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Stakeholder Analysis of Agricultural Drone Policy: A Case Study of the Agricultural Drone Ecosystem of Thailand

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***Abstract*—**This paper presents a stakeholder analysis of agricultural drone policies that meet the government's goal of building an agricultural drone ecosystem in Thailand. Firstly, case studies from other countries are reviewed. The stakeholder analysis method and qualitative data from the interviews are then presented including data from the Institute of Innovation and Management, the Office of National Higher Education Science Research and Innovation Policy Council, agricultural entrepreneurs and farmers. Study and interview data are then employed to describe the current ecosystem and to guide the implementation of agricultural drone policies that are suitable for the ecosystem of Thailand. Finally, policy recommendations are then made that the Thai government should adopt in the future.

***Keywords*—**Drone public policy, drone ecosystem, policy development, agricultural drone.

I. Introduction

ICT Technologies are currently receiving more attention in the field of agriculture. The drone is an emerging technology which could help improve agricultural productivity by reducing cost time, and physical risks to workers. The agricultural sector is very important to the economy and society of Thailand. When considered overall it was found that the number of agricultural workers accounted for approximately 28% of the total labor force and 6.4 million households. Moreover, agricultural land covers 40% of land in Thailand [1]. However, the agricultural sector accounts for only 8% of Gross Domestic Product (GDP) [2] and is growing slower than other economic sectors. In addition, the agricultural sector is facing a labor shortage problem and many agricultural workers are elderly. The Thai government is therefore committed to formulating public policies and developing an agricultural drone ecosystem. It is expected to be a way to increase productivity, help solve the problem of labor shortages and improve the quality of life of people who depend on agriculture.

In this paper, the concept of an agricultural drone ecosystem that suits the Thai ecosystem is proposed by analyzing successful projects and by interviewing key stakeholders. The paper is organized as follows. The background theory is presented in Section II. Successful cases obtained from previous world-wide research are described in Section III. Key stakeholder analysis and qualitative interview data are presented in Section IV. The results and conclusions are presented in Sections V and VI, respectively.

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II. Unmanned Aerial Vehicle

An unmanned aerial vehicle (UAV), or drone, is an aerial vehicle capable of sustained flight without the need for a human operator on board. An UAV can be remotely controlled, semi-autonomous, autonomous, and is capable of performing many tasks [3], including agriculture-related tasks. The advantages of drone use are as follows:

- Low risk
- Low cost
- Small size
- High mobility
- Flight duration not limited by pilot fatigue.

Drones are being rapidly developed and are used in a variety of ways in line with the developments in computer and sensor technology. It is evident that the use of drones is cost effective and is increasingly widespread.

Nowadays, drone technology is applied in the following ways: 1) rescue drones are used to inspect remote areas to detect life. 2) Using drones in agricultural fields allows farmers to observe the growth of agricultural products precisely, check soil conditions and assess the health of plants. When problems arise, farmers will be able to identify and resolve problems quickly. 3) Drones are used in construction fields to survey the construction site, which can reduce the cost of employing people to survey and reduce human errors. In addition, during construction, drones can be employed to observe construction workers and are able to examine the materials used in construction. 4) A warehouse utilized drones in the retail areas to alert the police in the event of crime. Drone technology for agriculture can be divided into two types as follows:

- Data mapping drones are designed to collect real-time agricultural data to monitor plant health and to plan planting. Drones are now widely used in developed countries, for example, the United States and Japan, which have developed technology for the Normalized Difference Vegetation Index (NDVI) from drone photography and satellite imagery.

- Spraying drones are used for labor saving and safety, and for spraying chemicals, fertilizers and water in agricultural plots. Currently, spraying drones are widely used around the world including the Philippines and Thailand.

