The 4th International Conference on Agriculture and Agro-Industry
ICAAI2022
Transforming Value Chains for Global Security
Mae Fah Luang University, Chiang Rai, Thailand
November 10 -11, 2022

Journal of Food Science and Agricultural Technology

International peer-reviewed scientific online journal Published online: http://rs.mfu.ac.th/ojs/index.php/jfat

Original Research Article

Durian Farmer Adoption of Smart Farming Technology: A Case Study of Chumphon Province

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ARTICLE INFO

Article history:
Received 7 September 2022
Received in revised form 3 October 2022
Accepted 10 November 2022
Published 16 January 2023

Keywords:
Durian
Agricultural risks
Farmer adoption
Smart farming technology

ABSTRACT

The uncertainty of agricultural risks not only affects farmers, but also causes all stakeholders in the supply chain. Durian is one of the important agricultural exporting products in Thailand and a high-value fruit crop of Chumphon Province. Durian farmers have faced yield loss after outbreaks of disease, pests, and squirrels intensify, deterioration of soil and water quality, and the threats of unpredicted farm income over the past few years. The adoption of smart farming technology like drones and sensors, can serve as a solution to alleviate risks in agriculture, but not all farmers are adopting technology. This study aims to explore determinants affecting the adoption of smart farming technology for durian farmers in Chumphon province. Survey data of 108 farmer households were randomly conducted and analyzed by using Binary logistic regression and descriptive statistics. Demographic characteristics, socio-economic variables, and farming systems were examined to explain the farmer adoption. Findings showed that farmer adoption of technology was significantly affected at p-value (< 0.05) by farmer's age, farmer's main occupation, access to extension services, and farm size with the percent correct of 74.1% and goodness-of fit of 0.062. Therefore, younger farmers with larger farm sizes were more likely to adopt agricultural technology than older farmers with farm sizes. In addition, farmers who adopt technology could reduce employed labor, and fertilizer costs, indicating that smart farming technology provided better farm performance and less cost. The influence of extension services on the adoption of technology should be encouraged to help farmers to adapt and mitigate the agricultural risks with appropriate technologies and specific conditions of durian farms. Continuous training and educating farmers via extension services are essential for the sustainable adoption of smart farming technology.

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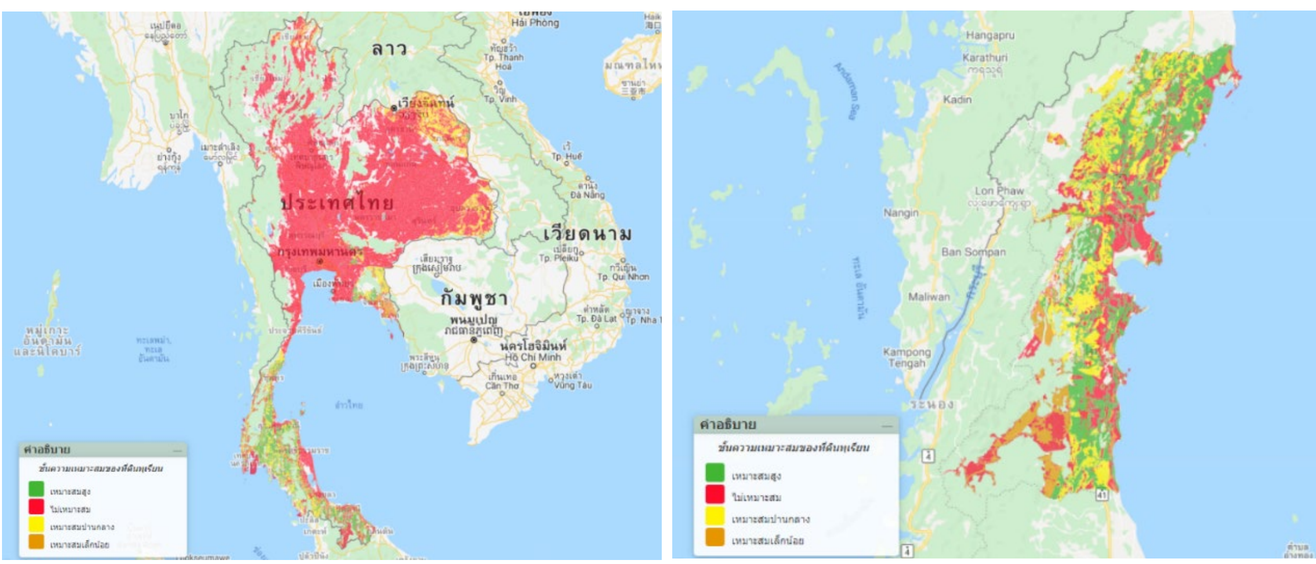
ISSN: 2408-1736

