is categized into two aspects. Firstly the quality requirement of the agricultural product and the perving value of effort spending on farming work. The quality requirement is the result of contact-farming, which the factory will set the quality required to the farmer. Contact-farmer need to try their best to achieve the requirement with the advisory provide from the contact company, so the farmer feel like they have the trustable consultant this offer make farmer gain the confidence on the success of implement the smart farm.

"Nowadays farmers in this area nobody does the farm traditionally. They mostly do an evaporative cooling system (EVAP) farm for contact-farming deliver the pig to the factory. If we are doing the pig in traditional farming, it is risky to meet the factory requirement. The company will give us the piglet and give the consultancy on the vaccine and feeding "(Pig farmer#1)

The relative advantage of smart farming is occurred to achieve the quality requirement so the farmer willing to invest in the smart farming event though it needs an expensive capital requirement approximately 4-5 million bath/ farm, they believe that

it will pay back in a certain period, so they decided to start to implement this innovation by asking the loan for investment.

Another reason for relative adventive throughout technology adoption is the value of effort in the young generation, and the old generation is different. In the young generation, they value their effort to spend on farm work quite high. So they look for the opportunity that can reduce their effort spent on the farm work then they can use the surplus effort to spend on other valuable stuff.

"Personally, when I do the farm work, it is so tried so if I can do something on the smart machine to replace my manual work I will do that "(Banana Farmer#1)

The relative advantage of smart farming occurs to fulfill the need to reduce the effort in farm work, which the young generation value quite high. In contrast, the old generation is familiar with the hard work on the farm, and seeing this hard work is not an issue; it is the norm for a farmer. This aspect is interesting one of this study so the need for innovation adoption has to be thinking in terms of pain point solving. The young generation farmer is seeing that the effort on-farm work is the pain point for them, but the old generation does not see that it is a problem, so the adoption of innovation on smart farming in the young generation is higher than in an old generation.

4.6 Farmer who not yet implement smart farming

The researcher conducted a semi-structured interview with four farmers who were still doing the farm traditionally. Two of them are coconut farmers, one of them is shrimp farmers, and another one is a rice farmer.

According to the interview, three out of four farmers have the same concern about smart farming implementation. It is about capital investment, and the expected result may not be good as expected, so they hesitate to decide to implement the innovation or technology on their farm.

"The reason that I do not adopt the smart agricultural machine is the concern on money investment. That machine is so expensive and I am not sure about the result. The result sometimes is difficult to expect since it influences the uncontrol factor in it.(Coconut farmer#1) "

The concern on capital investment in this group of farmers is the same as interview the technology providers group as the farmers not maturely confident about the outcome, so they decide it not to proceed to implement the smart farm

While shrimp farmer who is a new generation farmer expresses their rejection of the smart farm concept by precise analysis of the need to implement the smart farming concept with the support reason. Notable quote.

"The money to implement smart farming in my farm is not a problem but as the product of my farm is giant freshwater shrimp which the market has concern on the size of shrimp more than the number of shrimp per pound. The smart farming technology in shrimp feeding is suit to the farmers who feed the white leg shrimp which their concern is not the size of shrimp but it is the amount of shrimp per pound(Shrimp Farmer#1)"

According to the interview result, they were showing a proper analysis of smart farming need on his farm. He clearly understands the need to implement smart farming in the shrimp industry and able to review the need for this innovation on their farm. So the young generation farmers have access to media and ready to learn quickly on the technology and innovation related to their business. Also, they can analyze the result of implement smart farming whether or not it will reduce their pain point or improve their product quality. These processes of thought will make the young farmer making the right decision on smart farming implementation.

CHAPTER V
CONCLUSION AND RECOMMEDATION

5.1 Conclusion

The researcher can found two drivers to implement smart farming, which is the quality requirement of agricultural products and perceiving the value of effort in farm work.

