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Cost Efficiency of Thai National GAP (QGAP) and Mangosteen Farmers' Understanding in Chanthaburi Province

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Abstract GAP has been implemented in mangosteen commodity, which is the important export commodity in Thailand since 2003. The direct market for GAP –based mangosteen has not yet developed. Therefore, the farmers could not get a direct benefit from GAP adoption, and they believed that GAP could not give them any visible benefits. The present study seeks to expose the GAP realistic economic incentives from farmers' GAP experiences in mangosteen commodity. One-hundred and twelve (112) respondents were randomly selected from 1,968 GAP mangosteen-certified farmers in Chanthaburi province which is the biggest mangosteen cultivation area in Thailand. This study reviewed that GAP certified farmers were satisfied with income from their investment more than the ordinary farmers (cost efficiency = 1.74 and 1.27, respectively). However, the production cost per rai was 11,554.7 THB/rai, higher than the ordinary farmers' cost (7,007.9 THB/rai). The GAP standard itself provides direct incentive through its knowledge and appropriate farming techniques which are classified as non-economic incentives. The proportion of high-quality mangosteen can be increased if the farmers effectively practice GAP on their farms.

Keywords: *GAP, mangosteen, farmers' incentive, cost efficiency*

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1. Introduction

Good Agricultural Practices or GAP is a global appropriate cultivation method for farmers to conduct food safety. It is an appropriate on-farm into cultivation management including inputs selection, farm management, and post-harvest management. GAP aims to encourage the farmers to produce safety agricultural products for consumers[9].The Thai Ministry of Agriculture and Cooperatives (MOAC) has promoted Thai national GAP (QGAP) as one of the effective tools to guarantee food safety of major agricultural products, through which the farmers are encouraged to increase sustainable cultivation and competitiveness in the global trade [11].

Under the MOAC food security structure, the Department of Agriculture (DOA) acting as the Certification Body develops GAP guidelines for farmers who register for QGAP certification. The Department of Agricultural Extension (DOAE) is authorized to extend the GAP system throughout the country. Since 2006, the DOAE has launched the project "Promotion of Safe Agricultural Products" for 31 kinds of crops nationwide [12]. The targeted communities use production processes which have the highest food contamination risks as affected by direct consumption. However, due to the limitations of the GAP extension and inspection services, GAP has the lower strictness level among global standards [8]. The farmers were inclined to select only some easy control points from GAP methods to suit to their conventional farming, which might cause sub-standardized and unreliable outcome for Thai agricultural food security [3].

Thai GAP-certified farmers paid a lot of attention for conducting GAP-based production by following the DOA and DOAE GAP instructions [3,8]. However, GAP-based products are not very popular in the local markets.The farmers showed reluctance to fully comply with the GAP instructions because they could not reach their expected economic targets by following the GAP standard [9]. GAPwas preparedmainly for export commodities. While some of the commodities were exported, the majority were sold in domestic markets.

Hobbs (2003) classified GAP economic incentives for the farmers into two main categories [6]. The first incentive was reducing the farmers' production costs such as efficient use of labors, input selection, and sustainable farm management methods. In a case study in Kenya, GAP significantly improved the producers' cost effectiveness in a competitive fresh vegetable market. The producers could also improve farming methods in terms of social, environmental, and economic aspects.GAP instructions led the farmers to control their production costs by implementing appropriate farming techniques. The second incentive was the premium price for GAP

products. GAP-based product quality might be more acceptable than the ordinary product. It was expected that farmers could easily fetch a premium market price. This is part of GAP economic incentives. Such expectation is presented at the beginning of GAP extension, but when it extended widely, the prospects for premium price may be diminished as part of economic and competitive principle in markets.

Hosono (2007) explained the characteristic practices of the fruit producing area in Chanthaburi province, Thailand. He found that the farmers always mixed several selected plants in their orchards (inter-cropping system) which made it hard for them to manage under the standard cultivation system. They mainly managed their orchards according to their conventional experiences, thus creating some conflicts with GAP procedure (such as fertilizing, watering, and input control) [7].

GAP is the appropriate farming methods for the farmers which can support the farmers to produce safe product. The GAP-certified farmers expected on the premium price from GAP product. However, direct price premium market for GAP-based product has not been developed yet in Chanthaburi province, the farmers might lack their motivation to implement GAP on their orchards. There have been many studies on GAP in the past that showed the importance of cost effective implementation including its impact of food safety [6,8,10]. However, very few studies focused on GAP farming conditions of important inter crops, such as mangosteen. Farm structure was usually not considered in depth. Therefore, one purpose of this study was to evaluate the practical farmers' benefits from GAP implementation without direct premium price market for GAP-based product. In addition, the GAP understanding of farmers on the important agricultural commodities for QGAP development was also evaluated. Finally, the economic incentives from GAP production were analyzed to examine the GAP production cost and income effectiveness as the result of adoption of GAP standards.

