Knowledge-based Economies

Towards a Knowledge Based Economy: Case Studies of the Use of ICT in Enhancing Agricultural Value Chains in Thailand

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1. Introduction

With increasingly intense competition in the international market, Thailand, well known as one of the largest agricultural producers in the world -- is facing many cost challenges, in particular those related to logistics and compliance to ever stringent hygienic standard imposed by importing countries. At the same time, Thai farmers are unable to respond to changing consumers' preference towards higher quality produce that would require a break away from their traditional cultivation practice. This is because most Thai farmers are in the low income group. They lack capital, information and knowledge needed to adjust their method of cultivation to produce higher quality and safer agricultural produce.

Globalization has rendered information and knowledge the critical factors in achieving a comparative advantage in any business. Information and communication technology or ICT provides the necessary linkage between all the players within the supply chain: farmers, food manufacturers, wholesalers, retailers and final consumers that are increasingly remote from one another. ICT also provides timely and accurate information that can facilitate farmers in making better business decisions that lead to greater efficiency and lower costs.

1.1 Innovation and KBE

In a knowledge-based economy (KBE), production, distribution and services activities are driven mainly by knowledge and information rather than capital and labor as in the traditional industrial economy. Research and development in science and technology are the fundamentals of KBE since these will create a learning society, leading to innovation. Charoenwongsak (2002), specified 4 important pillars of a KBE namely

1) Innovation and progress in science and technology
2) Human resource development
3) Information communication technology (ICT)
4) Regulations and policies for business and research

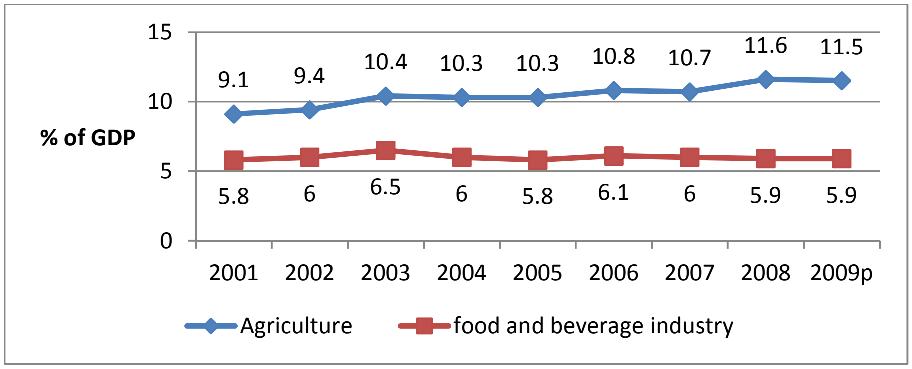
Innovation means the creation of new or more effective products or processes using technology, creativity, skills and experience. Innovation requires knowledge and information. Generally, there are two types of innovation namely: product innovation and process innovation. This paper focuses mainly on process innovation in agriculture sector in Thailand because product innovation, which is both knowledge and resource-intensive, is often exclusive to large corporate players in the market. Moreover, since the inefficiency of the supply chain management is one of the major problems confronting Thai farmers, it is more beneficial to focus on process innovation which provides better integrated solution.

According to the study “The Relationship between Productivity Growth and Types of Innovation: Evidence from Thailand manufacturing firms” by Kemasunan (2011), process innovation contributes to greater productivity improvement than does product innovation in the short-run. The reason being that process innovation often aims at creating or securing greater efficiency than product innovation. However, Prof.Dr. Kriengsak Charoenwongsak commented that, while the world has already advanced to the “fourth generation” economy, i.e., the knowledge-based economy. Thailand is still caught between second and third generation – the industrial and information economy. He criticized past government policies that emphasized promotion of a “creative economy”; which appears to focus narrowly on product innovation. According to his view, a creative economy is only just one of the many components of a knowledge-based economy, which consists of 10 different thinking dimensions; 1) analytical 2) critical 3) systematic 4) comparative 5) conceptual 6) creative 7) applicative 8) strategic 9) integrative and 10) futuristic . It is therefore critical that Thailand develop a learning or knowledge-based society in order to develop into a KBE.

1.2 The current background of Thailand agriculture sector

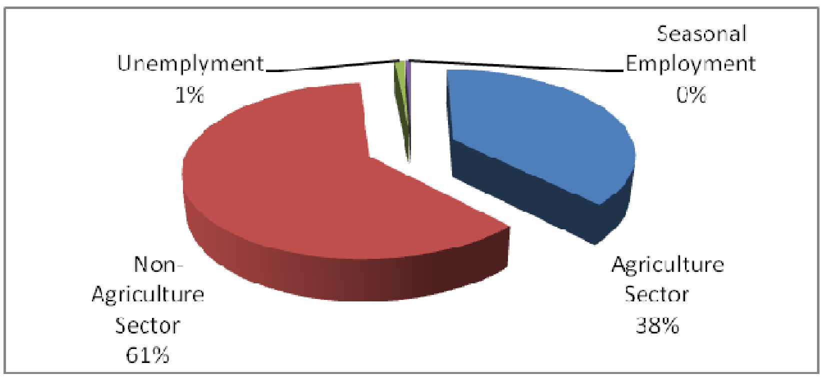
Thailand has changed from an agriculture- based economy into a non-agriculture-based economy where the industry and service sectors contribute to a majority share of the country’s GDP. However, during the last decade, the GDP share of the agricultural sector increased from 9.1 per cent in 2001 to 11.5 per cent in 2009 . The agro-industry contributed another 5.8 – 6.0 per cent to the GDP as can be seen from figure 1 below. The rising GDP share of agriculture sector can be attributed to the spectacular rise in the global prices of commodity, including agricultural produce, resulting from the surge in demand from China. Moreover, despite over 3 decades of industrialization, agriculture sector labor share remains as high as 38%, indicating the important role that the sector play in the country’s employment. The mismatch between the relatively low GDP compared with the much higher employment share indicates low labour productivity in the agriculture sector. It is therefore no surprise that most farmers in Thailand are still poor.

Figure 1: GDP contribution of agriculture agro-industry sectors



Source: National Income Account, the National Economic and Social Development Board

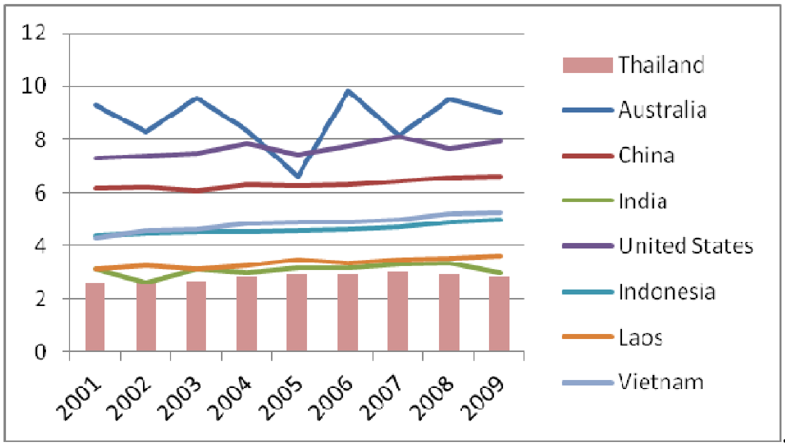
Figure 2: Composition of Employment



Source: Thailand Employment Report in 2009 The National Statistical Office

The quality of soil in Thailand is extraordinary fertile, especially the central region as it contains many river basins. The southern region, on the other hand, is the ideal location for oil palm and Para rubber trees. However, agricultural productivity in Thailand tends to be rather low compared to other competing economies. For example, Thailand's rice cultivation productivity of around 2.87 ton/ha. in year 2009 is considered one of the lowest among major price producers in the world such as Australia and the United States or even Vietnam and Indonesia as shown in figure 3 below. This is partly because most Thai farmers adopt an industrial-based cultivation where chemical fertilizers are used intensively. As a result, the quality of the soil has severely deteriorated, rendering increasingly lower yield.