The quality requirement of agricultural products is a powerful tool driving the farmer to decide to implement smart farming throughout the contact farming. As per the interview with two pig farmers who apply the smart farming concept in their farm the reasons that they decide to implement smart farming is based on the need for their product to pass the quality control of the factory. Throughout contact farming they can access the consultancy provided by the company in both animals feeding technical and management skills so they can gain more confidence on implement the smart farming event. However, they need to find out the capital investment via the bank loan; they are willing to do and confident with the outcome as they have known from the contract that if their product passes the criteria, they can sell to the factory at agreeing on a price then they can. So the quality requirement is one of the findings found in this study to drive smart farming implementation.

Another driver to implement smart farming is the perceiving value of effort spent on the farm work. According to the interview result of new generation farmer they have more concern on their effort spent on the farm work than the old generation do so the new generation farmer try to find the way to improve this issue by finding out innovation and technology to assist in term of reducing their effort on-farm work. The need for smart farming has occurred in this group of farmers. According to Roger's diffusion of innovation theory, the need for smart farming will fulfill the relative advantage which is one of the influential factors toward the adoption of innovation. This conclusion is aligned with the interview result from the fund provider and technology provider group as the majority of farmers who interest in smart farming are the new

generation farmers. The barrier that obstructs implement of smart farming is the concern on capital expected outcome and the complexity of the innovation.

The concern on capital investment is the factor that most of the interviewees answer as the barriers to obstruct adoption of smart farming. However deeply analysis the answer from interviewees founding the insight of the answer is they are not confident on the outcome of smart farming because if the actual problem is the capital investment concern the farmer can asking for the loan from the bank but in fact, they deny to go to the bank and reject the innovation adoption with the reason lack of capital investment. While another group of the interviewee who decided to implement pig smart farming event though they do not have enough capital investment they willing to loan from the bank because they are confident on the result that they will get after implementing the smart farming.

Another barrier is the complexity of innovation. In some smart farming systems, the complexity of innovation can create an obstacle to implement smart farming. From interview the technology provider group, there is some case that after the free trial period the farmer rejects the adoption of innovation because the bad outcome during the trial period but in fact, it was from unfollowing the right procedure.

5.2 Recommendation

According to finding found in this research, the quality requirement and the need to spend less effort in farm work in young farmer generation are the drivers to motivate the farmers to implement smart farming. In contrast, capital investment and complexity of use are the barriers that obstruct farmer to implement smart farming.

Base on the finding of drivers and barriers mentioned above so the government or concern parties should set up the project to promote smart farming implementation via offering the special loan for young generation farmer who interests in smart farming and has potential this will solve the found barrier on lack of investment. However, the project should be designed to focus on the young generation who has a family background in agriculture or has a strong inspiration to be a farmer this focus is based on the finding that most of the farmer's interest in smart farming is the young generation. The detail in this project should include the training on the smart farming

system which aim to train young generation on agricultural technology, economic analysis, and farm management, which are the essential matter toward sustainable agriculture. However, the old generation event they interest in smart farming less than the young generation. Still, they could involve in this project by sending the family member who is the young generation to be a family representative to attend the training before getting the loan. After the young family finishes the training, they can bring the knowledge that they have lean-to teach their family member accordingly. The detail of the offered loan will pay 50% after farmer completely passes the training then another 30% while the progress of smart farming implementation ongoing and another 20% will provide when there is a community member or visitor come to visit and register as a visitor at their farm at a certain number. This setup is to encourage other farmers to go and see the actual example, which aligns with the finding that most of the farmers will decisively make decisions when they can see the reality on the result. Also, the selection of participants is quite important because this project needs to aim for success, and the success case will be the role model in the community to allow others to follow.

Another recommendation is specifically focused on the technology provider group, which one of the essential parts of the smart farming implementation. From the finding, the complexity can be one of the reasons that cause the failure in smart farming implementation so the technology provider should produce their product in the way that farmer is easy to use. One potential solution is a modular concept which separates each system independently and each of them can connect to deliver what as per design so each part will separate function. This way will make farmer easier to use the system also when some system is broken it can be correctively maintained separately which will help to reduce the maintenance cost in the long run.

5.3 Limitation

The study was conducted for thematic paper for College of Management Mahidol University graduation requirement which could have credibility and trustworthiness toward interviewee; however, there are some limitations in this study.

Firstly, the definition of smart farming in this study is the utilizing of science and technology in agriculture. This study does not classify the level of utilization in agriculture.

