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Chapter 4
Comparative Study of Non-ICT Supported Agricultural Supply Chain and ICT Supported Ones

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Abstract

This chapter illustrates the development and application of ICT in agricultural supply chain in Thailand and CLMV region. ICT is gradually playing an important role in agriculture as well as in other fields in parallel with the development of the technology itself. There are clearly remarkable advantageous of ICT supported agricultural supply chain over the non- ICT supported ones. The benefit of ICT application in agriculture including networking among farmers and other stakeholders, relevant information provider toward precision agriculture evolvement, productivity improvement, and disaster prevention, etc. Thailand and Vietnam are comparatively advanced in ICT application in agriculture while Cambodia, Laos, and Myanmar are all in the initial state. Strong support from the government to alleviate the problems of lack of knowledge and high investment are recommended for the better application of ICT in the near future.

Keywords: Thailand, CLMV countries, ICT, Agricultural supply chain

1. Introduction

Mobile technology is currently an essential tool to communicate each other among people. Together with price falling down of information and communication technology (ICT) hardware and services, the usage of mobile technology has widely spread over into various industries including agriculture. It has made farmers and other stakeholders in agricultural supply chain more affordable to obtain ICT hardware and services

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(Bhandhubanyong and Sirirangsi 2020). The international organizations such as Food and Agriculture Organization (FAO) of the United Nations and International Telecommunication Unions (ITU) together with governments such as Thailand Ministry of Digital Economy and Society have promoted their policies for internet usage in the provinces and 5 G mobile networks are planned to be launched in several countries including Thailand as an early adopter. Consequently, the ICT application included in agricultural supply chain is estimated to grow up exponentially in the very near future.

Since there are only few studies relating with the application of ICT in agricultural supply chain from upstream to downstream. By collecting data from relevant papers and websites, the research has studied and tried to answer the five main questions which are (1) which categories of ICT have been applied in the agricultural supply chain? (2) In which section (s) of the agricultural supply chain ICT supported in agriculture has been used in Thailand? (3) Are there any ICT applications in agriculture in Cambodia, Laos, Myanmar, and Vietnam CLMV countries? (4) Do ICT applications in agricultural supply chain contribute benefit to all stakeholders comparing to Non ICT one? and (5) What policy implication should be recommended to promote the application of ICT in agricultural sectors in CLMV countries and Thailand?

2. Agricultural Supply Chain

Supply chain is the integration between of business activities starting from supplier input, production, wholesales, and retailers to provide valued-added products or services to end customers (Suthivatnarueput et.al., 2003). The application of supply chain has been used in various indutries such as oil and gas, and petrochemical including agriculture. The supply chain of agriculture can be divided into three categories which are upstream, midstream and downstream (Bhandhubanyong and Sirirangsi, 2019). The details of each categories of supply chain are as follows:

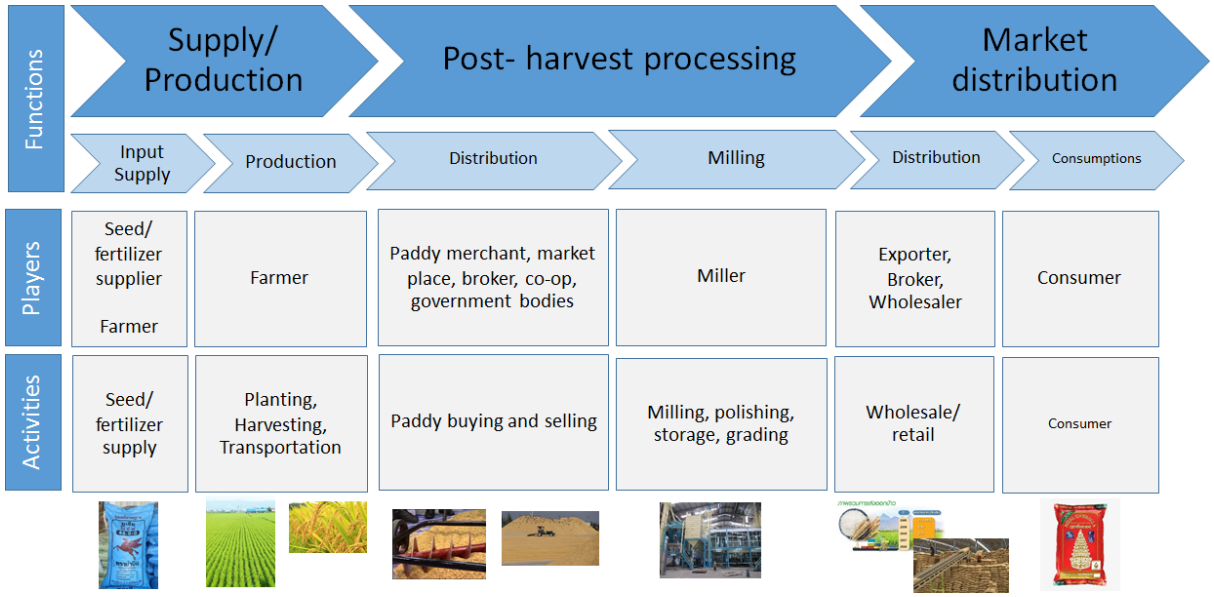
I. Upstream supply chain covers activities of input and raw material for planting preparation including seed varities, fertilizer, land, working capital. Stakeholders involving in this activities are seed varieties agents, fertilizer agents, farmers, land owners and banks. In addtion, production is also another activities in this categories. The production in agriculture consists of growing, havesting and drying agriculture products