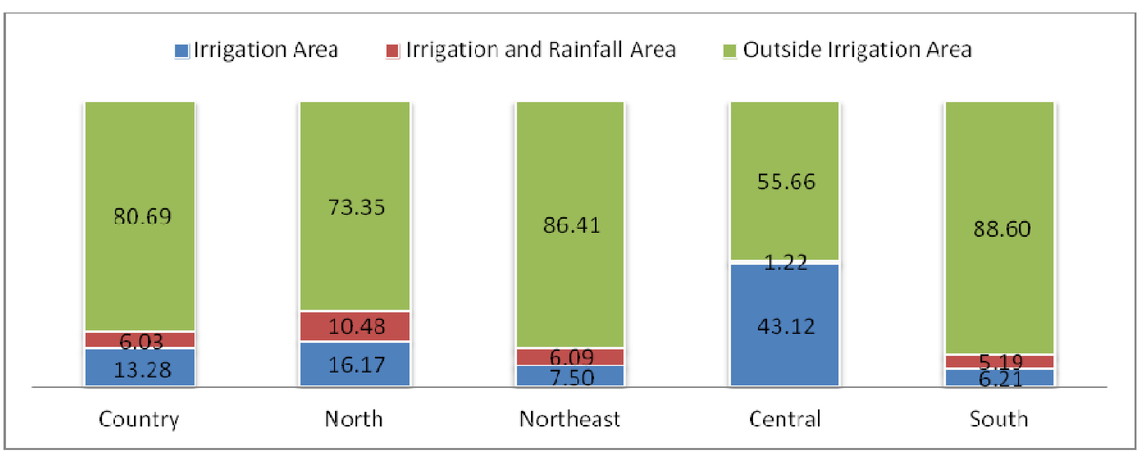
Figure 3: Rice Productivity (ton/ha)



Source: International Rice Research Institute (IRRI)

Water is the main resource of agricultural productivity. An irrigation system can provide adequate and stable supply of water to farmers, boosting productivity. However, cultivation outside the irrigated area still faces uncertain water supply that can take a toll on productivity. In 2008, only 20% of the nation's total agricultural land was irrigated. Most of irrigated areas lie in the Central plains where rice is cultivated as can be seen in Figure 4 below. In the driest and poorest region in Thailand, the Northeastern region, only 7.5% of the land was fully irrigated and 6.09% partly irrigated. That is, as much as of 86% of the land relied entirely on rainfall. Worse, the supply of rain in the northeastern region is often inadequate and highly volatile, unlike in the southern region where the supply of rain is ample and consistent.

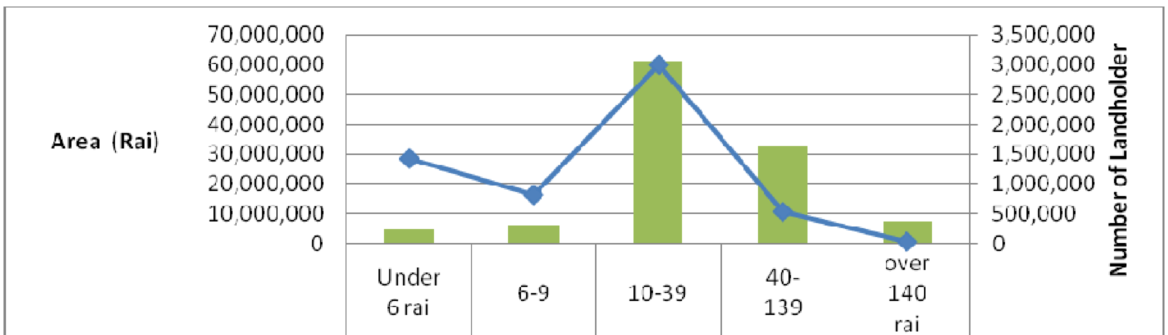
Figure 4: Proportion of irrigation area in Thailand year 2008



Source: Thailand Office of Agricultural Economics (OAE)

Another factor contributing to the relatively low productivity of agricultural farms in Thailand is the suboptimal scale of farm operation. According to the Agricultural Census in the year 2008 conducted by the National Statistical Office (NSO), 3 out of 4.8 million landholders, or over 60 per cent, own farms that are between 10-39 rai or 1.6 to 6.4 hectares. Only 27, 371 landholders, less than 1 per cent of all landholders, own farms that are larger than 140 rai or 22.4 hectares as can be seen in figure 5 below.

Figure 5: Land distribution and number of landholders in 2008



	Under 6 rai	6-9	10-39	40-139	over 140 rai
Area	4,721,340	6,142,119	61,255,350	33,015,357	7,500,235
Number of Landholder	1,431,088	818,281	3,005,634	537,486	27,371

Source: The National Statistics Office

Since most farmers operate small scale farms, they do not have the bargaining power in the product market *vis a vis* middlemen, food manufacturers or large distributors, whichever case may be. At the same time, they lack capital, knowledge and information required to respond to changing market demand or quality standards imposed by importers.

The fourth factor contributing to low agricultural productivity in Thailand besides deteriorating soil quality, insufficient water source and suboptimal scale of operation, is the logistics cost. The cost of logistics for the agricultural sector was estimated to be as high as 20-25% of the sector's GDP, while the number for the nation as a whole is roughly 20%, compared with a figure of 10% in most developed economies[1]. Undoubtedly, high logistics cost cuts into the relative competitiveness of Thai agricultural and food products

The high logistics cost can be attributed to several factors. First, most agricultural product supply chains in Thailand remain "traditional". That is, farmers sell their produce to

[1] Sorat, Thanit, The Agricultural sector Supply Chain, Logistic Digest: Logistic Supply Chain Information for Thai Industries. Article can be viewed (in Thai) at http://www.logisticsdigest.com

the middlemen with little information about the prevailing market conditions. For example, the lack of up-to-date information about the state of demand in the market may result in over production. As a result, farmers have to incur unnecessary warehouse costs and costs associated with the loss in the weight and the deterioration in the quality of their produce that allowed middlemen to depress the purchasing price . These costs add up to "inventory cost", which was estimated to contribute to as high as 47% of the total logistics cost[2]. Second, transportation of agricultural produce in Thailand relies almost entirely on road transport, whose per unit cost can be as 3.5 times higher than rail transport[3]. Third, low quality packaging contributes to the relatively high rate of product damage during transportation. Clearly, lowering logistics lost for farmers involve many

More recently, we have witnessed the demise of the role of middlemen globally as manufacturers and supermarkets reach out directly to farmers to shorten the supply chain[4]. Large agricultural manufacturers and retailers try to manage their own supply chain by using vertical integration via contract farming. Contract farming is a forward contract between a company as the buyer and a farmer as a seller of the agricultural produce. Generally, the contract will stipulate that the company will buy all the produce from the farmer at a certain agreed price. However, to ensure the quality of the produce, farmers are required to strictly follow production or cultivation methods set by the buyer. While the transfer of the cultivation method may promote higher farm productivity, the conditionality of the contract can be overly stringent, imposing excessive costs or risks born by the farmer.

For example, the farmer may be required to purchase fertilizer, animal feed, or pesticide at excessively high prices from the buyer, leaving them with meager margin. Even though contract farming helps eliminate the middlemen from the farmer's supply chain and provide farmers with guaranteed market and stable income, it also leaves farmers more vulnerable to buyers ,who clearly hold a superior bargaining position. The latter may impose conditions, obligations and restrictions which disadvantage the farmer and render him nothing more than an employee of the company as any value added that may arise from the contracted activity will be reaped by the company.

In Thailand, less than 5% of all agricultural farms operate under contract farming arrangement. These are mainly large scale farms as can be seen in figure 6 below.

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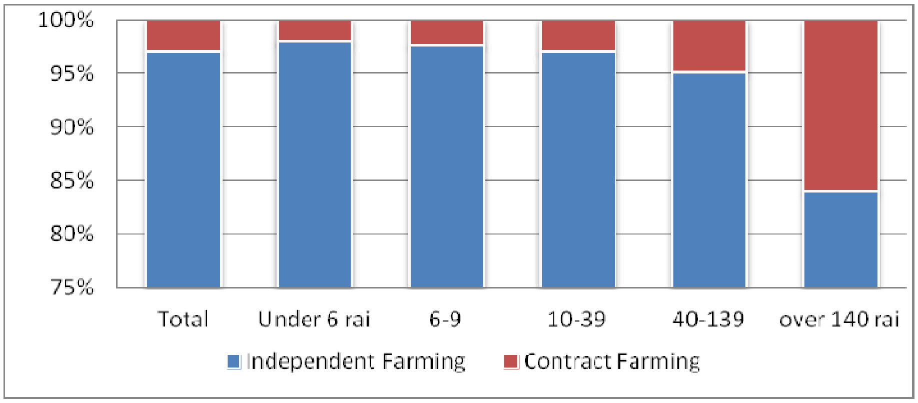
[2] Sorat as quoted above.

[3] It should be noted that only 2 per cent of freight movement in Thailand is dome through rail transport. The numbers for land and sea transport are 86 and 12 per cent respectively.

[4] Reardon, Timmer, C. Peter Timmer, and Julio Berdegue (2004), The Rapid Rise of Supermarkets in Developing Countries: Induced Organizational, Institutional and Technological Change in Agrifood Systems, Electronic Journal of Agricultural and Development Economics 1(2): 168-183.