III. Literature Review

A. Successful Case Studies

In regard to agricultural drone ecosystem research in Thailand, this article reviews successful case studies using agricultural drones in countries with ecosystems similar to Thailand as follows:

1) Republic of China

The Chinese government has emphasized the development of agriculture. China was the world's top agricultural producer in 2017 [4]. Rice, corn, wheat, vegetables, and cotton were the top five crops. However, there is a relatively high cost of maintaining plants, including excessive use of chemicals which cause soil deterioration and water contamination. In addition, China also faces a labor shortage but most agricultural workers are elderly. Therefore, China has plans to adopt drone technology in agriculture. Agricultural drone use in China [5] comprises 95% spraying drones and 5% for data collection and analysis. The current Chinese agricultural drone business model is as follows:

- Farm owners purchase drones directly from manufacturers.
- Farm owners use drones from an entrepreneur.
- There is an online platform for farmers to choose the services according to their needs.

The government supports the use of drones in the form of subsidy programs for the purchase of drones, starting at the local government level up to federal policy to advocate the use of agriculture drones. For the private sector, there is enthusiasm for developing hardware, platforms, training and services to encourage the use of drones. When analyzing the challenges or limitations of agricultural drones in China, it was found that

- Legal restrictions: allowed to fly only during the day.
- Management restrictions: farmers have limited investment capital and the drones are new to farmers.

2) Japan

Japan's agricultural sector is focused on the production of rice, milk, meat, vegetables and fruit. Rice cultivation accounts for 40% of the total agricultural area but agricultural workers account for only 7.5% of the total workforce. Most importantly, agricultural workers have an average age of 67 years, and over the past 10 years, agricultural workers have decreased in number from 2.2 million to 1.7 million [6].

Drones have been developed to fly along specified routes on the farm automatically. The drones spray pesticides at a target point with a high number of pests. Drones can work 24 hours a day, allowing farmers to spend the rest of their time on other tasks [7]. At the same time, drones are able to provide useful crop data through advanced photo analysis and show the cultivated area in need of fertilization. Japanese farmers prefer to use drone technology to spray pesticides in rice fields as they save time and labor.

The Japanese government encourages the use of drones without limiting the maximum distance. It simply states that flight is permitted as long as the operator can see the drone without the use of assistive devices (except glasses/contact lenses). When analyzing the challenges or limitations of agricultural drones in Japan, it was found that the following were evident:

- Legal restrictions: (A) drone use in the airspace at airports is prohibited. (B) Drones cannot be operated higher than 150 m above ground level. (C) Drones cannot be used over crowded areas (densely inhabited districts). (D) An operating distance of 30 meters or more between the drone and a person or land surface features must be maintained. (F) Objects must not be dropped from the drone.
- Management restrictions: There is a shortage of next-generation farmers. The average age of farmers is 67-68 years old and they may only have four or five years left of farming. Therefore, it is a challenge to successfully utilize drones quickly.

3) Malaysia

Most of Malaysia's agricultural land is cultivated with a wide range of industrial and food crops such as rubber, palm oil, cocoa, pineapple and pepper, while rice cultivation is not enough for domestic consumption. Farm systems can be both small farms for small farmers and large farms for industrial crops. In 2019, the agricultural sector had a 7.1& share of the GDP, with palm being the main product that adds value to the agricultural sector [8]. The Malaysian government initiated the development of agricultural drones, which are now widely used. It is suitable to use UAVs on small or medium-sized farmland for efficient field crawling and survey. In Malaysia [9], drone technology is used in agriculture as follows:

- Palm farms use photographic drones to monitor palm growth from the outset by monitoring the fertility of plantations. Then check the growth of the palm trees, such as checking the nutrients, etc.
- The rice field uses a drone to take a picture to see the growth of rice. Drones can help collect data to store in the rice database. So that farmer can then rice planting maps with reliable data. Moreover, drones are also used to spray fertilizer.

Considering the challenges or limitations of agricultural drones in Malaysia, it was found that:

- Legal restrictions: It is legal to fly drones in Malaysia, but there are the following regulations: 1) Drones must not fly in airspace within an airport traffic zone, or more than 120 m above the ground and drone pilots must maintain direct vision with the drone during operation. 2) Drones must be licensed by a government agency for the commercial use. 3) Drones weighing more than 20 kilograms cannot be flown without permission from government agencies. 4) No registration is required for drones providing

specialized services such as agriculture, construction, photography, exploration, patrol, or search.