II. Midstream supply chain includes post-harvest activities which covers milling, polishing, storage and transportation of harvested agricultural products in order to transfer the products to downstream. The relevant stakeholders in this category of supply chain are middlemen, millers, brokers, agricultural co-operatives.

III. Downstream supply chain covers marketing and distribution activities of agricultural products to the end users. The stakeholders are middlemen, transportation companies, wholesalers, retailers, logistics providers and consumers.

The following Figure 4-1 shows an example of Thai rice supply chain, relevant activities and relevant stakeholders.

Figure 4-1 Thailand Rice's Supply Chain



Source: Bhandhubanyong and Sirirangsi, 2019.

3. Information and Communication Technology (ICT) in Agriculture

Information and Communication Technology (ICT) encompasses communication technologies which are wireless network, internet, computors software, hardware, middleware, video-conference, social networking and other media application (FAO and ITU, 2016). The objective of ICT is to access, retrieve, store, transmit and manipulate information in a digital form. ICT has been applied in several industries including agriculture. FAO and ITU specifies the different categories and their functions of ICTs in

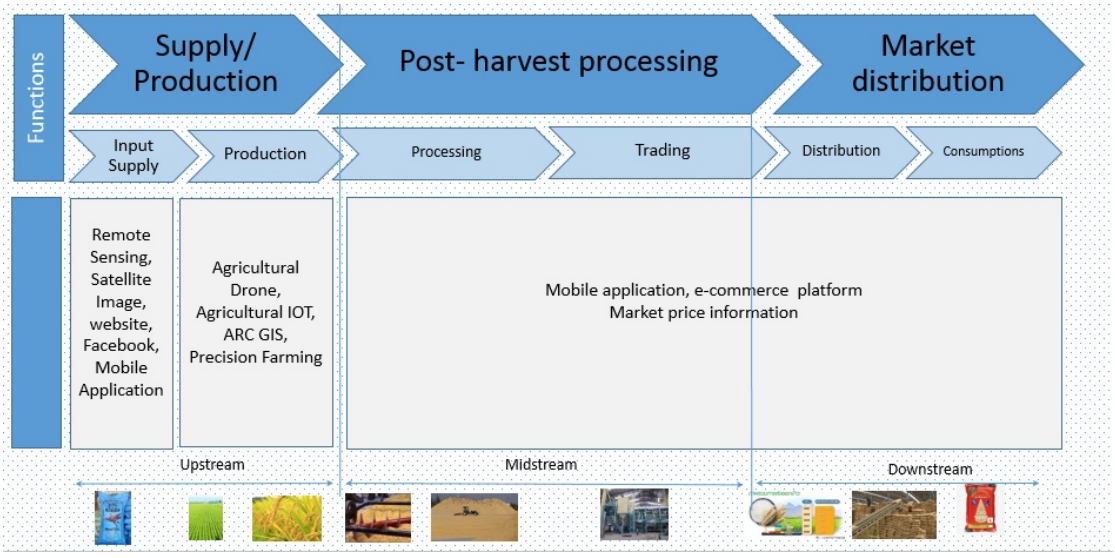
agriculture which are

I. Telephone: Interactive voice responses
II. Computer and Website: Agriculture and market information
III. Broadcasting: Expertise sharing, advisory and community
IV. Satellite: Weather, universal accessibility and remote sensing
V. Mobile: Advisory, sales, banking and networking
VI. Internet and broadband: Knowledge sharing, social media, e-community, banking, market platform and trading
VII. Sensor networks: Real-time information, better data quantity and quality, decision making
VIII. Data Storage and Analytics: Precision agriculture, actionable knowledge