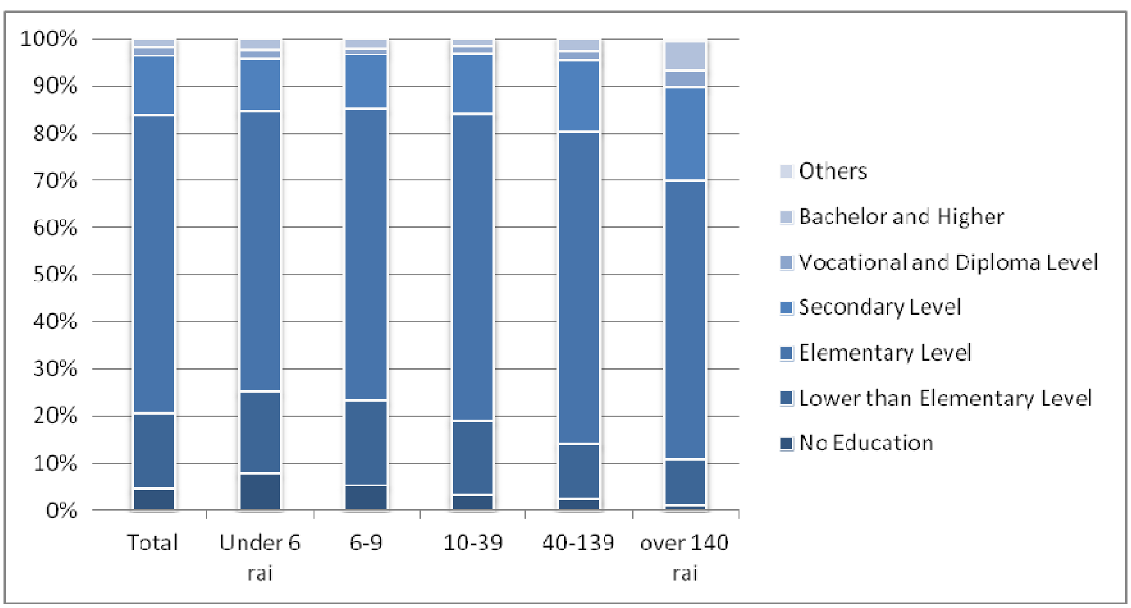
Figure 6: Number of Contract Farming and Independent Farming in 2008



Source: NSO

When talking about knowledge, perhaps the the first proxy indicator is the level of education. Although, knowledge is not acquired exclusively by education, the latter reflects the basis from which knowledge can be acquired and processed. From figure 7, it can be seen that almost 85% of Thai farmers completed only primary education. The figure is slightly lower for farmers with large scale operation at 70%. With such little education, Thai farmers are easily exploited by the middlemen or other parties in the supply chain and far from ready to become involved in a KBE.

Figure 7: Number of agriculturalists classified by level of education in 2008



Source: NSO

The lack of education may not pose such a disadvantage if farmers have access to information so that they may expand the horizon of their knowledge through learning. As mentioned earlier, one of the corner stones of the KBE is the information and communication technology (ICT) since access to relevant information can help provide small players in the market gain better bargaining position against larger business partners. Thus, the more accessible and affordable are ICT services for the masses, in particular, farmers and people at the bottom of the pyramidry, the higher the probability of succeeding in establishing a KBE.

On this issue, the Thai communication industry underwent rapid expansion, but mainly in mobile voice communication rather than data. According to the 2010 ICT survey conducted by the Thai NSO, the number of mobile users increased from 28.2% to 61.8% in 6 years. However, the number of computer and internet users as a percentage of total population did not increase as dramatically. In the year 2010, the figures are 30.9% and 22.4% respectively as can be seen in figure 8.

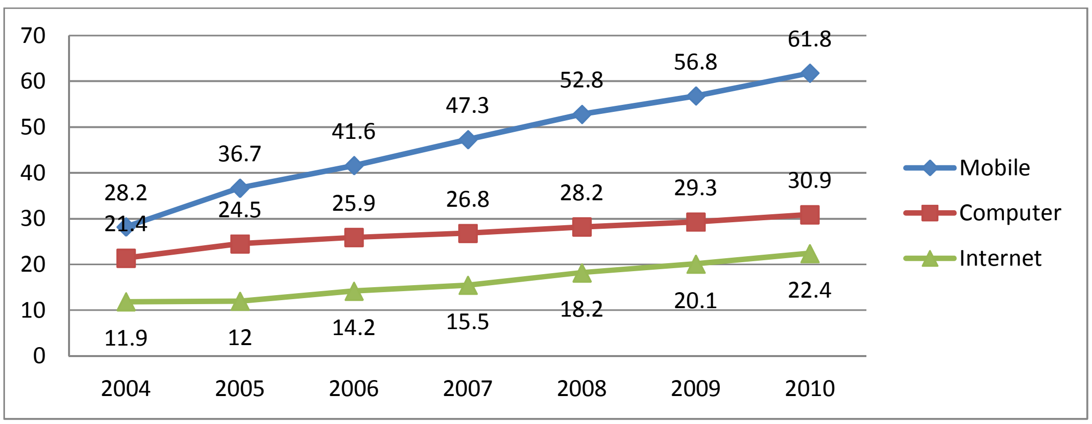


Figure 8: Percentage of ICT users in Thailand as of total population.
Source: 2010 NSO ICT survey.

The above figures show access to ICT services only at the national level. They do not illustrate the digital divide between the urban and rural areas. Figure 9 shows the gap between the numbers of users as a percentage of the population in the municipal and those in the rural area. The difference in the access figure was as high as 20 per cent in 2004 but narrowed down to 15 per cent in 2010 as illustrated in figure 9 below. The same is not true in case of internet and computer services, however, as shown in figure 10. The gap between the percentage of internet and computer users in the municipal versus the rural area appeared to have widened rather than narrowed. This is because, due to the much delay in the 3G license auction, broadband internet service in Thailand is provided mainly

through DSL cables, whose roll out concentrates mainly in urban areas[5]. There is no doubt that the low rate of access to the vast pool of information made available in the internet poses a major obstacle for Thailand in trying to transform its economy into a knowledge-based one.

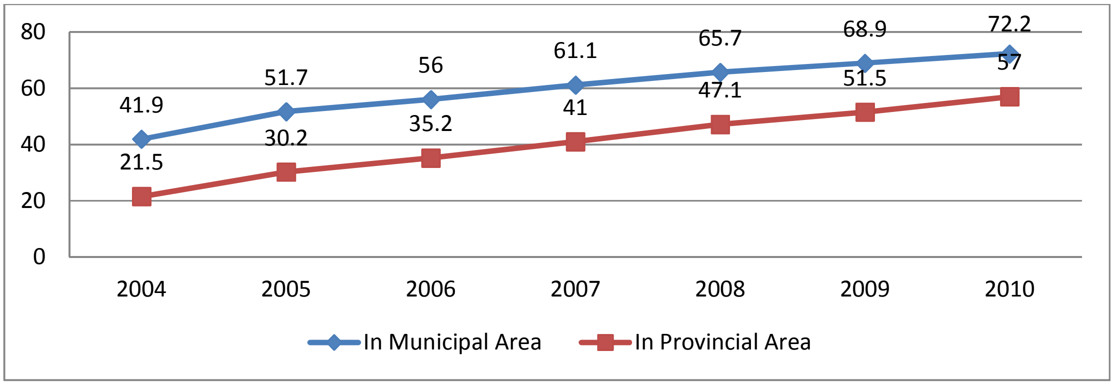


Figure 9: Percentage of mobile phone users in Thailand classified by area.
Source: 2010 NSO ICT survey.

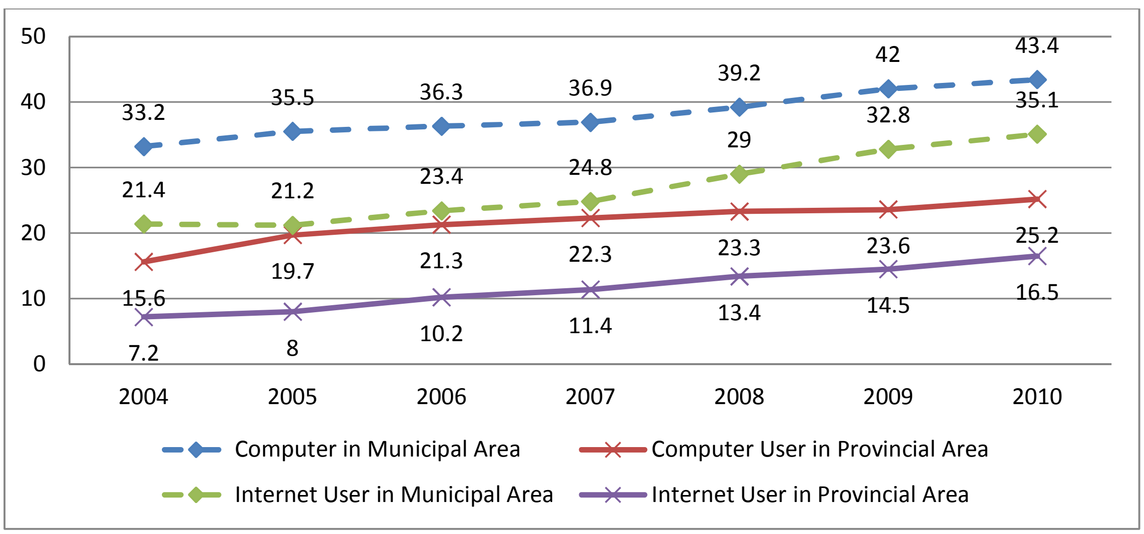


Figure 10: Percentage of computer and internet users in Thailand classified by area.
Source: 2010 NSO ICT survey.