- Management restrictions: Young people are more likely to move to urban areas. Malaysian farmers have an average age of 50 years, so sharing technology with the elderly is a challenge.

B. Agricultural Drone Ecosystems in Thailand

Agricultural drones are gaining attention in Thailand's agriculture sector. This is because drones can increase production quality and control production accuracy.

For the government sector of Thailand, the Ministry of Agriculture and Cooperatives has set agricultural technology access targets in the 20-year Agriculture and Cooperatives Strategy (2017-2036) to increase their competitiveness and motivate farmers to access agricultural technology [10]. In addition, a meeting of the information technology, communications and telecommunications subcommittee with the Senate was held to hear information and exchange views on the use of drones and to present the results of the study to the government.

In terms of skills development, the Ministry of Labor, together with the private sector, provides training courses for the general public who are interested in drones for agriculture in order to increase their drone skills and to encourage them to become a smart farm.

The Office of Agricultural Economics studied the cost-effectiveness of using drones to help farming in the central and lower northern regions. It was found that hiring a drone service to spray herbicides, pests, and rice hormones can reduce spraying time by 3-5 times when compared to manual labor. It also reduces the use of chemicals by 15-20% without residue in the body [11]. However, the use of drones for agriculture in Thailand is still limited compared to the country's total agricultural area. In the future, it is expected that the cost of using drones for agriculture will be lower, while labor costs will likely increase. Therefore, if drone manufacturers are very competitive and drones are popular among farmers, it will make the use of drones to increase exponentially.

Agricultural drones can be divided into two types of possession:

- Owning a drone for personal use: Agricultural drone prices range from 100,000 to 400,000 Baht. Farmers can also generate additional income from contracts to spray crops for other farmers.
- Contractors or independent organizations: A service price of agriculture drones depends on the location of the agricultural plots, the chemicals used and the nature of the plants.

Agricultural drones have two types of use:

- The first type is surveying and planning, such as land surveying and tracking plant growth. It is also used for production forecasting or farmland management planning.
- The second type is in the production process, such as sowing, fertilizing or spraying chemicals. Drones are mostly used in rice fields because they can fly unobstructed in open areas and are easy to control.

Considering the challenges or limitations of the agricultural drone ecosystem in Thailand, it was found that:

- Technological Restriction: One battery can keep the drone in the air for just 10-15 minutes.
- Legal Restrictions: 1) Only registered drones are allowed to fly in Thailand. 2) Registration in the case of an individual, you must provide the owner name-surname, serial number, drone brand, etc., along with a photograph of the registered drone and the owner's ID card. 3) Registration in the case of a dealer, a list of drones specified in the form of the National Broadcasting and Telecommunications Commission is required. 4) Third party physical, life and property damage must be insured. The insurance limit is not less than 1 million Baht per time. 5) Drones cannot be flown at an altitude of more than 90 meters (300 feet) above the ground or above a town, village, community, or other gathering places. 6) The limitations and redundancy of the application process involving multiple agencies can lead to confusion and delays in implementation, including regulatory oversight and the lack of flexibility which may hinder the use of drone technology for agriculture.
- Management Restrictions: 1) The environment is not suitable for the use of agricultural drones such as hot weather. 2) Farmers still lack awareness of the benefits and efficacy of drones in agriculture. 3) Farmers may cultivate areas far away from drone spraying services.

IV. Methodology

A. Key Stakeholder Analysis

1. Identify Stakeholders

In this article, we have identified the ecological stakeholder groups in regard to agricultural drones and categorized them into four groups.