4. ICTs in Agricultural Supply Chain

The research had been conducted by collecting relevant cases of ICT supported in different categories in agricultural supply chain in Thailand and in CLMV countries from relevant websites and papers and specify ICT category in different sections of agricultural supply chain from upstream to downstream. Figure 4-2 below specifies ICT supported in different categories of agricultural supply chain in Thailand. Examples of ICT supported in Thailand and CLMV countries are explained in the following sections of this paper.

Figure 4-2 ICTs supported in Agricultural Supply Chain



Source：By authors.

4. 1 ICTs Supported in Agricultural Input Supply section

4.1.1 Remote sensing/ Image Satellite Application

There are three main organizations in Thailand providing in remote sensing and GIS services to public which are Geo-informatics and Space Technology Development Agency (GISTDA), Chulabhorn Satellite Receiving Station (CSRS) and Geo-informatics center (GIC), and Asian Institute of Technology (AIT).

The GISTDA was established on 3 November 2000 as Thai public agency (GISTDA, 2020). Its objectives are to develop space technology and geo-informatics applications to general public, develop satellite data, and help provide human resource development in satellite remote sensing and geo-informatics. GISTDA developed the first operational earth observation satellite of Thailand named the Thailand Earth Observation Satellite (THEOS) project since 2008. The THEOS is currently operated. GISTDA is currently planning for the second Thai earth observation satellite project.

GISTDA has involved with agricultural sector by applying remote sensing and GIS techniques to monitor the cultivated area of rice maize, sugar cane and cassava plantation. Suitable harvest date of each agricultural products and total production of each product shall be estimated and relevant studied information is displayed on their website. According to the research study of Bhandhubanyong and Sirirangsi (Bhandhubanyong and Sirirangsi, 2019), small scale farmers had never made use of this application since it was very complicated tools which require a lot of techniques while the education level of surveyed farmers was primary school to vocational school.

Chulabhorn Satellite Receiving Station (CSRS), located at Faculty of Engineering, Kasetsart University, Bangkok, was established in 2011 under the collaboration between Chinese and Thai Governments about Small Multi Mission Satellite receiving station project (CSRS, 2020). The CRRS has provided academic services relating with satellite image interpretation in areas of agriculture, natural resources observation, natural disaster warning, etc. For their agricultural research projects, they utilized satellite image to estimate the plantation area of rice, cassava, sugar cane, rubber, pine apple, and cassava together with the classification of plantation ages of rice in a particular rice field. In addition, they provides precipitation map, draught map, normalized difference vegetation index (NDVI) and land surface temperature map

through their website.

Geo-informatics center (GIC) located at Asian Institute of Technology (AIT), Thailand is one of leading remote sensing and GIS organization in the region (GIC, 2020). Established in 1997, GIC has offered and undertaken various training, workshop and research projects with academic, public and private organizations in Bangladesh, Cambodia, Indonesia, Laos PDR, Nepal, Thailand, Philippines, Sri Lanka and Vietnam. Their specialization in agricultural sectors are applications of remote sensing and GIS in rice mapping, drought and crop monitoring.

4.1.2 Website/ Facebook to provide weather forecast information

One of the most popular service using website and Facebook is to provide weather forecast information in Thailand. The Thai Meteorological Department provides up to date information of weather forecasting, hydrological, agro Meteorological, geographic information system **(**GIS**)**, climatology datum, weather warning, storm tracking and earthquake report in Thai and English **(**Thai Meteorological Department, 2020**).** The Department reports their forecast and studies on their website and Facebook**.** For their website, daily weather forecast, 7-day weather forecast, shipping forecast, aviation, ocean wave forecast, world weather forecast, storm tracking, earthquake report and other relevant information can be found. In addition, daily weather forecast is reported in the Department's Facebook.