To conclude, Thai farmers face several challenges in trying to boost their productivity and hence, income. Excessive use of fertilizer, inadequate or unreliable water supply and suboptimal scale of operation all contributed to low productivity. At the same time, high

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[5] Office of the National Telecommunications Commission, Report on the Telecom Market: third quarter 2010. Downloadable at www.ntc.or.th (in Thai only)

logistics cost, which can be attributed to the over reliance on relatively costly road transport -- due to the underdevelopment of the alternative rail transport -- and excessive inventory costs as farmers lack key market information to ensure that production is in keeping with demand.

The lack of education and knowledge on the part of small scale farmers poses a major challenge, let alone the gaping digital divide and the stagnant development of high speed data network (specifically, 3G) that leaves Thailand well behind even less affluent neighboring countries such as Laos, Cambodia and Vietnam. Section 3 will illustrate how the use of ICT can help small farmers deal with these challenges in order to be able to capture a larger share of the value generated in the supply chain. But before doing so, chapter 2 will briefly explain the agricultural logistic supply chain, which will help readers understand and appreciate the nature of the problems to be presented in the case studies.

2. Supply chain management in agricultural products

This section examines the efficiency of the supply chain of agricultural products in Thailand. Unfortunately, many farmers are not aware of the significance of the supply chain management nowadays. With a well-managed supply chain, there are ample opportunities to create higher-value products that can help generate higher income for those participating in the chain.

Participants in a supply chain can be categorized into 3 main groups, namely:

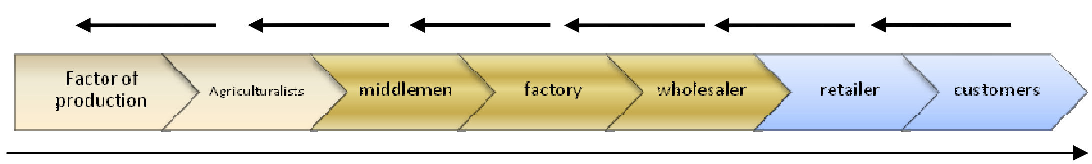
1) *Upstream group*; owner of raw materials input or factors of production – i.e., farmers.
2) *Midstream group*; middlemen, factories that process agricultural produce, wholesalers, etc;
3) *Downstream group*; exporters, retailers and consumers

Nowadays, modern supply chain management emphasizes the flows of 3 principal elements in a supply chain

1) flow of physical goods and services (including factor of production, intermediate and final goods and service)
2) flow of data and information among parties in supply chain
3) flow of financial transactions, e.g. transfers and payments

While the various activities that take place in the supply chain management are

1) Demand forecasting
2) Strategic sourcing or Procurement
3) Transportation
4) Inventory control
5) Material handling
6) Warehousing
7) Packaging
8) Order fulfillment
9) Customer service



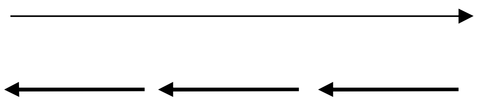


Figure 11: Supply chain diagram with flows of materials

A good supply chain management requires the sharing of data, information and technology between various participants along the chain. Information sharing may begin with the communication of changing consumers' demand from purchasers abroad to domestic exporters, then backward to the manufacturer, middlemen and eventually, the farmers. These players must be able to effectively (speedily and accurately) convey the message and coordinate with one another in trying to change the product or procedure to meet customers' expectations or demands.

The main problem in the Thailand agricultural supply chain is that farmers are rarely informed about the market condition. Also that their produce often end up in a market where there is an excess supply and the price of their produce is heavily depressed. This is because there are several layers of middlemen in between manufacturers and farmers that make a living from trading margins. Hence, these middlemen are reluctant to pass on any market information to farmers so that they hold a superior bargaining power when megotiating the purchasing price. Also, as mentioned earlier, most agricultural farms in Thailand are small scale. With a large number of farmers, supply control and production coordination are difficult to arrange as each farmer makes independent production decision.

The agricultural market can be considered a "imperfect competitive market" due to asymmetric information problem. In the jargon of supply chain management, this is the "bottleneck" of the flow of information in the chain. As a result, the monetary flow from consumers that would or should have gone to farmers end up in the pockets of participants in the middle of the supply chain such as middlemen, wholesalers or manufacturers who managed to depress the purchase price of agricultural products in order to maximize their margins.

But the obstruction of the flow of information along the agricultural supply chain has become untenable with emerging rules and regulations that require better communication and coordination among members in the supply chain. . For example, both the European Union and the United States have established high sanitary and phytosanitary (SPS) standards for imported agriculture products. Exporters have to plan the procurement and set the delivering plan to respond to the particular demand and communicate such plan to the middlemen, who would, in turn, inform the farmers. The latter would then have to plan their cultivation accordingly.

A good plan must include an accurate estimation of the loss rate that may occur along the supply. The farmers need to be informed about the time it will take and the condition under which the agricultural produce will be transported and delivered to the hands of consumers. It should be noted that the supply chain management also include the packaging process, which can help reduce the loss rate. Then, selecting the appropriate transportation is the next step.

Moreover, import regulations of agricultural produce nowadays also require traceability. That is, the importer must be able to verify the identity of all participants in the supply chain starting with retailers, importers, exporters, manufacturers until farmers as the primary producer. Thus, traceability requires a well managed and well documented supply chain.

3. Case Studies for KBE in the Thai Agricultural Sectors

This section compiles interesting case studies involving the using of ICT in the agricultural product supply chain to improve farm productivity or efficiency in the product supply chain so that (small) farmers can capture a larger share of the agricultural supply chain. The cases are selected to address key challenges facing small scale famers in Thailand. These are

1) compliance to stringent sanitary standards imposed by importing countries: cases selected concern the use of ICT for traceability in the *organic rice* and *tangerine s*upply chain

2) Lack of market information: case selected concerns the use of ICT for dissemination of market information in the *longan* supply chain.

3) Lack of knowledge about cultivation technique: case selected concerns the use of ICT in providing customized cultivation method in the *rice* supply chain.

4) Inadequate water supply : case selected concerns the use of ICT in *community water management* in Songyang subdistrict.

In each product supply chain case, ICT is applied to enhance the productivity or cut production costs borne by farmers. The water management case does not focus on the use of ICT in any specific agricultural supply chain but rather, illustrate the use of ICT to improve the management of agricultural production.

3.1 Using ICT for Traceability: The Case of Organic Rice and Tangerine

Thailand has been and remains a major exporter of rice in the global market. However, rice exports have been increasingly subject to traceability rule imposed by the importing country beginning with the European Union (EU), which passed EU's General Food Law that required mandatory traceability throughout the feed and food chain as of January 2005. More recently, as of July 1, 2011, Japan also required traceability of all imported food product as an enhanced safety measure. As traceability is the ability to verify the history, location, or application of a product by means of documented recorded identification throughout the supply chain, it has significant implications to the "traditional" agricultural supply chain. As for tangerine, it has become one of the major inputs in exported canned tangerine and fruit juice from Thailand to many countries. Like rice, traceability, is required by major importing countries.

3.1.1 The organic rice case study

This case study involves the establishment of a product traceability system for rice compliance with the EU's food law that requires traceability or backward checking system for verification and quality control (QC) on all food and agricultural products. The project was initiated by researchers from the Department of Computer Studies, the Faculty of Science, Konkhaen University with funding from the Thai Research Fund, a major research funding agency in Thailand.