Secondly, data collection through the interview will not cover all types of agricultural farms and all areas in the country, so the specific detail of each agricultural toward the implementation of smart farming is out of the scope of this study.

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APPENDICES

Appendix A: Interview Questions

Question for interview smart farm fund provider group

No	Questions
1	When there is a customer come to the bank asking for the loan for smart farming what kind of smart farming asper they normally do?
2	How does the farmer who come to the bank asking for a loan(for implement smart farming) explain to you on their need of a smart farming?
3	How does the bank evaluate the customer who asking a loan for implement smart farming and How the bank confident that the customer can pay back the loan?
4	If there any case that the farmer who intend to get a loan for smart farming implementing but finally they change their mind?
5	Who is the most customer (smart farming loan) that interest in a smart farming loan?

Question for interview smart farm knowledge influencer group

No	Questions
1	How do you explain the benefit of smart farming to farmers who interest?
2	Who is the majority group of people interest in smart farming?
3	Is there any case that the farmer interested in smart farming coming to get consult from you but finally they decide not to implement smart farming in their farm?
4	How does the framer who interest in smart farming need to have as a basic knowledge or infrastructure before implement smart farming?
5	How does the farmer who interest in smart farming do a research about farming before implementation

Question for interview smart farm technology provider group

No	Questions
1	How do you explain the benefit of smart farming to farmers who interest?
2	Who is the majority group of people interest in smart farming?
3	Is there any case that the farmer interested in smart farming coming to get consult from you but finally they decide not to implement smart farming in their farm?
4	How does the framer who interest in smart farming need to have as a basic knowledge or infrastructure before implement smart farming?
5	How does the farmer who interest in smart farming do a research about farming before implementation

Question for interview farmer group who already implement smart farm

No	Questions
1	Why do you think that smart farming is needed for your farm?
2	Do you have any concern on smart farming at the beginning? And how you manage it?
3	Why do you dare to implement the smart farming event it has a risk?
4	The result of implement smart farming is same as you expected before how?
5	When you have a smart farming system at your farm do you need to adapt anything during learning curve?

Question for interview farmer group who not yet implement smart farm

No	Questions
1	Do you think your productivity in your farm is in good level and do you think can it be better?

2	What do you fear or concern about smart farming? What do you do to reduce those concerns?
3	Have you ever heard about smart farming, how do you believe in the effective smart farming?
4	Why you select to operate your farm with the traditional way?
5	Have you ever visit the farm that implement smart farming or watch the media about that? What do you feel like?

Appendix B: Interview Transcription

1.Fund provider group

Interviewee number:1

Name: Mr.Nattapong Pornwuttiwet

Position: BAAC manager, Saiburi branch, Pattani

1. When there is a customer come to the bank asking for the loan for smart farming what kind of smart farming aspect they normally do?

Answer *"They mostly come to the bank with the idea to implement some technological equipment or some smart system such as solar cell system , smart watering system… to implement in their farm but need some budget to buy those that why they came to get the loan. "*

2. How does the farmer who come to the bank asking for a loan(for implement smart farming) explain to you on their need of a smart farming?

Answer *"Normally they explain that they see that idea from their friend or someone in their community and they think that it would be good if they make the same at their farm"*

3. How does the bank evaluate the customer who asking a loan for implement smart farming and How the bank confident that the customer can pay back the loan?

Answer *"The bank has a solid structure to evaluate to approve for the loan all branch need to follow the checklist. At BAAC there are many loan project so different campaign has different minor criteria so smart farming is one of the loan project at BAAC .Normally the bank will consider 4 aspects to approve the loan i.e. financial ,accounting, marketing, and management aspect."*

4. If there any case that the farmer who intend to get a loan for smart farming implementing but finally they change their mind?

Answer *"No I have not seen that before. I think when they come to the bank they would have a confident on their idea at some level so they might no change their mind"*

5. Who is the most customer(smart farming loan) that interest in a smart farming loan?

Answer *"More than half of our customers who interest to get the loan for smart farming is the young generation let say their age below 35 years old and their family originally the farmers who still doing the farm in the traditional way. they would like to continue their family business but do it in a better way"*

Interviewee number:2

Name: Ms. Natthanichar Siripraiwan

Position: BAAC Loan officer, Nakhon Ratchasima branch, Nakhon Ratchasima

1. When there is a customer come to the bank asking for the loan for smart farming what kind of smart farming aspect they normally do?