4.1.3 Mobile application to provide weather forecast information

One of mobile application in the input supply section of Agricultural supply chain is to provide weather forecasting. King Mongkut Institute of Technology Ladkrabang **(**KMITL**)**, one of leading university in Thailand, has studied and forecasted several weather indicators such as surface precipitation rates, temperature, humidity, wind speeds with direction and water paths of hydrometer in details for each country in Asia and Pacific by using several mathematical models with their artificial intelligent **(**KMITL 2020**) .** They provide the aforesaid weather information via their own application named "WMAPP" to the public. In addition, daily weather forecast is also available in the Facebook.

4.2 ICTs in Agricultural production section

4.2.1 Agricultural drone

Agricultural drone has been used in Thai agricultural industry since 2016 (Bhandhubanyong and Sirirangsi, 2019). Its capacities are able to fly automatically according to the assigned boundary, carry water or other liquids up to thirty-six kilograms in order to spray fertilizers and hormones. In addition, picture and video recording of plantation can be captured by drone. The most popular brand of agricultural drone in Thailand is DJI which is the Chinese agricultural drone brand. There are also several Thai-made brands available in the market. DJI and other Thai Made-brands have been looking and hiring local drone agents to sell and repair their drone products to the local market. Several local agents of agricultural supply input have been applied as drone agents with the brand owners to broaden their product lines to serve the local market.

The benefits of agricultural drone are time saving, money saving, high quality of fertilizer spray, and data collection. For time saving, it takes five minute to complete fertilizer or hormone spray in one rai plantation (1 rai equal to 0.39537 acres) comparing with at least thirty minutes of human labor. The direct labor cost of human labor for fertilizer spray with other benefits including lunch and water is approximately 100-120 baht per rai while the cost of drone services is approximately 60-80 baht per rai depending on travelling distance of drone service provider. The wind power causing by drone propeller can flip the paddy and maize leaf over. Consequently, the fertilizer and hormone can be sprayed thoroughly. Comparing with the human labor, drone has less chance to damage rice and field crop. For data collection, recorded picture and video together with smart software is used to analyze and forecast crop yield and monitor crop health.

4.2.2 Precision Farming/ Agricultural Internet of Things (IOT)

Precision Farming is farming management concept based on observing and accurately measuring data which are light, humidity, temperature, moisture contents from the field together with responding to the field crop and farming according to data (Wikipedia 1, 2020). IOT in agriculture is a system built for monitoring crop field and plantation with the assistance of sensors embedded in the system to control the environment and nutrition factors in the agricultural system (Writer, 2020).

DTAC, one of Thai mobile operators, has developed and DTAC precision farming services to the subscribers (DTAC, 2020). The services engage with modern and intelligent systems to adapt with environment and be able to measure and control factors of particular plants. Embedded sensors in the system shall monitor and detect change of agricultural variables such as humidity, nutrition, temperature, in real time basis. The relevant data from sensors shall be analyzed and interpreted on cloud computing system

named “DTAC Intelligent Farm”. The result from algorithm is shown in DTAC mobile application in the real time basis. Once a subscriber (farmer) see the result on his (her) mobile phone, he (she) can control their variable and relevant factors by clicking on the mobile application to activate the IOT system such as water spraying.

Komomi Co, Ltd., is a startup company in Thailand (Komomi, 2020). Their products are designer and contractor of agricultural IOT technology. Their IOT system is able to monitor environment and nutrition factors together with control of irrigation system by their smart mobile application.

CM Plant Factory Co., Ltd., located in Bangkok, is a startup company in vertical farming plantation (CM Plant Factory, 2020). Horizontally diversified from LED distributor, the company has developed their own IOT system in closed environment and plant different categories of high value-added vegetables because of high investment cost in IOT system and closed environment. Their IOT system can continuously measure relevant variables such as light, temperature, humidity and water content. Once a controlled variable is higher or lower than predetermined threshold value, the system shall automatically adjust the environment by taking specified actions such as water spraying or light dimming.

4.2.3 Geographic Information System (GIS)

GIS is a framework for gathering, managing, and analyzing spatial or geographic data in term of digital map (Wikipedia 2, 2020). The application of GIS can be applied in mapping in agriculture and irrigation. Thailand Royal Irrigation Department has used GIS with specialized software to calculate water requirement based on planting date, crop types, and temperature data and rice paddy data in irrigation area. Authorized users can use web browser and mobile devices to display and check their land information and make measurement with ease (Supergeotek, 2020).