The rice supply chain consists of players in the

(1) upstream (farmers and middlemen that buy rice from farmers for millers),

(2) middle stream (rice mills) and

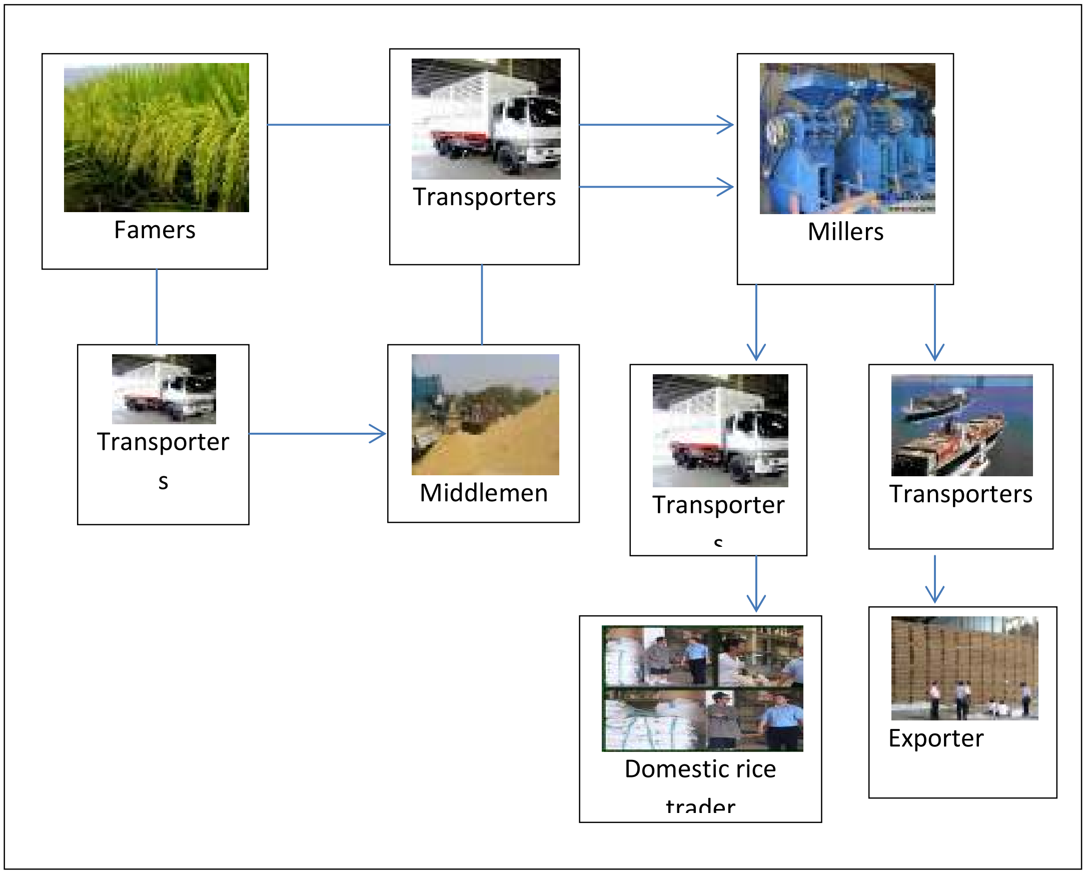
(3) downstream production (wholesalers, retailers and exporters) as well as

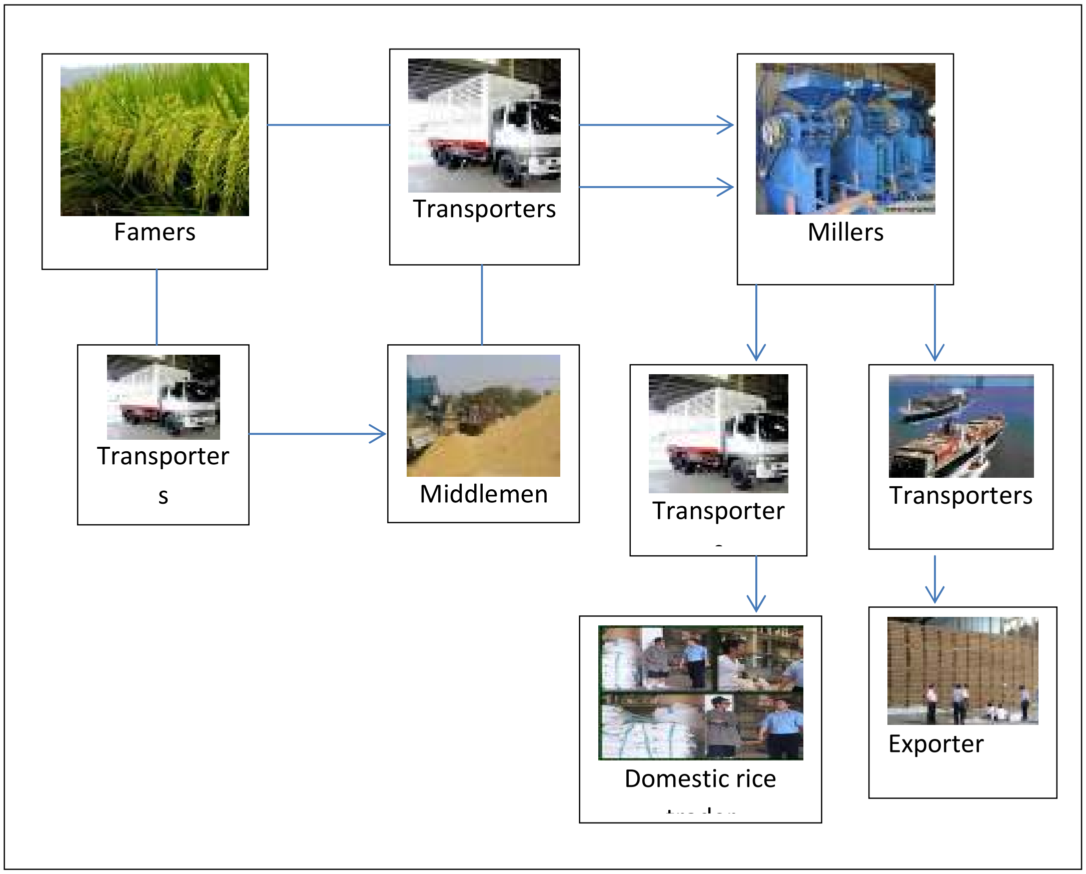
(4) those involved in the transportation of the product (shipping and trucking companies) as shown in Diagram 3.1.1 A below:

In order to design the appropriate ICT to facilitate traceability of the product, a SWOT analysis which defines the "Strength, Weakness, Opportunity and Threats" of the industry was conducted. The strength of the industry lies in the fact that most farmers, with the support of the government, are able maintain good agricultural practices (GAP) standard and the organic fertilizer producers and rice mills also maintain good manufacturing practice (GMP) standard. Moreover, Thai rice enjoys high recognition in the global market and Thai farmers are genuinely committed to improving the quality of their products to meet market demand and expectations. However, the weakness lies in the fact that they have little

knowledge about various marketing channels Thus, the distribution channels become a bottleneck problem in supply chain, depressing the price of the produce. Another weakness identified was the lack of coordination and cooperation among farmers in sharing their knowledge regarding production know-how as well as resources.

Diagram 3.1.1 A





To be able to meet the traceability requirement imposd by importing countries, researchers initiated a project to assist the farmer' community in creating an efficient traceability system for their products beginning with the identification of the working procedures and actions of each participants in the supply chain. At the upstream level, farmers need to record and store the information on cultivation such as seedling source, fertilizer usage, harvest, packaging etc. following the GAP or organic farming method. The documentary system and record methodology were provided by the Department of Rice, the Ministry of Agriculture and Cooperatives.

The middlemen, agricultural cooperatives and rice mills, as the participants in the midstream group, must record and slot the rice purchased according to its supplier. Then, each slot of rice from different origin will be packaged with electronic product code (EPC), which can be a barcode or a radio frequency identification (RFID). The code will contain information on the origin of the rice, the production process and the processing in midstream. Finally, the packaged rice with the EPC is transported to the downstream level, the wholesalers and retailers. Consumers can access the traceability system of the product bought on-line through *www.thairicetrace.com* by entering the specified EPC. The product with this traceability system is tagged with brand "Rice Trace, Food Safety".

The system is also designed to facilitate farmers that do not have access to a computer. Manuals on how to record basic data stock, manage rice stocks, advertise products through e-commerce and the issuance of bar codes and traceability are provided. Farmers that do not have computers and printers can ask a "central bar code issuer" to send them bar codes and can approach the manager of the "e-marketplace" to help them with e-marketing.

The researchers confirmed that consumers are able to trace the organic rice product by using the EPC code. Moreover, the producers and product processors can also track the product. However, the authors found the website to be rather primitive as there are no instructions or elaboration of any kind, just a place where the code can be entered. Clicks do not open linked websites that are supposed to provide about organic rice farming, the traceability project and system. Also, the facility to track the product is not operational.

Researchers claim that organic rice brands "Rice Trace, Food Safety" fetch a price premium of around 40-50% when compared with other organic rice brands and reported monthly sales of 500 kilograms. They report that traceability instills consumers' confidence in the product and hence, can be a useful tool for product differentiation that can help enhance the value of a product. However, they reckon that the sales figures can also be subject to other factors besides traceability, which requires more thorough quantitative study.

3.1.2 The Tangerine Case Study

Similar to the case above, a group of researchers from Chiang Mai University have set up a traceability system for tangerine farmers by affixing their products, often packaged in boxes and net bags, with "Quick Response (QR) Code".[6] Customers can access traceability information embedded in these codes by downloading the "QuickMark" program, the QR code reader program, from website www.chiangmaisweettangerine.com on to their mobile phone. With the program, by scanning the code on the product, the consumer may receive the product data including information about the particular orchard, product data, QC approval date etc, instantaneously. The website also allows customers to place order online, hence, bypassing middlemen.