INTRODUCTION

Durian is one of the fruits with the highest export value. The export value of durian and its products was 2,351.65 million US dollars in the year 2020, accounting for 67.80% of the total export value of fruit products (Department of Trade Negotiations, 2021). Thailand is one of the countries where the climate and topography are suitable for durian growth, resulting in good productivity and high value-added as shown in Figure 1a. The high value of durian caused farmers to switch their crops to durian plantations. The major durian cultivation areas in Thailand are Chumphon (24.79%), Chanthaburi (24.66%), Rayong (8.39%), Nakhon Si Thammarat (6.78%), and Yala (6.78%) provinces (Department of Trade Negotiations, 2021). Chumphon has 232,011 rai of durian cultivation (Figure 1b), accounting for 11.23% of the total economic crops cultivated area in Chumphon with a total market value of 31,457.38 million baht (Strategic and Information for Development of Chumphon Province Group, 2021). Durian is considered as the most valuable agricultural product in Chumphon. Durian farmers face several problems such as durian cultivation due to disease and insect outbreaks, weather instability, and low quality of durian due to labor shortage, resulting in lower farm incomes and deteriorating durian quality over the past few years.

In the 21st century, farmers around the world are increasingly adopting technology in the agricultural sector from seed to harvest to increase productivity and efficiency. Smart farming technology help farmers to manage farm and resources accurately, leading to sustainable farming and enhancing competitiveness. Technologies used by durian farmers include sensors and drones, which help farmers to record data and monitor unusual conditions. According to the Agricultural Development Plan (2023 – 2027), Thailand has started adopting technology in the agricultural sector since 2011. The plan focused on increasing the productivity of the farm and reducing the cost of production, as well as makes strengthens Thai agricultural products to compete at the national level and create a good image in Thai exports (Thailand board of investment, 2020). Since the lack of skills of Thai farmers in using technology, a few farmers can use technologies to optimize the productions, increase the quantity and quality of products, and alleviate the risks in agriculture. This study aims to explore determinants affecting the adoption of smart farming technology for durian farmers in Chumphon province. Demographic characteristics, socioeconomic variables, and farming systems were examined to explain the adoption decision.



(a) Thailand (b) Chumphon province

Figures 1. Suitable area for durian cultivation in Thailand

MATERIALS AND METHODS

Description of the study area

Chumphon province is located at the top of the southern region. It is about 498 kilometers from Bangkok (the capital) by car, covering an area of 3.75 million rai or 6,011 square kilometers, which ranks the fourth largest area in the southern region. Chumphon has a slender area along the north and south with a length of about 222 kilometers, with an average annual rainfall of 1,943 millimeters, an average annual air temperature of 27.2 degrees Celsius, and an average annual relative humidity of 81% (Data from 1991-2020). Chumphon Province consists of 8 districts including Pathio, Tha Sae, Muang Chumphon, Sawi, Thung Tako, Lang Suan, Phato, and Lamae. In 2020, the population is 509,208 people, 80% of the total population work in agriculture sector. Agricultural areas account for 67.37% of the total area where top five major economic crops are oil palm, para-rubber, durian, coffee, and coconut, respectively. Chumphon province ranks the second-largest durian plantation area after Chanthaburi Province.