4.3 ICT in Agricultural midstream and downstream

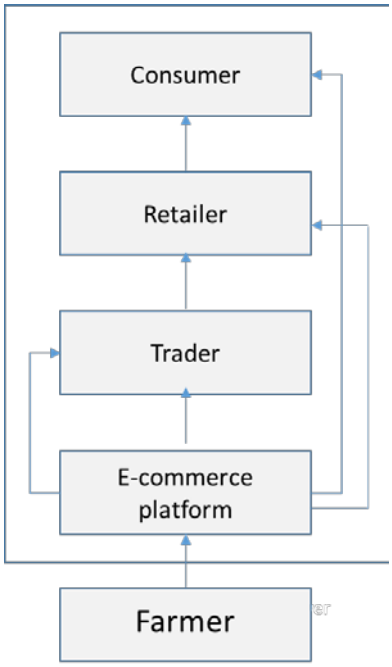
4.3.1 Agricultural e-commerce platform

An agricultural e-commerce platform is a type of software that includes the features needed to create an e-commerce activities for buying and selling agricultural products online (Joiner and Okeleke, 2019). The ultimate goal of the platform is to provide another way for farmers to sell their products and be able to easily reach new customers. According to the supply chain of agricultural e-commerce platform shown in Figure 4-3

below, the platform can assist farmers to bypass and selling their products directly to the consumers or end users, comparing with the traditional supply chain which consumer shall buy agricultural products from retailer. In addition, traders and retailers can also buy directly from farmers via the e-commerce platform.

Examples of agriculture platforms in Thailand are Folkrice, Getkaset, Cropperz, Farmkaidee and Afarmmart. Folkrice is a mobile application to provide an online market between farmers and buyers for organic rice products (Lilavanichakul, 2019). Getkaset and Cropperz are mobile application to provide an online market between farmers and buyers for different kinds of agricultural product. Farmkaidee is a mobile application to provide an online market between farmers and buyers for fresh agricultural products, fertilizer, hormone and agricultural machinery. Afarmmart is a mobile application to provide an online market between farmers and buyers for agricultural products including field crops, vegetable, meat, for agricultural input including seed, seedling, together with different kinds of processed foods (Afarmmart, 2020).

Figure 4-3: Supply chain of agricultural e-commerce platform

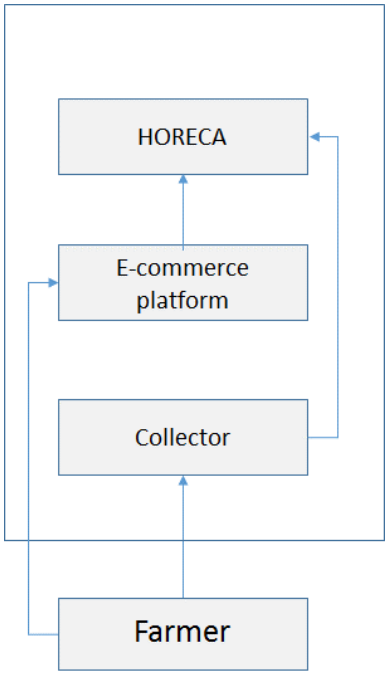


Source: By authors.

Another types of agricultural platform providers is a platform provider that collects a large amount of fresh agricultural products from farmers and sell these products to hotel, restaurant and catering (HORECA) customers. Their supply chain is illustrated

in Figure 4-4. Examples of this types of platform providers are Freshket, IFresh, Farm Fresh. Freshket is an E-commerce platform to provide an online market between farmers and collectors and HORECA customers. Its products covers from vegetable, meat, eggs, milk, fish, fruit and canned foods. IFresh is an e-commerce platform to provide an online market between farmers and collectors and HORECA customers for vegetable, meat, eggs and different kinds of ingredients. Farm Fresh is an e-commerce platform to provide an online market between farmers and collectors and HORECA customers for meat products.

Figure 4-4: Supply chain of agricultural e-commerce platform for HORECA customers



Source：By authors.

4.3.2 Mobile Application

The DTAC mobile operator has developed and offered a mobile application named “Farmer Info” to subscribers as special services (DTAC, 2020). They provides relevant agricultural data including market price of different agricultural products, agricultural news, best practices in agriculture, weather forecast, satellite image and management recommendation for plantation based on precision farming concept. In addition, there are several mobile applications in agriculture sector available in the market such as WMSC: water information from Thailand Royal Irrigation, Rice Pest Monitoring: rice pest information and LDD Soil Guide: soil condition information.