In conclusion, these two case studies exhibit the use IT to establish product traceability that is easily accessible by both the consumers and retailers and distributors. Although the initiation has been prompted by the need to comply with stringent rules of importing countries, it has provided many positive spillovers for the farmers. The

[6] A Quick Response code is a specific matrix barcode (or two-dimensional code) that is readable by dedicated QR readers, smart phones, and to a less common extent, computers with webcams. The code consists of black modules arranged in a square pattern on a white background. The information encoded may be text, URL, or other data.

establishment of the traceability system opened a new world for farmers, who, until now, were oblivious to the advancement in information and communications technology that can help to promote and differentiate their products. The internet has been exploited not only to facilitate traceability, but also to promote alternative marketing channel where farmers can sell their produce directly to potential customers and hence, improve their bargaining position against middlemen who used to be the captive purchaser.

Although the system is still in its early stages, it has marked a significant progress and better, offer great marketing potentials for small farmers and bringing together, for the first time, the farmers and all parties involved in the rice supply chain.

3.2 Using ICT for cultivation and market information dissemination: The Case of Off-season Longan

Longan is one of the major agricultural export of Thailand. Most longan orchards are located in the northern region of Thailand. Presently, there are roughly 1 million rai of longan orchards, or roughly 160,000 hectares. Due to the surge in the number of longan orchards during the year 2000-2007, farmers have been facing chronic problem of excess supply of longan during the peak supply months of July- August such that the government had had to step in to help support longan price. But thanks to technology, longan can now be grown out-of-season. Out-of-season longan can fetch much better prices if the timing of the supply corresponds with the demand that tends to peak during November - February, which marks several international and Chinese festivities.

However, cultivation of non-seasonal longan is knowledge intensive as the weather condition is not be favorable to cultivation – i.e., too cold or too much rain. Farmers need to know in detail the optimal timing and quantity of the application of flowering chemical (potassium chlorate), which depends on several factors including the age and type of the tree, the amount of light, etc. that only experienced farmers know. The farmers also need to know appropriate pruning techniques that will allow optimal application of the flowering chemical. Most importantly, famers need to know the market condition in order to ensure that the timing of the production is in keeping with the market demand. In the past, only 30 per cent of farmers who cultivated off-season longan succeeded.

In growing off-season longan, farmers often seek casual advice from academics with whom they are familiar or phone up radion stations that provide advice regarding agricultural farming. Thus, the use of ICT can help farmers access these cultivation techniques (watering, application of fertilizer and pesticides, harvesting, etc.) and share experiences by systemicly compiling the relevant information in a website where all farmers may access

The longan supply chain consists of longan farmers, longan manufacturer, transporters and exporters. The researchers have conducted a SWOT analysis for the industry and pointed out the weakness of the Thai longan supply chain as follows:

1) Product quality; there is no established standard drying procedure, no product standard classification and no grading.
2) Response to market demand; there is no systematic two-way communication between farmers, manufacturers and transporters so that information regarding consumers' demand and preference does not flow up the supply chain.
3) Cost of production; There is lack of planning and management of the cost of production.

This project, conducted by researchers from Chiang Mai and Mae Jo University and in association with the Thailand Research Fund and the National Electronics and Computer Technology Center (NECTEC), aims to create a learning community among off-season longan farmers and by using the ICT in order to promote the exchange information and coordination. The key idea is to collect off-season longan farm data (soil type, chemical application, whether condition, amount of rainfall, etc.) and other key cultivation variables) from pilot farms, totaling 65 in this project, in order to formulate the timing and the volume of the expected yield from each longan farm by different chemical application using the "fuzzy neural network" method. With such information, farmers can have access to efficient cultivation method and at the same time, obtain information about the expected supply of longan (from member farms) at any particular point of time and so, can plan their own cultivation accordingly. All this help to smooth the supply of longan and hence, its price as well.

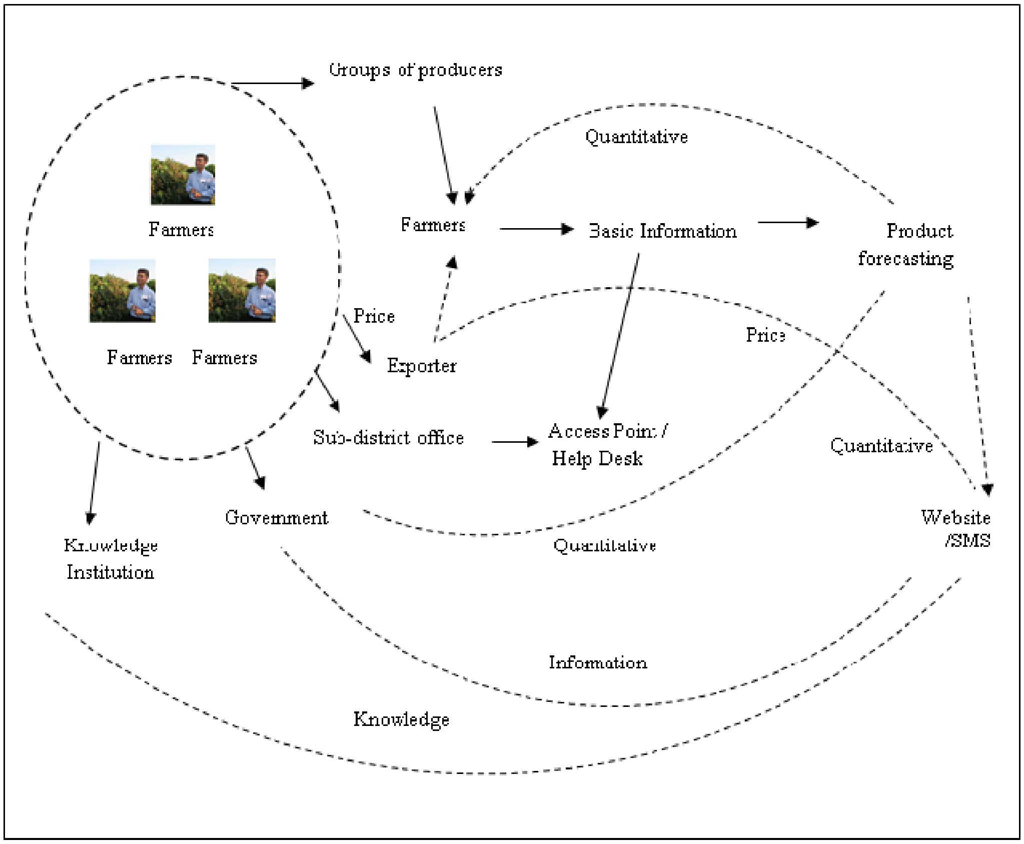
To facilitate better farming and market information flows between different parties along the supply chain, researchers have established a website the www.thailongan.net, which provides the following information:

1) Longan orchards in the community, including data on the particular farmer, cultivation , location using satellite graphic, production forecasts, market and production news etc.
2) Bidding price from the manufacturers and price of longan sold in major markets or retail stores.
3) Cultivation information and techniques in video clip format

Indeed, only a few farmers will have a computer or are computer-literate. To facilitate farmers that do not have access to the internet, the Subdistrict Administrative Organization (SAO) provides the access point and a help desk. Farmers can access the data through the computer provided by the SAO and can seek help from the officers assigned to

the help desk as can be seen in Diagram 3.2 A below. Moreover, farmers that do not have access to a computer can receive notice about the date of the planned chemical application or price of longan via SMS.

Diagram 3.2 A The Longan Information Network



To administer the community database and the website, a community chief information officer (community CIO) was appointed by members of the community. After the establishment of the information system, the emphasis has been on improving the production forecast program to assist in more accurate cultivation planning, establishing a local radio station following the and updating the longan market situation such as the price movement, and disseminating useful knowledge and techniques in longan cultivation and creating efficient communication links with the universities.

To conclude, this project is designed to help farmers to have access to cultivation techniques and to be better informed about present and predicted market condition of their products in order to be able to better plan their cultivation to avoid the supply glut problem that plagued the industry in the past. As a result, farmers can sell their products at higher prices and cut excessive production cost. Statistics reveal that farmers which participated in this project on average incurred production cost that was 34 per cent lower than those that did not participate, while their revenue doubled those of the seasonal longan farmers.

This project is currently under the financial support of 9 national Universities. It is uncertain whether the scheme can be self financed when the financial support ends – i.e.,

whether longan farmers will be willing to contribute to the maintenance of the information collection and analysis system.