This study is benefits for main stakeholders in GAP system (farmers, and Institutions engaged in GAP system). This is because this study was used many cases from the farmers' GAP implementation in case of Thai mangosteen market which direct premium price market for GAP-based product have not been developed yet. GAP farmers can access the closely-real economic structure, including clarifying the actual incentive from GAP implementation. Institutions engaged in GAP system can apply the result of this study for their GAP database closely practical modernizing. The authors expect that this study clarified the farmers' economic incentive through adopting GAP. The development of GAP can improve Thai food safety from the farm gate which influenced Thai food safety in the global trade.

2. Mangosteen Production in Thailand and Chanthaburi Province

Mangosteen (*Garcinia mangostana*) recognized as "Queen of fruit", is a highly prized fruit in Southeast Asia. In 2012, Thailand produced 278,919 tons from 65,448.32 hectares (1 hectare = 6.25 rai) [1], accounting for more than 50% of global output. The major production areas of mangosteen were in the eastern and the southern parts of Thailand. Thailand has a 90% of share in world market.

The area in Thailand plated with mangosteen ranged between 64,000 – 80,000 hectares, while the harvested area dramatically increased from 43,797 hectares in 2004 to 65,448 hectares in 2013, with a 49.4% growth [1]. Increasing demand for mangosteen in the world caused such a rapid growth of production. The majority of Thai mangosteen were exported to China which is the largest tropical fruit importer in Asia. The export to China rose from 34,709 tons in 2005 to 127,992 tons in 2009. Since mangosteen is an important Thai export commodity, farmers and intermediaries were required to pay attention to the food safety for the consumers[7].

Chanthaburi is located in the eastern part of Thailand, which is one of the strategic areas for GAP implementation due to its status as the largest fruit production area in the country. In 2013, Chanthaburi farmers cultivated mangosteen in 21,961 hectares with the total production of 105,929 tons, accounting for 38% of the total production in Thailand [2].

Although the number of mangosteen GAP-certified farmers declined, 3,670 mangosteen orchards were still inspected and certified for QGAP certification. They constituted 64% of the total number of fruit orchards in this province [2]. GAP was wildly extended to Chanthaburi farmers [5]. In 2010, the number of mangosteen GAP-certified farmers decreased to 8,210 orchards in eastern Thailand; however it still was the highest number followed by durian (*Durio zibethinus*) and longkong (*Lansium parasiticum*).

3. Methodology

Chanthaburi was chosen as the study area because of a large number of active mangosteen growers certified by the DOA which consisted of 1,968 farmers [5]. The sample size of 112 growers was calculated by using the formula of [13]. The respondents were randomly selected by simple sampling methods in Tha Mai (33), Khlung (46) and Makham (33) districts which are the biggest mangosteen cultivation areas in Chanthaburi. The proportional sampling depended on the size of the GAP-certified farmers in each district. These three districts are located on the borders between Chanthaburi and Trat provinces, where a large number of traders/exporters opened buying stations of mangosteen. A number of exporters also opened buying stations in Khlung district, while Tha Mai district attracted retailers including national chain super markets. In Makham district, the provincial agricultural cooperative established a business link with one of the three biggest exporters who collected high-quality mangosteen. QGAP-certification was a requirement for those farmers who would sell high-quality products to export-traders.

The data were collected from farmers in the crop year 2013/2014 by structured questionnaires. The questions covered the socio-economic profiles of the farmers interviewed, their fruit production revenues, costs, GAP understanding and attitude towards GAP, its implementation and so on.

The questionnaires included 8 GAP-components (water source, cultivation site, use of agricultural hazardous

substance, pre-harvesting management, harvesting management, product storage and on-site transportation, worker health and welfare, and data recording), in order to evaluate the level of GAP farmers' understanding. The example situations of GAP implementation were presented, then the farmers answered accordingly following their practical farming methods. According to the complexity of GAP content, farmers' understanding was scored into two categories (1= disagree, and 2 = agree).