Description of smart farming technology

Drone is one of the most widely used new technologies in various industries. In the agriculture sector, Thai farmers have slightly become familiar with flying vehicles in recent years. Some farmers have see drones as their primary device with advantages in labor-saving, adapting equipment for seeding, precise fertilization, and chemical spraying. These devices have shown that using drones can reduce farming costs, especially fertilizer, chemicals, and labor costs (Thailand Board of Investment, 2020).

Sensors for measuring the properties of plant materials and soil conditions are a very important category of sensors for high-precision agriculture because they are the main factors affecting durian farms directly. This may include measurements such as temperature, humidity in the plant materials or soil, and mineral contents (Horizon Magazine, 2016).

Sampling and sample size determination

The accidental sampling technique was used to collect as many samples as possible as farmers existed or with cooperation. The sampling frame was 509,208 in Chumphon province. There are 100 sample households that were determined by using a simplified formula (Yamane, 1973) and simple random sampling. Assume a 90% confidence level and 10% the desired level of precision.

$$n = \frac{N}{1 + Ne^2}$$

where, n is the sample size, N is the population size, and e is the desired level of precision.

Data sources

Survey data of 108 farmer households in Chumphon province were collected with questionnaire, which included three parts: farmer characteristics, farm management, and technology adoption behavior. Selected farmers who adopt the technology were interviewed on benefits of smart technology adoption.

Data analysis

Descriptive data analysis and binary logistic regression were used to analyze the data and explore determinants affecting the adoption of smart farming technology for durian farmers in Chumphon province. Descriptive statistics including mean, frequency, standard deviation, and percentage were used to summarize and present the characteristics of demographic, socio-economic, and farming systems.

A binary logistic regression model is a statistical tool to determine the effect of independent variables (x) on a dependent variable (y). It helps to predict dependent variables from known variables or factors. In this study, binary logistic regression models were used to identify demographic, socio-economic, and farming systems that drive the adoption of smart technologies. The dependent variable (y) is measured as a dummy variable, with a numeric value of 1 if the farmer adopts smart technology, and 0 if otherwise. For independent variables (x_i), based on the review of previous research, eight potential explanatory variables were considered significant factors affecting technology adoption including farmer's age, farmer's main occupation, farming experience, access to extension services, farm size (Chanthavong *et al.*, 2018; Punpinij & Keawvan, 2001), farm loan (Punpinij & Keawvan, 2001), number of plants planted, and harvesting season. The binary logistic regression model is as follows:

$$p(y) = \frac{1}{1+e^{-\beta(x_i)}}$$

where: $p(y)$ is a probability of event y, e is exponential function (e = 2.71828), $\beta(x_i)$ is a coefficient of the independent variables I

Results and Discussion

Profile of respondents

The smart farming technology adoption of respondents is shown in Table 1. The categorization of the samples into adopted technology groups will require the use of sensors to measure soil water quality and/or the use of drones. About 57.4% of the total sample had adopted the technology and 42.59% had not adopted technology.

Table 1. The frequency and percentage of smart farming technology adoption

Technology adoption	Frequency (N=108)	Percent
Adopt	62	57.41%
Not adopt	46	42.59%

Three respondents out of 108 respondents were interviewed about the advantages and disadvantages after respondents adopted the technology. The first, respondent was able to reduce costs by reducing the number of workers as drones can be used to fertilize in a shorter time, more convenient, and can be done manually without hiring a lot of labor to fertilize. But there were difficulties with frequent refueling due to the low carrying capacity of the drone and the need for regular maintenance such as battery replacement.

The second, respondent was able to purchase a fertilizer that was more relevant to the durian plant conditions and was able to nourish the soil to be suitable for the durian tree growth due to the use of sensors to measure soil quality. This reduces the cost of purchasing fertilizers that do not meet the needs of the plants. As for the problem has not yet been found.

The third, respondent was able to nourish the soil more suitable for the durian trees and obtain good quality yields by using soil acidity and alkalinity sensors. A common problem was the occasional malfunction of the device that requires multiple measurements. From these interviews, it can be concluded that applying the technology can enable farmers to reduce fertilizer costs and labor costs. It will be expected that farmers could reduce costs and will be able to better manage their farms. But there were some issues related to the device's performance in actual use.