- Research and Innovation Policy Council
- Innovation and Management Institutes
- Agricultural entrepreneurs
- Farmers

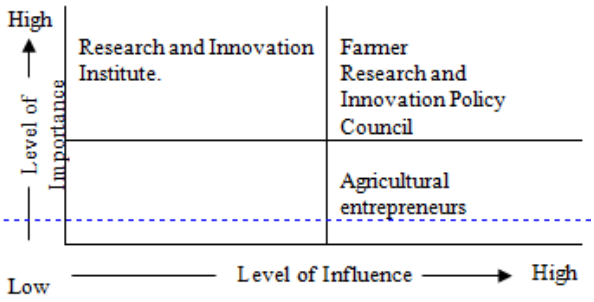

Fig. 1 Stakeholder Priority Matrix

2. Priorities of Stakeholders

After determining the organizations related to the drone agricultural ecosystem, we analyzed each person's priorities based on the stakeholder priority matrix.

In the stakeholder priority matrix, the matrix matches the degree of stakeholder priorities to their degree of influence. The matrix helps to identify who is critical to the success of drone agriculture policy. The stakeholders in the upper half of the matrix are highly important and/or highly influential. They are the influencers that drive the policy. Those in the lower half may be members, but it is unlikely that they have the power to drive the policy.

From Fig. 1, Farmers, Institutes of Research and the Innovation Policy Council include any person or organization that is impacted by the policy. The Department of Agricultural Extension is important in formulating policy, but has no direct impact in the implementation of the policy. Institutes of Research and Innovation include organizations that have a role in recommendation and consultation. Agricultural entrepreneurs influence policy success as they are individuals who have to adapt and follow policies as service providers.

3. Interview Topic Identification

This section describes the topics of interviews for each stakeholder in detail. The questions were given in the context of their relevance to the construction of a drone policy for agriculture.

TABLE I
THE TOPIC OF INTERVIEWS FOR EACH STAKEHOLDER

Stakeholder	Topic of interviews
Regulators	Recommendations for agricultural drone policy.
Farmers	An encouragement of drone ecosystem and issues that need government support.
Agricultural Entrepreneurs	Drone technology knowledge and issues that need government support.
Research and Innovation Institutes	Preparation guidelines for agriculture drone technology.

Table I presents the points used to interview groups of stakeholders which is divided into 4 groups: The first group is the organizations involved in policy-making. The questions focus on the recommendations of the agricultural drone policy. The second group is farmers, whose questions will cover their expectations for an ecosystem that will facilitate the adoption of drones. The third group is entrepreneurs in agricultural technology, whose questions relate to the need to enhance knowledge about drone technology. The last group is research and innovation institutes, focusing on the perspective and preparation to support agricultural drone technology.

V. RESULTS

A. The Interview Results

In this part, examples of stakeholder interview opinions are presented. The results reveal some potentially important findings. Each sector has begun to focus on young farmers because they will help drive the adoption of modern technologies such as drones in agriculture. Moreover, they may help to drive Thailand into a new era of agriculture or smart farms.

B. Direction for the Development of Agriculture Drone Technology in the Context of Thailand in the Future

There have been major regulatory changes regarding world trade and investment. As a result, international trade and investment are more competitive. Therefore, Thailand needs to develop the potential of agricultural production. Improving farmers' knowledge to become professional farmers ('Smart Farmers') is an important mechanism in strengthening farmers to expand their careers and obtain stable income from their farming.

TABLE II
INTERVIEW RESULTS

Stakeholders	Interview results
Regulators	1) Governments should provide a test environment that allows startups to use drones in an agricultural platform. 2) Governments should pay more attention to the information they receive about the use of drones. 3) Governments need to have guidelines and a framework to collect big data from drones that can be used for further development. 4) The government sector should establish a business model for using drones in agriculture. For example, Thailand wants to be a drone manufacturer or a drone leader in ASEAN; drones should be classified for agriculture, such as survey flights and crop spraying, etc. 5) They should educate children and young people about drone technology, such as drone trials, and analyze data acquired from using drones in schools.
Farmers	1) Farmers want to use drones but there are not enough drones. During the spraying season, farmers all spray chemicals at the same time, which increases the demand for drones. However, there is an insufficient number of drones to meet demand. As a result, farmers employ other methods to spray the crops as they cannot wait for the drone service. 2) Some farmers were not impressed when using a drone service because the drone service provider lacked skill and expertise. Therefore, using the drone is not worth the investment. 3) Some farmers do not want to use drones to spray chemicals because they sympathize with those who have lost their to drone technology 4) The government needs to control drone prices to encourage farmers to use more drones on their farms. 5) The government should encourage young farmers by providing low-interest funds, so that young farmers can apply technology in farming and transfer technological knowledge to older farmers.
Agricultural Entrepreneurs	1) The government should set standards for flights and drone repair and determine the characteristics of drone pilots to suit the context of Thailand 2) The government should provide incentives to young farmers to encourage them to use digital technology in agriculture.
Research and Innovation Institutes	1) The first part is about the physical aspects of drones. The drone has to be fabricated from a light material to be able to carry more weight and to allow it to fly for a longer period. 2) The second part focuses on control systems and artificial intelligence, such as use the artificial intelligence to classify plants and weeds. This allows spraying in specific areas. There is no need to spray the whole farm. 3) Policy-makers should take into account the development trends of agricultural drone technology, such as the possibility of autopilot.