5. ICT in Agriculture in CLMV countries

Technology in agriculture has been gradually played an important role in Thailand and the CLMV countries. Since start-up developers have seen potential of using smart mobile, ICT supported in agriculture and other technologies are means to improve productivity in agriculture in this region. Cambodia, Myanmar and Laos are in the early state of development in ICT supported in agriculture for different agriculture industries while Thailand and Vietnam have implemented and expanded ICT supported in their agricultural supply chains.

5. 1 ICT supported in Agriculture in Cambodia

IOT and mobile app in agriculture has been developed and implemented in Cambodian agriculture. Firstly, "Smart farm assistance" IOT and mobile app has been developed and introduced to help farmers monitoring their soil and humidity condition together with being able to control their water system remotely via their mobile phone (Hong, 2019). With over 50,000 farmers registered, Agribuddy, agricultural platform found in 2015, is the second example of a mobile platform to keep track of rice, cassava and maize production (Chan, 2019). The platform also helps farmer buying agricultural inputs such as fertilizers, hormone, seed, seedling in bulk volume and assist farmer who look for funding from commercial banks together with linking farmers with agricultural traders.

5. 2 ICT supported in Agriculture in Laos

Laos is in the early state of using ICT supported in agriculture sector. Together with Germany's TE food International, Laos government has developed their mobile app for livestock to make a reporting livestock disease from farmers to alert authorities via their mobile phone (Pimmata, 2019).

5. 3 ICT supported in Agriculture in Myanmar

An Example of ICT supported in Myanmar is Greenway mobile App, developed by two former agriculture students, Yin Yin Phyu and Thein Soe Min (Thomas, 2019). Launched in 2016, there have been over 100,000 farmers downloaded this mobile app. This mobile app has six main modules. The first module is farming practices: detailed information of farming tips and best practices. The second is weather forecasting: possible dramatic change in climate and weather informed. The third is daily news: updated agricultural news with one click. The fourth is market trend price of daily crop: a guideline of a strategic decision making concerning selling prices and time to trade. The fifth is inclusive: the module developed for participation of all agricultural stakeholders such as government, NGOs, traders, local shops and etc. The sixth is question and answer: answers to farmer's questions provided by specialized experts as solutions to the problems.

5. 4 ICT supported in Agriculture in Vietnam

Vietnamese government policy has changed to raise the production of high-valued added crops like floriculture, horticulture and livestock feed to substitute low value-added rice and other field crop production to promote their local output, export output and income (East Asia Forum, 2019). The government has also convinced to expand using data, information, mechanization and new technologies including artificial intelligent, internet of thing, and other modern ICTs to support the aforesaid policy.

There are several ICT supported in agriculture in Vietnam. Examples are "THUOC BVTV" is a pest control improvement mobile application to help identify the least toxic pest control method for their crop and typical pest (The sustainable trade initiative, 2019). The objective of this app is to reduce the uses of toxic pesticides and offer relevant information of non-chemical pest control alternatives to promote sustainable environment. Another example is "GMA" mobile app developed to bridge an information gap between farmers and local authorities (Vietnamnet, 2017). The app provides the market information and quotation price for different kind of agricultural products.

With over 100 observation site, Agrimedia, a Hanoi-based start-up, provides

farmers and agricultural companies with the detailed weather information and updated threats by pests (Tomiyama, 2018). In addition, there are several companies planning to use AI-based system to reduce their labor and improve their quality control in several agricultural industries such as shrimp farm (Minh Phu Seafood) and cow dairy farm (Vinamilk)

6. Comparative studies between applying ICT supported and Non ICT supported in the Agricultural Supply Chain

According to above study, there are various benefits and costs applying ICT in agricultural supply chain comparing with non ICT ones. The benefits of applying ICT in agriculture are as follows:

6.1 Bridging network among farmers and other stakeholders

Mobile app and platform plays a critical role in this category. Farmers with traditional supply chain shall sell agricultural products to collectors, merchant or brokers. The collectors, merchant or brokers shall sell to wholesaler/ retailer. Then, the wholesaler/ retailer will finally sell to end-users and consumers. Since the e-commerce platform links farmers with other stakeholders, the farmers can sell directly to collectors, merchant or brokers, wholesaler or retailer, or even to consumers.