According to some respondents who did not adopt technology, the key reason that farmers did not choose to adopt the technology in farming as they did not know how to use it and were difficult to understand because they were unfamiliar with the technology. Another important reason was the high cost of investing in equipment, making farmers reluctant to make investment decisions.

Table 2 presents the profile of respondents separated by technology adoption. The age of the sample was separated by technology adoption. The age of respondents that adopts technology had an average age of 52 years old with a range from 30 to 71 years old which was different from the average age of the not adopted technology group. According to Puey Ungphakorn Institute for Economic Research (2019), more than a third of agricultural households had elderly workers. and with elderly workers as the heads of the household.

Table 2. Sample separated by technology adoption

Characteristics	Not adopt technology			Adopt technology		
	Min.	Max.	Avg.	Min.	Max.	Avg.
Farmer's age	35	74	54.4	30	71	52
Farming experience (years)	2	30	17.15	2	45	20.02
Main occupation (farmer)	0	1	0.74	0	1	0.91
Number of family members	1	7	3.71	1	8	3.85
Number of plants planted	1	4	1.94	1	5	1.87
Farm size (rai*)	2	51	16.22	2	100	22.97
Access to extension services	0	1	0.25	0	1	0.28

* 1 rai = 0.16 hectare

The farming experience of the respondent hadan average of 17.15 and 20.02 years for without adopt technology group and with adopt technology group, respectively. Most respondents were farmers as the main occupation with 81.48% which consists of 74.19% and 91.30% were not adopted technology group and adopted technology group respectively. The number of family members was mostly four people per household, or 37.04%, with an average of 3.85 of those who use technology. The number of plants planted represents either monoculture or polyculture. Monoculture makes it easier for farmers to manage and make them more proficient in plants than mixed gardening. On the other hand, polyculture can help diversify the risks that farmers face. According to the results of the sample study, the average number of plants planted was 1.91%. Respondents who adopt technology hada large average farm size than those who do not adopt the technology.

Factors affecting smart farming technology

Table 3 shows that sample adoption of smart farming technology was affected statically significantly by farmer's age (x_1), main Ada (2006) summarized the factors affecting technology adoption into 4 factors, one of whichwas receiver variables. It was found that access to extension services varied with technology acceptance. In this study, Access to extension services hads significantly influencedthe adoption of smart technology ($p = 0.032$). A sample who had access to extension services was more likely to adopt the technology by 271.8% than a sample who did not have access to extension services. In accordance with, Akudugu et al. (2012) analyzed that building adoption of modern agricultural technology, it was related to the people's access to agricultural extension services. This was mainly due to obtaining official information and gaining knowledge and understanding of technology applications. This gave farmers the courage to decide to apply those modern agricultural technologies in their gardens. Therefore, supporting people's access to agricultural extension services was very necessary to create more acceptance for farmers to use modern agricultural technology in farming. In addition, agricultural extension support will also be able to obtain information from the people involved to analyze ways to reduce the risks and uncertainties that may arise about the effectiveness of the technology. including finding ways to prevent or manage problems that will lead to greater acceptance in the future (Akudugu et al., 2012).

Table 3 shows that farm size (x7) influences the adoption of smart technology. A sample that had a large farm was more likely to adopt the technology by 103% than a sample with a small farm size. Similarly, a study by the Fertilizer Soil Management Extension Group (2016) found that farmers with large or large acreages were more likely to increase acceptance or confidence.occupation (x_2), farm size (x_7), and access to extension services (x_4) at p-value (< 0.05). This model exhibited to be suitable for prediction because it gave Hosmer-Lemeshow goodness-of fit of 0.062, which means that the main hypothesis is accepted (p-value > 0.05), a pseudo-R square of 0.281 and a prediction accuracy of 74.1%. A sample who had a younger age and didfarming as a primary occupation was more likely to adopt the technology by 93.8% than those older ages and 24.3% than having a secondary occupation as a farmer respectively. The result of the study on farmer's age was found to be consistent with the results of the experiment of Chaweesuk and Wongchaturaphat (2012) which stated that age had significant implications for technology adoption and Chaiwanich (2008) and Aedum (2006) found that younger people were more accepting than older people. Likewise, a report of aging and the productivity and agriculture of Thai agricultural household by Puey Ungphakorn institute for economic research (2019) that older farmers were often associated with the possibility of using modern machinery and lower integration.