Answer *"They mostly come to the bank to get the loan for purchasing some technological agricultural machinery and another aspect would be the equipment for agricultural product processing "*

2. How does the farmer who come to the bank asking for a loan(for implement smart farming) explain to you on their need of a smart farming?

Answer *"The explain their need verbally normally they tell that they saw their fried or people in their village do this and they would like to do so"*

3. How does the bank evaluate the customer who asking a loan for implement smart farming and How the bank confident that the customer can pay back the loan?

Answer *"BAAC has the criteria to evaluate for loan approval this will apply same in all areas. The detail and special criteria of each loan project is announced from the head quarter."*

4. If there any case that the farmer who intend to get a loan for smart farming implementing but finally they change their mind?

Answer *"No, but some farmer may ask loan but if bank seeing that their loan need meet criteria of their proposed loan campaign so the bank will help putting that loan in correct project or campaign."*

5. Who is the most customer(smart farming loan) that interest in a smart farming loan?

Answer *"New generation which has their family background in agriculture .They want to enhance their family business"*

2.Knowledge influencer group

Interviewee number:1

Name: Mr.Skay Thepbun

Position: Researcher, The smart farm and agricultural solution, Maejo University.

1. How do you explain the benefit of smart farming to farmers who interest?

Answer *"Normally when we go to the farmer to introduce them on the smart farming system we will discuss the pain point of the traditional agriculture such as the intensive labor need to run the farm , high cost of labor.. we will explain them that the smart farming system will help them to overcome these pain point"*

2. Who is the majority group of people interest in smart farming?

Answer *"Most of them are new generation, who tired with the office work and retired person. Some of them has family background working in agriculture "*

3. Is there any case that the farmer interested in smart farming coming to get consult from you but finally they decide not to implement smart farming in their farm?

Answer *"No, when they interest in smart farming and come to consult one on one with us they will not change their mind I think once they decide to come to get consultancy with us they maturely want to implement smart farm so they will not change their mind "*

4. How does the framer who interest in smart farming need to have as a basic knowledge or infrastructure before implement smart farming?

Answer *"Their farm should have the basic infrastructure such as water system and electricity system in order to implement smart farming properly"*

5. How does the farmer who interest in smart farming do a research about farming before implementation ?

Answer *"I think no need any basic knowledge just need the interest they can lean. Our research unit provide the free training the farmer can attend , normally farmers will use the word of mouth to persuade other farmer to come"*

Interviewee number:2

Name: Asst. Dr. Chotpong Karnchanaprachote

Position: Lecture, Faculty of Engineering and agro-industry, Maejo University.

1. How do you explain the benefit of smart farming to farmers who interest?

Answer *"My research work is based on the actual problem in the farm so when I have to explain the farmer it will involve with the problem that they normally face"*

2. Who is the majority group of people interest in smart farming?

Answer *"There are three group of farmers who interest in smart farming i.e. contact-farming farmers around 75% , new generation farmer around 20% and wealthy person who want to avoid land tax around 5% (University lecture)"*

3. Is there any case that the farmer interested in smart farming coming to get consult from you but finally they decide not to implement smart farming in their farm?

Answer *"No, once they come to us they quite sure that they need the technology to help them"*

4. How does the framer who interest in smart farming need to have as a basic knowledge or infrastructure before implement smart farming?

Answer *"I think they should have a basic system such as watering system and has sufficient water resource also farmer need to have money as smart farm implementation require significant investment"*

5. How does the farmer who interest in smart farming do a research about farming before implementation ?

Answer *"80% from word of mouth with the farmer network and 20% from the social media or the internet "*

Interviewee number:3

Name: Mr. Narichphan Penpoldee

Position: Researcher, NECTEC

1. How do you explain the benefit of smart farming to farmers who interest?

***Answer** : " Our work is to study on what the farmer do and what is their problem then we research to provide the solution for them so our communication to them will include the existing problem and solution "*

2. Who is the majority group of people interest in smart farming?

***Answer:** "Mostly young generation because they have knowledge about science and technology"*

3. Is there any case that the farmer interested in smart farming coming to get consult from you but finally they decide not to implement smart farming in their farm?

