Cost Reduction in Farm-Based Agriculture Through Increased Grower Maturity

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ABSTRACT

In agriculture, many methods and systems have been developed to support farming activities focusing on the utilization of knowledge, technology and enforced standards. However, the existing capability of the grower resulting from education is a major obstacle to the full utilization of daily agricultural processes. Consequently, costs and risks associated with agricultural business cannot be effectively managed. This paper presents an alternative sustainable agricultural framework to assist the grower with managing costs and risk management through an improvement in grower capability. A maturity model is applied and developed into a Grower Maturity Model where an increased maturity level translates into better management of costs and risks. Since knowledge plays an important role in capability improvement, a specific learning framework in agricultural business is also developed to represent the relationship between learning and costs and risks. The results show that costs in agricultural processes can be sustainably and effectively reduced through better knowledge and an increase in the capability level of growers. Ten okra growers in Samut Sakhon province exporting to Japan are used as case studies.

Keywords: agricultural management, good agricultural practices, grower maturity model, knowledge management, sustainable agriculture

บทคัดย่อ

ในอุตสาหกรรมการเกษตร วิธีการและระบบมากมายได้ถูกพัฒนาขึ้นเพื่อสนับสนุนกิจกรรมทางการเกษตร โดยมุ่งเน้นการใช้ประโยชน์จากความรู้ เทคโนโลยี และมาตรฐานที่บังคับใช้ อย่างไรก็ดี ความสามารถของเกษตรกรมีผลมาจากภูมิหลังด้านการศึกษา ซึ่งเป็นอุปสรรคสำคัญในการดำเนินกิจกรรมทางการเกษตรอย่างมีประสิทธิผล นอกจากนั้นยังไม่ได้มีการจัดการต้นทุนและความเสี่ยงที่เกี่ยวข้องกับธุรกิจการเกษตรอย่างมีประสิทธิภาพ งานวิจัยฉบับนี้นำเสนอแนวความคิดที่เป็นทางเลือกในการทำการเกษตรอย่างยั่งยืน เพื่อช่วยเหลือเกษตรกรในการบริหารต้นทุนและความเสี่ยงผ่านการพัฒนาระดับความสามารถของเกษตรกร โดยนำแบบจำลองวุฒิภาวะมาประยุกต์และพัฒนาเป็นแบบจำลองวุฒิภาวะของเกษตรกร ที่แสดงให้เห็นว่าระดับของวุฒิภาวะที่เพิ่มขึ้นจะนำไปสู่การจัดการต้นทุนและความเสี่ยงที่

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ดีขึ้น เนื่องด้วยความรู้มีบทบาทสำคัญในการพัฒนาระดับความสามารถ ทำให้มีการพัฒนาแนวความคิดการเรียนรู้ในธุรกิจเกษตร เพื่อแสดงให้เห็นความสัมพันธ์ระหว่างการเรียนรู้กับต้นทุนและความเสี่ยง ผลจากการศึกษาแสดงเห็นว่า ต้นทุนในกระบวนการทางการเกษตรลดลงได้อย่างมีประสิทธิภาพ และยั่งยืนผ่านความรู้ที่มากขึ้นและระดับความสามารถที่สูงขึ้นของเกษตรกร กรณีศึกษาและตัวอย่าง คือ เกษตรกรผู้ปลูกเลี้ยงกระเจี๊ยบเขียวเพื่อส่งออกไปประเทศญี่ปุ่นจำนวน 10 รายที่มีพื้นที่ปลูกอยู่ในจังหวัดสมุทรสาคร

คำสำคัญ: การจัดการเกษตร การปฏิบัติทางการเกษตรที่ดี แบบจำลองวุฒิภาวะเกษตรกร การจัดการความรู้ การเกษตรแบบยั่งยืน

INTRODUCTION

Under globalization, many countries have agreed to adopt a free trade mechanism where products and services can be traded more freely between markets (Kennedy & Rosson, 2002). This is seen as a way to utilize resources more efficiently and allow countries to collaborate with each other for utmost benefit (Porter, 2008). However in reality, the first priority for every country is to try to protect the products and services of its local providers (Ardakani, Yazdani, & Gilanpour, 2009). To avoid any free trade violation, non-tariff trade barriers are introduced usually focusing on screening and consequently resulting in increased production costs for the exporting countries. Regulation and standards are the two most common non-tariff trade barriers typically utilized (Sumner, Smith, & Rosson , 2002) because there are differences in capabilities and knowledge between developing and developed countries.