3.3 Using ICT for Customized Cultivation

The advantage of chemical fertilizer is the convenience of usage unlike organic fertilizer, which is complicated to prepare and generally less effective in enhancing production. As a result, Thai farmers prefer the chemical fertilizer, especially in rice, feed corn, cassava and oil palm cultivation. Unfortunately, excessive and prolonged use of chemical fertilizer eventually leads to gradual deterioration of soil quality reducing yield in the longer run. In case of rice, overdose of nitrogen in the soil, which is widely observed, causes the rice shaft to collapse. Moreover, since Thailand cannot produce chemical fertilizer domestically, the product has to be imported and the price is rather high. The cost of chemical fertilizer is estimated to contribute to as much as 60% of the total cost of rice production. The government provide partial subsidy for the purchase of customized fertilizers, roughly 10 per cent of the total cost as well as provide interest-free credit through the Bank of Agriculture and Agriculture Cooperatives. Thus, an efficient use of fertilizer will not only help cut unnecessary expenses, but help improve the quality and safety of the farm produce that is in keeping with market demand.

Rice farmers are, apparently, in dire need of knowledge and skills in soil management. But different plots of cultivating land have different soil type and condition, and hence need specific mix of fertilizer. Prof. Dr. Tassanee Attanan, a professor at the Faculty of Agriculture, Kasetsart University, has compiled all soil types in Thailand, which totaled to over 200[7]. Each soil type differs in terms of the texture, color, slope, permeability, drainage, thickness of layer, percentage of sand, silt and clay, total nitrogen for each layer, etc. The soil database based on the physical features will provide vital information that can help farmers in making more efficient fertilizer adding decisions.

It is important to note that this project is aimed at "empowering" famers by equipping them with the knowledge and tools to make key "production decisions" themselves, rather than rely on fertilizer vendors that only want to "push" their sales. The project involves participation from many parties and thereby, creating a valuable network between the academic, state officials and the farmers themselves.

Firstly, the classification of soil series mentioned above is undertaken by inquiring at the Division of Soil Survey and Classification, the Department of Land Development, Ministry of Agriculture and Cooperatives, which is located in every province. The soil series database

[7] http://www.thaiagro.com/

is accessible on-line via website www.soil.doae.go.th. Moreover, additional soil profile can be added into the program on-line as well.

Secondly, the soil must be tested by the soil test kit in order to specify the NPK (Nitrogen – Phosphorus – Potassium) data of the soil that is specific to the plot of land. Many farmers thought that soil analysis is overly complicated. However, the kit provided under the project has been designed to be user-friendly and can provide the result within 30 minutes. The analysis is updated each time fertilizer is added to the soil. A "site-specific nutrient management" program is made available in the website www.ssnm.agr.ku.ac.th. Farmers can download the program into their computers. Currently, the program is available for rice, corn and sugar cane.

To obtain specific recommendations with regard to optimal fertilizer mix[8], farmers have to enter relevant soil data into the downloaded program and follow the instruction by selecting the province in which the plot of land is located, the type of cultivating plant, the soil type and the figures for NPK composition in the soil.

Thirdly, as this project is not only about improving the use of fertilizer in rice cultivation, but also changing the attitude of farmers about the significance of being self-reliant and the importance of participation, network, sustainable cultivation, data and information as well as knowledge and learning. Twenty "lead farmers" were identified and provided with extensive training in sustainable farming, including the optimal fertilizer use. These leaders worked on experimental plots of land in order to be able to gain practical experience in sustainable farming in order to conduct similar training for other farmers in their own community.

This project received good response from many farmers and government departments involved in the pilot project. To be able to reach a large number of farmers, over 200 "leading farmers" were trained to become familiar with the technique. These leaders will then disseminate the soil management technique and provide relevant training. As a result, the project was further developed to allow access to the system through mobile SMS service since most farmers do not own a computer, but a mobile phone. Farmers may obtain information about the optimal fertilizer mix through SMS by merely entering the 3 digits for the N-P-K composition of the soil as indicated by the soil testing kit provided.

The study found that the cost of fertilizer for farmers who participated in the project fell by a remarkable 47%, while rice yield went up 6%. Moreover, the use of self-customized fertilizer can also help reduce the counterfeit fertilizer problem faced by many farmers.

[8] The optimal fertilizer mix for each plant and soil series is based on extensive quantitative analysis.

3.4 Using ICT for Community Resource Management

Climate change which brought more volatile and less predictable weather pattern has taken a major toll on the agriculture sector, which is highly dependent on the weather be it rainfall or temperature. Consequently, concerns about possible food crisis are looming.

As stated earlier, most agricultural farms in Thailand still rely on rainfall since irrigated land contributes to only roughly 20 per cent of the total agricultural land area. But even in the irrigated areas, water supply is inadequate at times. Therefore, efficient water management can help smooth water supply, contributing to higher agricultural productivity. This project, undertaken by researchers from the Faculty of Agriculture, Ubon Ratchathani University, focuses on using the ICT to help manage water supply for the farming community in two selected areas namely, the Songyang subdistrict and the Maha Chanachai district, both of which are located in the Northeastern Province, Yasothorn.

In the Songyang subdistrict area, most farmers cultivate jasmine rice and sticky rice, while some plant cassava and lettuce. A large part of the area is irrigated by pumping water from the Chi River. But only 22 per cent of the farm declared adequate water supply from irrigation. Most relies on rainfall and hence, faces production uncertainty. Most rice farmers also cultivate twice a year, which demands sufficient water supply throughout the two crops.

According to the SWOT analysis conducted by the Songayang Subdistrict Administrative Organization (SAO), these farms lack technology in general and inadequate water resource during the drought period. The latter is partly attributed to inefficient water supply system. The network of irrigation canals is limited such that many farms cannot access irrigated water supply. Farms that are directly connected to the canal are unwilling to allow water to flow through their paddy fields for fear that their precious fertilizer will be washed away into the adjacent farms. Expansion of the irrigation canal network is both time consuming and expensive. Inadequate and unpredictable water supply led to low yield and high cost of production.

To alleviate the water shortage problem, the community had dug a canal parallel to the irrigation canal and apply water pumps to feed water to the canal. Farmers that requested water must pay the electricity cost of the pump with partially subsidy from the government. However, the management of the distribution of water through water pumps was very inefficient as the timing and the volume of the water pumped into the subcanals do not coordinate with those demanded by the farmers such that much of the water pumped was wasted. Also, there is no coordination among farmers when making request for pumped water. For example, farmers with farms located along the same subcanal may request water at different time of the day, trickering multiple pumping service which

consumes electricity unnecessarily. Thus, there was an urgent need to install a more efficient water distribution scheme.

To help solve the water supply problem, the researchers and Songyang SAO decided to embark on a venture to build participatory approach to the management of water. Several community meetings and hearings were arranged to hear out the problems and suggested solutions. A consensus was reached that the dispensing of water was to be centralized to save electricity costs borne by individual farms arising from uncoordinated pumping of water[9]. Each farmer must specify the volume and date or the water requested, while the pumping station must record pumping details such as the name of the pumping station, the volume of water pumped, the duration of the pump operation Also, it was decided that the funding of additional canals so that more farms would have access to irrigated water supply are to be mobilized both from the government and the community itself. Water users will contribute to the fund through usage fee.

The Decision Support System (DSS) for water management helps coordination between water users, water pump officers and the SAO to support an integrated water management. The system consists of 3 main components namely 1) Water management system; 2) Information management system and 3) Reporting system.

Firstly, the water management system requires all water users to register. The users must form groups. Only the head of the group can place a request for water supply. The request must specify the aggregate volume of water requested by members of the group, the time that the water supply is to be delivered and route by which the water supply is to be delivered. This data will be shown on line.

Secondly, the system also provides the daily water pump record from different pumping stations which contains the detail of water level at station, pump usage, usage period, pumped water volume, electricity units used with calculated cost, zone and timing. The information will be sent to information management system which is available to monitor.

Lastly, the reporting system provides a water users report which contains the name of the recipients of the allocated water as well as the date, time and duration of pump usage, volume of water pumped and the electricity cost to be collected from the users. The information can be updated and monitored easily by the SAO, the head of village or even every villager. The system which compiles and reports all information on-line facilitates efficient and transparent water management scheme that is acceptable and appreciated by all parties involved.

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[9] The applied electricity cost at pumping stations is partially subsidized by the Department of Irrigation for the supply of pumped water during the dry season or dry periods during the rainy season as dictated by the department. Supply of pumped water during other periods will be charged at cost.

4. Analysis

The first section of the paper reveals that the average Thai farmer faces several challenges in trying to increase productivity and their share of value added along the supply chain. Insufficient water supply, lack of knowledge about proper cultivation techniques and suboptimal scale of production. At the same time, lack of information about the market demand, in termsof both the quantity and the quality of the product, renders farmers captive to middlemen who, with superior information, often suppress the purchasing price of produce the buy from farmers.