Because most of the areas in the Thailand are cultivated, using drone technology for agriculture is a long-term business opportunity. Furthermore, drones are machines that help farmers to have a better quality of life. They can help reduce working time, labor cost, chemicals usage and also helps to limit human exposure to potentially harmful chemicals. In addition, an ecosystem that facilitates the use of drones should

be promoted as follows:

1) Farmers could make drone reservations with a smartphone application.
2) Farmers could be informed about the cost immediately through the application before deciding to use the drone spraying service.
3) A system could be established for farmers to find drone service providers and to make online appointments.

C. Policy Recommendations for Agricultural Drone Technology in the Context of Thailand

After analyzing the results of the interviews with stakeholders and the direction of drone development in Thailand, the results of the aforementioned study were used to make policy recommendations as follows:

1. Encourage research and development of innovative agricultural drones for further business expansion.

- Encourage research and development of precision agriculture innovations that effectively connect the application of drone technology to other agricultural machinery. Focus should be put on the utilization of domestic research and the adoption of existing technology to suit the context of each area.
- Encourage and support entrepreneurs and start-up enterprises to build innovative prototypes that benefit agricultural products and services, especially agricultural drones. In addition, a dedicated environment or sandbox for testing innovative prototypes and to assess limitations, effects and risks before commercial development should be established. This includes government measures to create an environment conducive to the growth of the agricultural drone business.

2. Encourage ecosystems for the efficient use of drones.

- Amendments to related laws and regulations to facilitate the use of drone technology, such as reducing restrictions and controls in the agricultural sector. This includes developing law and regulations to support commercial drone agriculture.
- Create a central business platform to match drone operators and service recipients.
- Encourage the application of drone technology for agriculture in conjunction with other technologies such as Internet of Things, big data analysis and satellite technology.
- Accelerate the formation of regulatory mechanisms in the manner of working integration between the government sector, aviation regulators, the agricultural sector and the data management sector to facilitate the continuous and systematic monitoring of the use of drones for agriculture in the country as a whole. Moreover, such regulation can control flight volume, flight area, flight altitude, and limit flight routes to ensure safety and to prevent drone misuse.

3. Encourage all farmers to adopt agriculture drone.

- Develop training programs and allocate learning areas for farmers to understand the use of agricultural drones in accordance with the context of each area. In particular, applying drone technology with other agricultural machinery.

4. Develop skills and careers to support the development of personnel in the agricultural drone industry

- Improve the agricultural learning curriculum with an emphasis on building knowledge and precision agriculture skills.
- Promote vocational education institutions in human resource development, such as drone pilots and drone technicians to support the growth of business and the agricultural drone industry in the future.

VI. Conclusion

The agriculture sector can be considered as the foundation of food security and the economy of Thailand. The majority of the population of Thailand still works in the agricultural sector. However, agricultural employment is likely to decline due to the increasing use of agricultural technology. Therefore, bringing technology to enhance the potential of farmers in the area is important. This research focuses on policy recommendations for agricultural drone technology by using a stakeholder feedback analysis process. The results of the study are presented in the form of prioritizing policy recommendations.

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