In agriculture, the Global Good Agricultural Practice (GAP) is a standard mostly accepted worldwide. Although it covers health and safety as well as the credibility of producers, it posits difficulties and uncompetitive trade for developing countries. In practice, many different versions are adopted by each country. In Thailand, Good Agriculture Practice by the Ministry of Agriculture and Thai Good Agricultural Practice (GAP) by the Thai Chamber of Commerce are examples of this adoption. However, there are still problems with perceptions in the values of these standards from both growers and exporters themselves. Furthermore, it is enforced only on exporting goods; Thai growers tend to undertake contract farming with exporters who provide the necessary support ranging from knowledge to equipment and investment. More importantly, the lack of the required capability level to understand the standard and to utilize appropriate technology by Thai growers is a key fundamental issue. This is in contrast to the support from the government agencies which focuses on providing knowledge and certification to improve growers. The academic sector, especially research from universities, is the key knowledge provider. However, it is evident that the level of transferred knowledge from a university is beyond the grower's background to comprehend.

Internationally, other methods have been introduced and implemented; for example, the promotion of organic farming concepts and the systems approach to assist in business decision-making (Kropff, Bouma, & Jones, 2001) or ecosystems to foster the ecological equilibrium in order to control plant disease, insects, and pests (Tilman, Cassman, Matson, Naylor, & Polashy, 2002). The concept of Knowledge Management is also applied in agricultural operations. In Iran, the Agricultural Knowledge Management System (AKMS) was developed as a platform for partners to transfer knowledge and research to the growers (Malekmohammadi, 2009). There has been an experimental study on the distribution of innovation and technology to small-scale growers where knowledge is mostly specific and not holistic (Hartwich, Pérez, Ramos, & Soto, 2007). Information and Communication Technology (ICT) is also used as a platform to share agriculture knowledge, marketing knowledge, and information on agricultural promotion by the government and private sectors (Ferroni & Zhou, 2012). The Knowledge Management (KM) model has also been developed for agricultural extension practice based on the SECI model (Socialization-Externalization-Combination-Internalization) for knowledge creation (Boateng, 2006).

In summary, since fundamentally, growers lack knowledge and capability, short-term solutions are typically deployed and potentially could damage the overall business in the long run. This paper addresses this issue and proposes that the associated costs and risks can be better managed with increased maturity of the grower.

PROPOSED GROWER MATURITY MODEL IN AGRICULTURAL INDUSTRY

This paper proposes a maturity model, also known as the "Grower Maturity Model (GMM)", of the knowledge worker in agricultural industry, specifically for the grower/producer. This framework is based on sustainable development where the costs and risks associated with agricultural processes are directly influenced by the capability of the grower. An increase in capability results in a better understanding of operational practices and better management of costs and risks.

The Capability Maturity Model (CMM) which was originally developed to improve software engineering practices is applied in this research to construct the GMM. Capability levels are defined as a guideline for growers to mature and to introduce discipline into their operational processes. These levels include initial, repeated, defined, managed, and optimizing (Curtis, Hefley, & Miller, 2001). By applying the CMM concept, the proposed GMM can then be constructed according to the Global GAP standard. Unlike the Global GAP which assesses the grower on the end results, the GMM provides guidelines to observe good behavior and manners at each level which indicate conformity to the Global GAP criteria. In other words, the GMM assesses the grower on mean activities rather than the end results.

The criteria to construct the GMM from the Global GAP are summarized and shown in Table 1 (Telavanich, Chakpitak, Chandarapong, & Tampprasirt, 2011).