***Answer** : "Yes, there are some cases that they are interesting in smart farming but they do not have enough money to do"*

4. How does the framer who interest in smart farming need to have as a basic knowledge or infrastructure before implement smart farming?

***Answer** : "I think they should have a water supply system which required for all agriculture and if they have the basic knowledge about electronic or electricity it would be good "*

5. How does the farmer who interest in smart farming do a research about farming before implementation ?

***Answer** : "Most of them use word of mouth means talking to other farmer and to get the knowledge"*

3.Technology provider group

Interviewee number:1

Name: Mr. Saitharn Mouangphongern

Position: Business Owner of Automatic watering boat, Nakhon Pathom.

1. How does the farmer who interest in smart farming they come to you and communicate their interest/idea?

Answer *"Farmers will call me directly as they can see my Facebook and YouTube they normally asking about the product function and price first."*

2. Is there any case that the farmer who interest in smart farming but finally they decide not to implement at their farm?

Answer " *"There are some cases that the farmers who interest in my product decide to reject after I inform him on the product price. But I do not know actually that my set price is too high or not*"

3. What is the fundamental knowledge or infrastructure that farmer need to have before implement smart farming ?

Answer *"It is not require much on the basic knowledge I try to design my product to be easy to use just push 2-3 bottoms only but they need to know the procedure to set up which I normally trained them when deliver the product"*

4. How do you train your customer on how to operate the system once install at their farm?

Answer *"Onsite training when deliver the product to them "*

5. How long of the learning curve for the farmer who just implement a smart farming system?

Answer *" Around 30 minutes"*

Interviewee number:2

Name: Mr. Thanongsak Jongsiri

Position: Business Owner of Hydro Thai (Smart water monitoring system), Bangkok.

1. How does the farmer who interest in smart farming they come to you and communicate their interest/idea?

Answer *"Farmers normally call me if they interest in my product most of them have seen my product from my Facebook"*

2. Is there any case that the farmer who interest in smart farming but finally they decide not to implement at their farm?

Answer *"There are some cases that the farmer decide to reject my product after free trial period because they receive bad output. After I investigate the result actually cause from their worker not follow the procedure. Mostly*

of the farmer is low skill labor so it is quite difficult for them to learn and understand how to use the technological equipment correctly"

3. What is the fundamental knowledge or infrastructure that farmer need to have before implement smart farming ?

Answer *"They should have known about smart phone using because my product need to run and control from smart phone"*

4. How do you train your customer on how to operate the system once install at their farm?

Answer *"I give them the user manual and VDO clip"*

5. How long of the learning curve for the farmer who just implement a smart farming system?

Answer *"About 1-2 hours for explain how to use but the set up I need to assist them do it at their farm"*

Interviewee number:3

Name: Mr. Wasanchai

Position: Business Owner of ASP control system (Smart watering system), Bangkok.

1. How does the farmer who interest in smart farming they come to you and communicate their interest/idea?

Answer *"Originally my company working on the control system then apply to the agriculture so it mostly about watering control , lighting control ,… so I have posted my VDO clips in YouTube if the farmer who are interested in my product they will call and asking for more detail "*

2. Is there any case that the farmer who interest in smart farming but finally they decide not to implement at their farm?

Answer *"Yes, there are some case that they do not have enough money to do."*

3. What is the fundamental knowledge or infrastructure that farmer need to have before implement smart farming ?

Answer *"They should have enough water resource. For the control side I try to design the product to be easy to use for them"*

4. How do you train your customer on how to operate the system once install at their farm?

Answer *"I will train the customer onsite our product is easy to use"*

5. How long of the learning curve for the farmer who just implement a smart farming system?

Answer *"Around 1 hour for onsite training is good enough for user"*

4. Farmer who already implement smart farming group

Interviewee number:1

Name: Mr. Choungchai Chaysamrong

Position: Farmer (Pig)