These case studies show that the ICT can be a powerful tool to help solve the problems mentioned above. . First, it can help connect different players along the agricultural supply chain so that vital market and production information may flow more easily both upstream and downstream such as in the case of the traceability of rice and tangerines. But just connecting people will not be sufficient if relevant information is not available. Therefore, concerned players involved in the supply chain need to keep proper record, process and share information systematically. As in the case of traceability, knowledge sharing and cooperation are key success factors. Designing a good data collection scheme is thus a prerequisite.

Second, ICT can help solve asymmetric information problem that can disadvantage farmers. As in the case of longan, because farmers lack information about the prevailing price of the product in the market and knowledge about alternative marketing or distribution channels, they merely accept low prices offered by middlemen. With access to accurate and timely price data, farmers can secure a better bargaining position and hence obtain better prices for their produce. However, when implementing ICT based information dissemination scheme, it is most important to ensure that the majority of farmers that do not own a computer have access to a public computer and those who are computer illiterate receive proper assistance at the site. Also, it is worthwhile to establish complementary dissemination channels, such as a radio program in this particular case, to maximize the reach of the information.

Third, ICT can help with activities that require cooperation and coordination among farmers on a broad scale. In the case study examined, ICT has been implemented in order to assist communal water resource management in the Songyang district to help cut cost. Without the management system, the cost of water pump accrued independently to individual farms was very high. With centralized management, such cost was dramatically reduced. In the Longan case, ICT was used to assist farmers in coordinating the supply of off-season longan to stabilize prices of the product at any particular time.

It is important to note, however, that in this case, ICT plays only a facilitating role in promoting transparency of the management system that has been meticulously designed

and agreed upon by members of the community themselves. In the case of water management, members of the community have to accept the water allocation rule whose actual implementation is reported and monitored by the use of ICT. In the longan case, members have to agree to coordinate their production in order to avoid the problem of excessive supply in the market. Without the consensus-building procedure, it is unlikely that ICT alone can help solve the water resource allocation problem.

Finally, ICT can help disseminate information that can be useful to both the supply and demand side of the production. On the supply side, ICT can be used to advertise cultivation techniques and methods that can help cut costs and boost productivity as in the fertilizer case where farmers can obtain optimal fertilizer mix by entering soil type and composition into the preset program. In the longan case, cultivation techniques of off-season longan are broadcasted thorough video clips. Similarly, from the organic rice and tangerine cast studies, ICT was used to disseminate information on cultivation of organic products, which includes tacit knowledge and experience accumulated by farmers. In such a case, the documentation and compilation of folk wisdom should be supported. This is perhaps a simple way to introduce KBE into a community since it promotes the culture of information documentation and sharing by members of the community, which is also useful in productivity improvement.

On the demand side, ICT can help with e-commerce. In this paper, there are two products which have the e-commerce channel; organic rice and tangerine. E-commerce allows farmers to conduct marketing directly with potential consumers without middlemen. Through the direct channel, farmers can obtain relevant demand information such as price, quantity and quality of product demanded by customers which can used as the basis to forecast demand, plan production and arrange more efficient supply chain. However, having a website is not sufficient to guarantee success in e-commerce, consumers need to be made aware of the availability and quality of the product. Hence, it is necessary to undertake a broad advertisement campaign before introducing e-marketing channel.

It is noteworthy that all of these case studies on the application of ICT to the agricultural supply chain have been conducted by various academic institutes in Thailand. This seems to suggest that it is perhaps unrealistic to expect farmers to initiate the schemes themselves. This is because most Thai farmers are small scale farmers with very little or no education. It has been evaluated that the minimum size for setting up the ICT system for agriculture sector should be at the subdistrict level where the number of population ranges from 2,000 to 4,000. As farmers in the same subdistrict have the tendency to cultivate the same produce it is easy to achieve scale economy for the system in such as a small area. Moreover, the Administration at the subdistrict level (SAO) has sufficient budget to implement the ICT system. It would appear that the role of the state and experts are crucial to promote a more knowledge-based agricultural production and trade. The key element is how to ensure that the project is well designed to suit the practical needs of the farmers.

Here, the success of some of the projects remain questionable, such as the traceability case where the website that claims to facilitate traceability and provide e-marketing appeared undeveloped when the research team checked in June 2011. By November 2011, the website was no longer available and the head researcher did not provide the research team with any explanation when contacted by phone and later by e-mail as instructed.

On the other hand, the case of fertilizer customization was met with success and the project has now been expanded to many crops besides rice as more and more farmers participated. This is because famers clearly benefitted from the project in terms of savings from excessive fertilizer costs and improved soil condition. Likewise, the project on water supply management, which is now implemented in many districts nationwide, is well received because there were tangible cost savings from electricity charges for water pumping services as well as better water allocation. Also, the off-season longan provides farmer with information about the location and the production capacity of longan orchards in the region as well as the name of the operator in order to facilitate better coordination and information sharing. The website is relatively well developed.

However, the success of the project in each and every case hinges on the community itself. They must be willing to collect, record and share data that is to be disseminated and accept rules and regulations attached to the scheme. In such a manner, it can be said that the use of ICT forms a basis for KBE. The customized fertilizer is a good example of the point made. Because soil information can be uploaded or downloaded on line through computers or mobile phones, farmers have better control of their production methods and costs. They have learned about the characteristics of the soil in their plantation and how to solve the problem themselves. The soil test tool kit and the user friendly program that provides instant recommendation on the optimal fertilizer mix provides the basis for inclusive knowledge on soil management and encourage the thinking, analyzing and problem solving skills that would permanently change farmers' attitude towards their own role in the agricultural supply chain.

5. Policy Recommendations

The case studies reveal that the application of the ICT can help solve many problems faced by small farmers engaged in agricultural supply chain such as the lack of market information, lack of knowledge about production and lack of coordination among the farmers themselves as well as between farmers and other players in the supply chain such as wholesaler, retailers and consumers. However, the scheme needs to be sufficiently simple to be able to engage farmers, most of whom have limited education. The traceability

case proved too complicated and thus did not succeed beyond the pilot stage. A successful scheme will require the participation of the farmers themselves as well as that of state officials and outside experts as well as proper financial incentives as explained earlier. Therefore, the following recommendations is proposed in building a knowledge-based economy in the agricultural production sector

Private sector(including farmers)

- Farmers need to bind themselves into an organized entity in order to be engaged in any ICT schemes. This is because the implementation of a knowledge based economy require the documentation, collection, and sharing of information between members. Once farmers are well organized, schemes that require any cooperation, coordination or consent of concerned parties can be easily implemented
- Once farmers can organize themselves into an organization, then they need to establish ties with the relevant academics or academic institutions that are equipped with the required expertise as well as with the local authority whose financial and administrative support will be required to successfully implement an ICT project.
- At the same time, farmers need to learn how to make "information based decisions". They need to develop a habit of collecting cultivation data and information that will help assist them in making key production decisions including the timing or frequency of cultivation, choice of fertilizer, the optimal marketing channel, etc.
- Various players along the supply chain such as exporter, trader, manufacturers, wholesalers and retailers need to reach out to the farmers by providing a systematic feedback mechanism which will inform farmers about the quality and characteristics of the product demanded by consumers. This may require a major change in the mentality of participants down the supply chain as most believe that by holding back market information, they are able to take advantage of the farmers. While this may be true in the short run, but a mutually beneficial relationship can provide more vibrant business prospects in the longer run.

The state

The case studies show that farmers are not in the position to initiate the ICT schemes themselves due to the lack of knowledge and expertise. If so, it is important that the state recognizes the importance of initiating the schemes by outside expertise. As in the case studies presented, the initial analyses simply requires a SWOT assessment to identify the problem areas to be fixed and the potential areas that can be exploited, which does not require a large sum of money. Then after, the ICT project can be designed to a specific

bottleneck or problem area. Again, the scale of the project can be small, especially when it is designed as a pilot project. The designing of the project, however, should solicit inputs from all concerned parties to ensure its practicality and feasibility.

Besides providing funding for the initial assessment study and the subsequent designing and launching of the project, the state may play an important role in terms of providing technical information such as rice breeds and soil types. Local administration, on the other hand, may also play an equally important role in the implementation of the projects as they may assist the farmers' community or association in setting up the communication platform or providing access to computers and assistance for farmers who are technically challenged. To conclude, in building a knowledge based economy, the state would need to do the following:

- commission an initial assessment study to identify the constraints and problems faced by farmers in the agricultural supply chain. Perhaps, it is practical to begin with a supply chain of the most important agricultural produce such as rice in the case of Thailand.
- commission a team to help design an ICT scheme that can help alleviate the identified constraint or problems that will work closely with the affected farmers. This step requires not only ICT or agriculture experts, but also specialists in group discussion as well as public hearing as stakeholders participation is crucial to the successful implementation of the scheme.
- Provide point of access to database or information pool for farmers who are not equipped to do so independently.
- Provide problem solving assistance to farmers who face problem in or have questions regarding the ICT scheme.

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