Global GAP is considered in the parts of knowledge framework and criteria required to be accomplished according to the Global GAP standards. However, the assessment criteria according to Global GAP are classified into three levels—Major Must, Minor Must, and Recommend. GMM has adopted the requirement levels of Global GAP to the maturity level as shown in Table 1.

Table 1 Global GAP transformation to GMM

Level	Description	Global GAP evaluation		
		Major	Minor	Recommend
1	Growers work based on past ingrained experiences.	✓ / ×	✓ / ×	×
2	Growers have enough data, and can repeat the old successes.	✓	✓ / ×	×
3	Growers can identify problems. Solutions may not be correct and no systematic management.	✓	✓ / ×	✓ / ×
4	Growers can systematically manage problems.	✓	✓	✓ / ×
5	Growers develop and operate by taking into account the environmental conditions and business sustainability. There is the utilization of technology in agriculture.	✓	✓	✓

Consequently, Major Must will be classified as the basis, that is, from the second level. Minor Must and Recommend will be classified in higher levels, respectively, so that growers can understand what requirements need to be learned before they can go to a higher level.

The requirements in Global GAP are divided according to the nature of agriculture. This research employs the requirements in the parts of fruit and vegetable growing, which consist of All Farm Base, Crop Base, and Fruits and Vegetables. These three frameworks contain 20 detailed requirements (Global G.A.P., 2007; 2009a & 2009b). Since the GMM is on maturity development, similar requirements thus are able to be grouped. The grouping yields assessment results similar to the Global GAP assessment. After such a grouping, there are only 13 issues remaining as shown in Figure 1.

Each requirement will employ the important criteria required to perform and also suggestions according to Global GAP to assign knowledge to each maturity level of growers consistent with the GMM. Global GAP looks at the end result and it is a short term solution. However, the GMM can improve the capability of the grower to have a more mature approach, which is received from learning and facilitates managing costs and risk in a more sustainable manner.

RELATIONSHIP BETWEEN COST AND LEARNING IN GMM

Growers always encounter uncertainties which are the main cause of grower losses. Therefore, every time growers must make a decision relating to farming, they need to consider the risk factors and manage the risk to achieve success in their agricultural business. Risks in an agricultural business can be divided into five types but this paper will be consider only three types of risk as shown in Table 2 (Drollette, 2009).

Sustainable development and maturity enhancement of the growers indicate the development of grower capability. Capability enhancement needs to promote continuous learning by the growers. System thinking is employed to

1) Record keeping and internal self-assessment / Internal inspection	2) Site history and site management	3) Workers health, safety and welfare	4) Waste and pollution management, Recycling and re-use	5) Complaints
6) Traceability	7) Propagation material	8) Fertilizer use	9) Irrigation / Fertigation	10) Integrated pest management
11) Plant protection products	12) Harvesting	13) Production management		

Figure 1 13 GMM criteria

Table 2 Risk in an agricultural business

Risk type	Source of risk	Indicator
Production	Low production yield due to unforeseen insects, pest, disease, climate etc.	Production yield (quantity/rai)
Marketing	Fluctuating production price, production level, market demand	Price level (baht/kg), Market demand
Financial	Input or investment higher than output	Income (baht/rai/season) - Cost of input (seed, chemicals, fuel, labor, etc.)

develop the learning system of the growers. In addition, systems that promote a common learning of activities and output (that is, exporter, buyer system and grower system) are connected together to develop system thinking. System thinking of growers and buyers is depicted in Figure 2.

Knowledge engineering can be applied to facilitate the knowledge management and to reveal the responsibility and knowledge required for the tasks expected to be learned and completed by the growers (Table 3).

The system thinking-based learning of the growers will facilitate their capability enhancement which leads to increased maturity levels as shown in Table 4.