Location: Nakhon Ratchasima

1. Why do you think that smart farming is needed for your farm?

Answer "*Nowadays farmers in this area nobody does the farm in traditional way. They mostly do evaporative cooling system (EVAP) farm for contact-farming deliver the pig to the factory. If we doing the pig in traditional farming it is risky to meet the factory requirement. The company will give us the piglet and give the consultancy on the vaccine and feeding*"

2. Do you have any concern on smart farming at the beginning? And how you manage it?

Answer *"Yes I have a concern on capital investment as to build EVAP farm need a big money around 4-5 million so I have to thinking about the result. But the company I have a contact with make the economic analysis to estimate on that I will get so my concern is released a bit"*

3. Why do you dare to implement the smart farming event it has a risk?

Answer *"I think because I have seen the estimation that the company calculated for me so the result is so attractive that why I have to continue with them"*

4. The result of implement smart farming is same as you expected before how?

Answer *"It is same as I expected but at the beginning there are some small obstacle but finally we can overcome it"*

5. When you have a smart farming system at your farm do you need to adapt anything during learning curve?

Answer *"For myself no need to change anything much"*

Interviewee number:2

Name: Mrs. Suwanna Suwanprapaporn

Position: Farm Owner- Pig (Contract Farming)

Location: Nakhon Ratchasima

1. Why do you think that smart farming is needed for your farm?

Answer *"Because I do a contact farming the company I have a contact with suggest to do this way"*

2. Do you have any concern on smart farming at the beginning? And how you manage it?

Answer *"I concern about outcome the result may not be in the same way that we thought"*

3. Why do you dare to implement the smart farming event it has a risk?

Answer *"Actually I do not interest in farming but this business is legacy of my brother who start it but he accidently passes away. I have to decide whether to finish it or continue it so I decide to continue because it the financial benefit is so attractive"*

4. The result of implement smart farming is same as you expected before how?

Answer *"The result is very good beyond my expectation especially the revenue"*

5. When you have a smart farming system at your farm do you need to adapt anything during learning curve?

Answer *"Just learn how to operate the equipment which not so difficult for me also need to lean on how to control people who are my worker because I work in Bangkok but my farm is in Nakhon Ratchasima so I will have a chance to go to my farm during weekend during the working day need to rely on my worker"*

Interviewee number:3

Name: Mr. Saitarn Muangphongern

Position: Farm Owner- Banana

Location: Nakhon Pathom

1. Why do you think that smart farming is needed for your farm?

Answer *Personally when I do the farm work it is so tried so if I can do something on smart machine to replace my manual work I will do that"*

2. Do you have any concern on smart farming at the beginning? And how you manage it?

Answer *"I have concern about the investment since I am not a wealthy person"*

3. Why do you dare to implement the smart farming event it has a risk?

Answer *"I have a background in engineering so I confident that science and technology can help farm work become more easy"*

4. The result of implement smart farming is same as you expected before how?

Answer *"It is good as I expected I can have more relax time and spend it on other valuable stuff"*

5. When you have a smart farming system at your farm do you need to adapt anything during learning curve?

Answer *"Not much to adapt myself since this technology I have invent and produce it myself"*

Interviewee number:4

Group: Farmer who already implement smart farming

Name: Mr. Phankawee Aungmalee

Position: Farm Owner- Shrimp

Location: Chumphon

1. Why do you think that smart farming is needed for your farm?

Answer *"The smart farm will increase the productivity of my farm and reduce operation cost"*

2. Do you have any concern on smart farming at the beginning? And how you manage it?

Answer *"About money investment but I carefully do the economic analysis and evaluate the possibility base on my experience"*

3. Why do you dare to implement the smart farming event it has a risk?

Answer *"I have background in engineering so I believe that if you do the right thing at the right time it will turn out to be a good result"*

4. The result of implement smart farming is same as you expected before how?

Answer *"It is better than I expected now I can expand my farm more which gain mre me revenue and reputation"*

5. When you have a smart farming system at your farm do you need to adapt anything during learning curve?

Answer *"Not much, using this technology is not so complicated for me"*

5.Farmer who not yet implement smart farming group

Interviewee number:1

Name: Mr. Jirasak Meeyod

Position: Farmer (coconut, dragon fruit and mango)