6.2 Productivity improvement

There are obvious evident that ICT supported in agriculture shall improve productivity especially production process of agricultural supply chain. Agricultural drone is an example of productivity improvement that clearly evidenced in time saving, 5 minutes to spray fertilizer or hormone for 1 rai comparing with 30 minutes manually for the same job. In addition, it is impossible to make bird-eye view pictures or videos without using drone. As a result remote monitoring of the health of plantation is also impossible without drone.

6.3 The availability of useful information

Farmers can receive agricultural information from ICT services such as market price of agricultural products, humidity, best practices in agriculture plantation, whereas it is quite difficult or take time to gather relevant agricultural data for non ICT one.

6.4 Decision making/ trigger point

Farmers can use agricultural information such as weather forecasting, market price of agricultural products for their farm planning and management for their decision making in including planting, harvesting, watering. Also, the data of environmental and nutrition variables from embedded sensors of agricultural IOT system uses as trigger points for taking actions such as water spraying, or nutrition adding to the system.

For incurred cost of using ICT supported in agriculture, farmers will incur their costs directly and indirectly for not only capital expenditures but also operating expenses such as monthly subscription fee of mobile air time and application. In addition, farmers need to buy smart phone or other mobile medias which can download, install and run mobile application app. To operate agricultural IOT, capital expenditure and operating expenses shall be incurred to farmers/ companies using the system. As a result, the decision in high value added plantation such as high price vegetable or livestock shall be considered to absorb the incurred cost.

7. Policy Implications

Based on the above study, the ultimate objective is to promote ICT supported agricultural supply chain in CLMV countries and Thailand. In order to reach the goal, policy implications are recommended as follows:

7.1 The National Strategies of ICT in Agriculture National Strategies

The national strategy should be studied and established in inclusive manner in order to envision the future state of national ICT supported in agriculture, pave the way to achieve the ICT supported in agriculture to achieve the goal and response to priorities and challenges of ICT supported agriculture in each countries.

7.2 The National and Regional Contest in ICT in Agriculture

The national and regional contest of ICT supported in agriculture should be promoted to build up the contest environment of ICT supported agricultural startup and innovation in the national and regional level. Startup companies, university students and farmers shall be potential target groups to promote design, build, use and engage with the contest of ICT supported in agriculture. Also, the collaboration among startup companies, universities and students should be engaged to build up cross disciplines of ICT supported in agriculture.

7.3 Connecting with Financial Institution and Investors

The government should engage with initial startup fund as seeds for future exploration. Additionally, the government should also develop networks with financial institutions and investors to finance the feasible startup and innovative projects.

7.4 Human resources development

The education background of most of traditional farmers is below undergraduate level. Operation of simple tools or mobile application would not cause problems to the farmers. However, in order to apply deep technical know-how such as operating advanced sensors for IOT, satellite image, GIS software and etc., would be crucial. There are two approaches. The first approach is to organize the short courses of “how-to” to train the present farmers of necessary application techniques for advance tools. The second is formal education on advance technology for agriculture such as the Innovative Agricultural Management (IAM) curriculum in Panyapiwat Institute of Management (PIM), Thailand promoted to high school students. This would ensure qualified, well-trained, up-to-date thinking agricultural workforces in the years to come.

7.5 Best Practices’ Knowledge Sharing

Government especially Ministry of Agriculture, technology development institution and academic institutions should set up knowledge sharing forum to promote and share best practices to design, develop and use ICT supported in agricultures. The successful startup companies and academic institution should be invited to explain their idea of the successful projects as “how to” knowledge to the society.

8. Conclusions

The paper explains the adoption and implementation of ICT supported in agriculture in different sections of agricultural supply chain, upstream, midstream and downstream in the CLMV counties and Thailand. Cambodia, Laos and Myanmar are in the early state of development while Thailand and Vietnam have implemented ICT supported in agriculture and other new intelligent technologies including AI and IOT. ICT supported in agriculture illustrates solid evident in helping bridging network between farmers and other stakeholders such as collectors, brokers, wholesalers, retailers and etc. in the agricultural supply chain. They can make any business transactions directly and easily comparing with traditional supply chain. In addition, ICT in agriculture also assist improve productivity, provide useful information for decision making comparing with non ICT supported one.

There are five suggested policy implications which are ICT supported agricultural national strategies, national with regional ICT supported in agriculture contest, best practices' knowledge sharing forum (s), innovation promotion with connecting the innovators or startup companies with financial institutions and investors, and human resource development for both "How to" short course level and formal education.

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