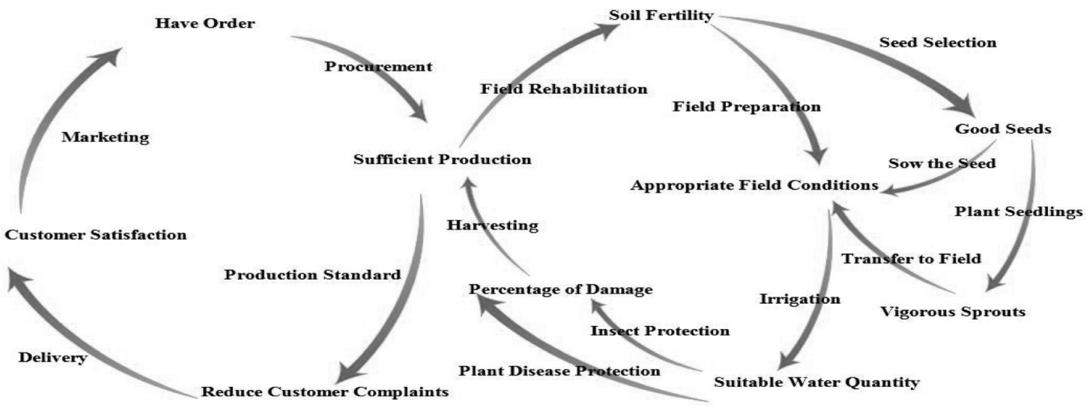

Figure 2 System thinking for okra growers and buyers

Table 3 System thinking types of knowledge

Type of knowledge	Attribute	Description
Inference knowledge	Resource	Principle of selecting practices
	Process	Practices or operation principles or guidelines from experience
	Output	Cautions/Output/Tactics
Domain knowledge	Know-How	Technical and practical knowledge
	Know-Why	Knowing cause and result from practices
Knowledge base	Know-Who	Source of experts, knowledge workers
	Document	Records, handbooks, reports
	Information	Data and Information

Table 4 System thinking to GMM improvement

Maturity level	What to think (Inference)			Know how	Know why	Knowledge base		
	Resource	Process	Output			Who	Doc	Inf.
LV 1	-	-	-	-	-	-	-	-
LV 2	-	/	-	/	-	-	-	-
LV 3	-	/	/	/	-	-	/	-
LV 4	/	/	/	/	/	/	/	-
LV 5	/	/	/	/	/	/	/	/

Table 5 provides an example of soil improvement based on system thinking to show the knowledge bodies that the growers need to take into account to increase their maturity level.

In applying the system thinking for maturity improvement, it can be seen that the GMM has one criterion more for each task. This reveals that each task may require different kinds of knowledge for the development and capability enhancement of growers. As seen in field rehabilitation, there is a requirement to know about the criteria of fertilizer use, site history, and site management. In addition, the record criterion involves many tasks because the record is an important fundamental in collecting data and statistics for further development.

CASE STUDY

This research considers a case study of okra growers who export to Japan. The growers are in a contract farming system with an exporting company and have more than 5 years experience in okra farming. Their education is to primary school level. All the crops in case study comply with the Global GAP standard. Moreover, the growers have more than 10 years experience in agriculture and have been farming okra on more than 2 acres (5 rais). There are 10 growers whose farms are located in Samut Sakhon province, divided into two groups—the GMM was not applied by group A, but was applied by group B.

The research comparatively studies the reduction of costs and production risk management of the two grower groups. The growers have costs as inputs for okra farming, including soil preparation, chemicals (pesticide, fungicide, hormones), fuel cost, labor cost for operation and product harvesting. The output is the product amount per rai.

Case Study 1 (Grower Group A)

General description: Initially, the five growers were satisfied with their business and the company because the amount of production and prices were satisfactory. However, the growers have been growing okra on the same site and there have been successive reductions in productivity. The growers have become discouraged because okra farming no longer yields the production rates expected.

Research process: The data were collected using interviews. The growers undertook their farming practices as usual and had been supported by the export companies based on the contract farming system. The growers have Global GAP certification. The data were evaluated according to the framework of cost and risk.

Results and analysis: The results from the case study are shown in Table 6 which indicates a deficit for all growers. The major cost is for labor which accounts for more than 60 percent of expenses. In addition, there are costs for seed, chemicals, plant nurturing, and plant disease and insect control. Those costs have remained constant due to the support and control by the contract farming company. The growers are still sustainable because their own hiring cost is not taken into account.