Location: Chumphon

1. Do you think your productivity in your farm is in good level and do you think can it be better?

Answer *"Yes, it could be more productive and having a better performance"*

2. What do you fear or concern about smart farming? What do you do to reduce those concerns?

Answer *"As I know it require an expensive investment. I strongly believe that the technology will help to improve performance"*

3. Have you ever heard about smart farming, how do you believe in the effective smart farming?

Answer *"Yes I heard about it before and I believe that it truly helps to increase revenue for farmer"*

4. Why you select to operate your farm with the traditional way?

Answer *"The reason that I do not adopt the smart agricultural machine is the concern on money investment. Those machine is so expensive and I am not sure about the result. The result sometime is difficult to expect since it has an influence of uncontrol factor in it"*

5. Have you ever visit the farm that implement smart farming or watch the media about that? What do you feel like?

Answer *"Yes, once I heard I fill like it could be implemented at my farm but I have to think about financial investment"*

Interviewee number:2

Name: Mr. Anukul Yongsarn

Position: Farmer (Shrimp farm)

Location: Chumphon

1. Do you think your productivity in your farm is in good level and do you think can it be better?

Answer *"I believe that it can improve the production"*

2. What do you fear or concern about smart farming? What do you do to reduce those concerns?

Answer *"No worry at all, I have a background in farm machinery so I strongly believe that if we apply the technology in agriculture it would result in better performance"*

3. Have you ever heard about smart farming, how do you believe in the effective smart farming?

Answer *"Yes I have learned it in class as well when I was in the university so I strongly believe on its effectiveness"*

4. Why you select to operate your farm with the traditional way?

Answer *"The money to implement smart farming in my farm is not a problem but as the product of my farm is giant freshwater shrimp which the market has concern on the size of shrimp more than number of shrimp per pound. The smart farming technology in shrimp feeding is suit to the farmers*

who feed the white leg shrimp which their concern is not the size of shrimp but it is the amount of shrimp per pound"

5. Have you ever visit the farm that implement smart farming or watch the media about that? What do you feel like?

Answer *"Yes, I want to try at my farm but after evaluate as I mentioned it not suit to my farm"*

Interviewee number:3

Name: Mr. Prasert Junhong

Position: Farmer(coconut)

Location: Chumphon

1. Do you think your productivity in your farm is in good level and do you think can it be better?

Answer *"Yes, it could be more productive and reduce labor cost"*

2. What do you fear or concern about smart farming? What do you do to reduce those concerns?

Answer "I fear about investment"

3. Have you ever heard about smart farming, how do you believe in the effective smart farming?

Answer *"Yes, I used to visit the farm where they use the technology it can prove that the technology can help farmers"*

4. Why you select to operate your farm with the traditional way?

Answer *"I am old and the investment require big money so I afraid that if it fail I will be so trouble and with the traditional way the productivity is acceptable"*

5. Have you ever visit the farm that implement smart farming or watch the media about that? What do you feel like?

Answer *"Yes, I use to watch TV about technology in agriculture. I would like to try on it but it requires capital investment"*

Interviewee number:4

Name: Mr. Somsak Muangphongern

Position: Rice Farmer

Location: Nakhon Pathom

1. Do you think your productivity in your farm is in good level and do you think can it be better?

Answer *"It may help the farmer working less tired"*

2. What do you fear or concern about smart farming? What do you do to reduce those concerns?

Answer *"Capital investment is my concern most of farmers do not have enough money to invest in technology"*

3. Have you ever heard about smart farming, how do you believe in the effective smart farming?

Answer *"Yes I do, I quite believe in it but have not try before.*

4. Why you select to operate your farm with the traditional way?

Answer *"Because I am familiar with this way also around this area there is no problem of workforce shortage, labor is available and they are my relative so operate in this way will help them to have work to do"*

5. Have you ever visit the farm that implement smart farming or watch the media about that? What do you feel like?

Answer *"I like to watch the VDO clip about agricultural technology but some clip may not suit to my farm. I like it but it may too expensive for me to acquire it"*