Table 3. Factors influencing the smart farming technology adoption

Dependent variable	B	S.E.	Wald	Sig.	Exp(B)
Farmer's age (x_1)	-0.064	0.028	5.010	0.025	0.938
Main occupation (x_2)	-1.413	0.688	4.217	0.040	0.243
Farm experience (x_3)	0.051	0.029	3.067	0.080	1.053
Access to extension services (x_4)	1.000	0.467	4.579	0.032	2.718
Farm loans (x_5)	-0.544	0.463	1.376	0.241	0.581
Number of plants planted (x_6)	-0.478	0.289	2.738	0.098	0.620
Farm size (x_7)	0.035	0.016	4.422	0.035	1.035
Harvesting season (x_8)	1.095	0.700	2.449	0.118	2.989
Constant	2.187	1.508	2.104	0.147	8.912
Pseudo R^2			0.281		
Percent correction			74.1%		

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CONCLUSIONS

Smart farming technology has helped farmers farm more accurately and better manage resources, leading to sustainable farming and increased competitiveness. The technologies used by durian farmers include intelligent data collection devices such as sensors and drones, but not all farmers are adopting technology. Since there are researches that study factors affecting the adoption of smart farming technology in other plants, but there is no work related to durian farmers in Chumphon and other provinces. The researcher presented this issue with the objective to study the factors affecting the adoption of smart farm technology for durian farmers in Chumphon Province. Demographic characteristics, socioeconomic variables, and farming systems were examined for the effect on technology adoption including farmer's age, farmer's main occupation, farming experience, access to extension services, farm size, farm loan, number of plants planted, and harvesting season. From interviews with 108 durian farmers in Chumphon province with an average age of 53.38, average of 18.37 years of durian farming experience, and an average farm size of 19.09 rai, it was found that the adoption of smart farming technology was significantly affected at p-value (< 0.05) by farmer's age, farmer's main occupation, access to extension services, and farm size with the percent correct of 74.1%. This research can be concluded that younger farmers with larger farm sizes were more likely to adopt agricultural technology than older farmers with smaller farm sizes. Farmers who do farming as a primary occupation and have access to extension services were more likely to adopt agricultural technology. The influence of extension services on the adoption of technology should be encouraged to help farmers to adapt and mitigate the agricultural risks with appropriate technologies and specific conditions of durian farms. In addition, farmers who adopt technology could reduce employed labor, and the use of fertilizer, indicating that smart farming technology provided better farm performance and less cost.

For suggestion, to further support the adoption of the technology of durian farmers in Chumphon province, it should start with a group of young durian farmers who are primarily engaged in agriculture, have large farm areas, and have access to services such as farmer associations. The integration of durian farmers under state supervision or independently can help farmers understand and access new technologies and can learn to use, share knowledge, and experience more.

For future studies, since this study uses only some variables and only for durian farmers in Chumphon province, there are still many variables, plants, and areas of interest to be studied about smart farming technology adoption, such as farmers' income, durian farmers in Chanthaburi province, sugar cane, and rice. It may be a risk that farmers face with farming, maintenance, or from the environment.

ACKNOWLEDGEMENTS

I would like to express my sincere thanks to my thesis advisor, Dr. Apichaya Lilavanichakul for her invaluable help and constant encouragement throughout the course of this research. I would not have achieved this far, and this thesis would not have been completed without all the support that I have always received from her. Finally, I most gratefully acknowledge my parents and my friends for all their support throughout the period of this research.

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