However, when considering the revenue, the production per rai is low. This means the revenue does not cover expenses, which leads to the deficit and increases the production risk and financial risk. The interview with the growers revealed that growing the same crop on the same sites tends to reduce the production per rai.

Case Study 2 (Grower Group B)

General description: The five growers learnt about the GMM to improve their capability level in June (end of export season). The demand for okra from Japan is from November to May. The delivery of goods from Thailand is thus very high in that period. The knowledge transfer was carried out in the non-harvesting season. The evaluation of the capability in cost and risk reduction commenced when the new harvesting season started.

Research process: Grower group B has been assessed by the proposed GMM and all are categorized in level 2 and the GMM results indicate

Table 5 Task 1 Rehabilitation field

Level	Inference knowledge: Resource	Inference knowledge: Process	Inference knowledge: Output	Know How	Know Why
1	N/A	N/A	N/A	N/A	N/A
2		IP 1 How to rehabilitate		H1 Use of soil fertilizers	
				H2 Reversion of soil surface	
				H3 Grow plants putting minerals into soil	
				H4 Flooding over soil > 30days	
3		IP 2 How to record	IO1 Might cause soil salinity	H1 Record according to the form	
			IO2 Disease might be reduced and may be a lack of soil nutrient	H2 Do Soil Mapping	
			IO3 Plant rotation will help to increase soil nutrient and provide income	H3 Plant Rotation	
			IO4 Flooding the soil will help to reduce disease and insects and increase soil nutrient	H3 Soil Test	
4	II1 Fertilizer		IO5 Soil enrichment with nutrients	H1 Type of chemicals, Nutrients in the fertilizers, Heavy matter, Certification	W1 Application of reliable and quality fertilizers
	II2 Machine to turn over soil			H2 The digging ability of machines	W2 effective turning soil over
	II3 Rotation of plants			H3 Applying P or N during rotation	W3 Increased soil nutrients and have income from production during plant rotation
	II4 Water pump for flood and drainage		IO6 Records and tasks have been performed effectively	H4 Consider how to do flood over and the way to drain water out after flood over period	W4 Reduce the energy cost
	II5 Person in charge			H5 Person in charge has to be trained such as record and soil type, fertilizer nutrients	W5 Increase ability to do the task
5	II6 Information on how to do field habitation		IO7 Product yield increase and sustainability	H1 Searching for information on internet, in books, from experts, or from success stories	W6 Effective field habitation, applied knowledge for sustainable development

that site management and site history need improving. These relate to field rehabilitation as the learning system. Hence, prior to the actual planting, field rehabilitation training has been transferred to grower group B by multimedia (videos) and manually. The knowledge was successively transferred to the growers after considering the information from the GMM evaluation. The growers started learning and employed their knowledge in growing okra during the harvesting season from September to December. The growers were interviewed again to determine any enhancement in their cost and risk reduction capability.

Results and analysis: The growers learnt and used the knowledge for development and were able to increase production, when compared with the non GMM learning group. From applying system thinking, the growers learnt and performed site preparation using different methods for site improvement and preparation. These impacted on the soil quality and produced increased yields. Although there was a small increase in expenses due to site improvement activities, the improved results produced higher yields (Table 7).

DISCUSSION

From the first and second case studies, it can be seen that learning by application of the GMM and system thinking resulted in increased grower maturity and capability to mange cost and risk. The case studies show that the growers could address site improvement which requires knowledge in terms of minerals, nutrients in the soil, and alternatives to managing soil improvement. Grower group B realized the increase in minerals and nutrients in the soil and the use of germicides and biological controls in the soil can increase production when compared with the growers in group A. who did not undertake suitable soil preparation. The knowledge transfer and learning from the GMM and system thinking helped to increase the revenue of the growers, which was due to the increase in the production per rai and thus mostly solved the deficit

Table 6 Expense and revenue of base case

Activity	Description	Details	Grower Group A (baht/rai)				
			A1	A2	A3	A4	A5
Expense	Site preparation	1 rai	500	500	500	500	500
	Cost of seed	1 rai	2,300	2,300	2,300	2,300	2,300
	Fertilizer	7 times × 15-25 kg × 20 baht	2,100	3,000	2800	3,500	3,000
	Pesticides	17 times × 125 baht	2,125	2,125	2,125	2,125	2,125
	Fungicide	9 times × 119 baht	1,072	1,072	1,072	1,072	1,072
	Fish fertilizer	10 times × 128 baht	1,280	1,280	1,280	1,280	1,280
	Fuel for watering	35 times × 20 baht	700	700	700	700	700
	Fuel for pesticides & fungicides	26 times × 20 baht	520	520	520	520	520
	Harvesting labor	60 days × 300 baht	18,000	18,000	18,000	18,000	18,000
	Total expense	B	29,497	29,497	29,297	29,997	29,497
Revenue	Yield × Price × Day of harvest	(y[1] × 22 × 60) =A	19,800	21,120	23,760	26,400	22,440
Summary	Revenue - Expense	A-B	-9,697	-8,377	-5,537	-3,597	-7,057

[1] "y"indicates the yield in kilograms per day.

problem. However grower B2 still had a deficit, perhaps due to other factors such as insects, plant diseases and weather conditions.

The growers were given greater capability to manage cost balancing and performance. It seems that the growers spent and invested more on site preparation but it was a worthwhile investment since it could boost production which suggests that the production risk could be managed. Once the production yield increased, the financial risk related to the production risk on outcome and investment could also be managed. However, analysis and development of grower capabilities in other areas may result in the costs being further reduced or production increased further. Marketing risk seems to have already been managed by the growers by joining the contract farming program with the exporter company. The buying price was agreed before the growing and the period of harvesting has been clarified. Therefore, the growers do not need to be concerned about price fluctuations and changing consumer demand, since the details and conditions which were agreed by growers and buyers were already included in the contract farming agreement.

CONCLUSION AND FURTHER WORK

The GMM is a tool that identifies the capability level of growers and provides the framework for the growers to realize the knowledge required in order to increase their maturity level. In addition, the GMM shows the knowledge source and the results from the development, that is, cost and risk reduction in the business. This is different from other standards like the Global GAP which looks solely at the final results and focuses on finding mistakes; thus, the emphasis is just on passing the evaluation and not on sustainable practice.

The description and case studies show that when the growers gradually know their own capability and the development guidelines, they will change their behavior which will lead to practices that increase their capability level and result in change and success in their agricultural pursuits.

Table 7 Expenses and revenue after learning

Activities	Descriptions	Details	Group B (baht/rai)				
			B1	B2	B3	B4	B5
Expense	Site preparation	1 rai	1,500	1,000	800	500	800
	Cost of seed	1 rai	2,300	2,300	2,300	2,300	2,300
	Fertilizer	7 times × 15-25 kg × 20 baht	2,100	2,100	2,380	3,500	2,100
	Pesticides	17 times ×125 baht	2,125	2,125	2,125	2,125	2,125
	Fungicide	9 times × 119 baht	1,072	1,072	1,072	1,072	1,072
	Fish fertilizer	10 times × 128 baht	1,280	1,280	1,280	1,280	1,280
	Fuel for watering	35 times × 20 baht	700	700	700	700	700
	Fuel for pesticides & fungicides	26 times × 20 Baht	520	520	520	520	520
	Harvesting labor	60 days × 300 baht	18,000	18,000	18,000	18,000	18,000
	Total expense	B	30,497	29,097	29,177	29,997	28,897
Revenue	Yield × Price × Day of harvest	(y^1 × 22 × 60) =A	36,960	26,400	33,000	35,640	29,040
Summary	Revenue - Expense	A-B	6,463	-2,697	3,823	5,643	143

[1] “y”indicates the yield in kilograms per day.

The aforementioned problem can be solved by learning the essential knowledge which they lack, namely, increasing their maturity level which leads to sustainable and continuous learning. The problem is eventually solved if there is learning by the grower according to the GMM.

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