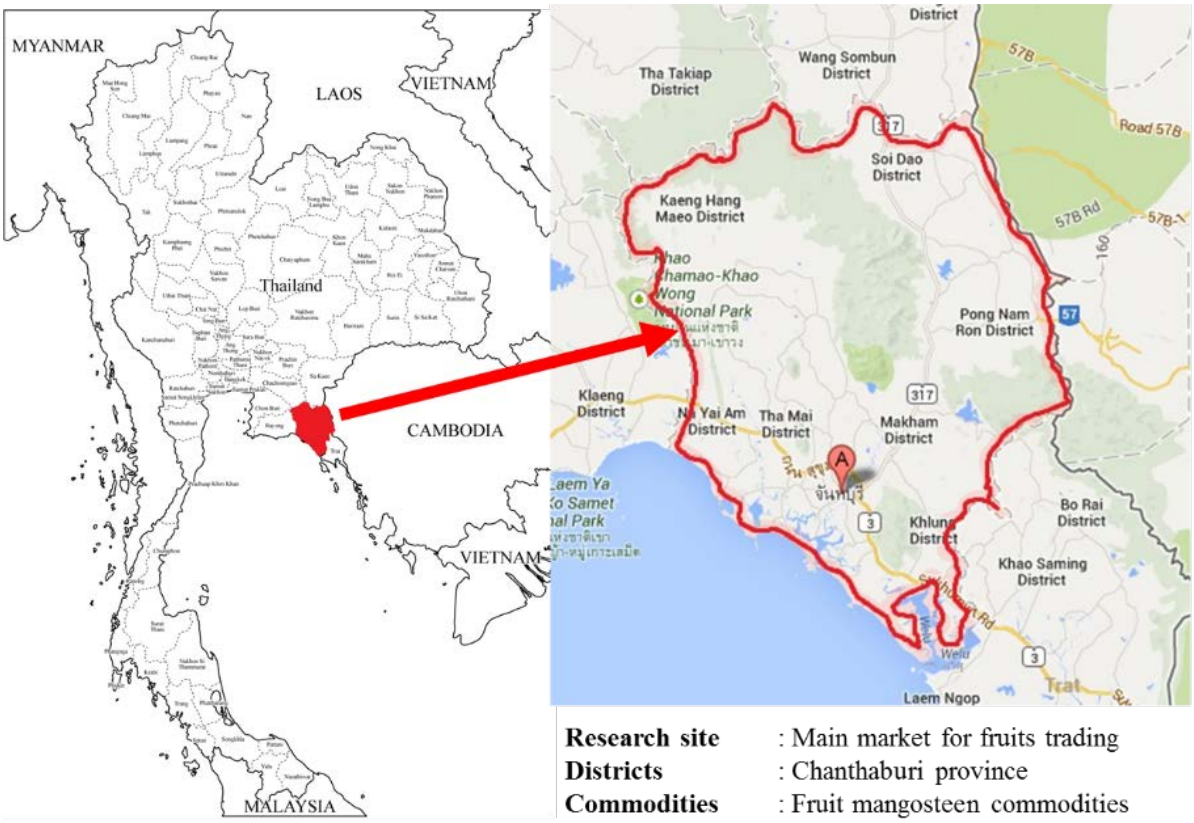

Figure 1. Chanthaburi province and study areas (Source: Google Map and www.freemap.jp (12th April, 2014))

Mangosteen are perennial plants, so the three main variable costs of production are insecticide, wage, and fertilizer costs [1]. Generally speaking, mangosteen price fluctuates according to its quality as determined by local traders in Chanthaburi. Considering the changeable price[1], the farmers' income was calculated by the following formula:

$$\textit{Farmers' income} = \left(Price_L \, x \; Quantity_L\right) + \left(Price_H \, x \; Quantity_H\right)$$

Price $_L$: average farmers' selling price for the low quality (THB)
Quantity $_L$: quantity of farmers' low quality products (Kg.)
Price $_H$: average farmers' selling price for the high-quality (THB)
Quantity $_H$: quantity of farmers' high-quality products (Kg.)

The respondents were interviewed in-depth by the research team at their farm sites, district agricultural cooperatives, and purchasing stations with the assistance of DOAE officers during April 2014. The data were analyzed by descriptive and inferential statistics. Frequencies, percentages, arithmetic means, and standard deviations were used to describe profiles of the respondents, farm characteristics, income, cost effectiveness, and GAP implementation, while ANOVA was performed to determine the differentiation of their GAP understanding, production cost and income, and cost effectiveness. In this study, cost effectiveness means the proportion of farmers' income from mangosteen commodity and annual investment in its production. Finally, regression analysis was employed to determine the practical additional economic incentives for the farmers considering their GAP understanding in each element.

4. Profile Background of Respondents

One hundred twelve (112) respondents were selected in this study; 29.5% came from Makham district, 41.0% came from Khlung district, and 29.5% came from Tha Mai district as shown in Table 1. Mangosteen cultivation was not specifically assigned by gender within their families because it is not labor-intensive needing high skills. Their ages ranged from 22 to 72 with the 32 – 51

[1]Mangosteen were priced differently according to the product qualifications, such as size (3 grades: 100 g., 90 – 99 g. less than 90 g.), skin (smooth and not-smooth), perfection (round and not-round), etc. Low-quality (LQ) mangosteen were going for 30 – 50 THB per Kg. (each weigh 70 – 90 g means 10 – 11 mangosteen for 1 Kg), while high-quality (HQ) mangosteen were priced between 80 – 130 THB. The HQ mangosteen were exported to high-end markets, such as Japan, Korea, and EU. While LQ mangosteen was exported to China, and borders markets.

age group being 53.3% of the total, following by those in the 52 – 61 age group. Although about three-fourths of the respondents graduated from primary school, they had considerable long experiences in mangosteen cultivation at 23.1 years on average (Makham 17.2, Khlung 27.1 and Tha Mai 23.4 years). They were familiar with GAP procedures, too. The majority of them participated in GAP scheme for 8 years (68.7%), followed by 2 years (12.5%).

It is noteworthy that all respondents cultivated fruit using the inter-cropping system. However, 28.5% of them separated their mangosteen orchard from other fruits and crops. Income from mangosteen ranged between 14,000 to 28,600 THB/rai, while production cost was estimated to be between 8,900 to 17,000 THB/rai. Production costs varied according to farm structure and farm management, including inputs such as labor and productive materials, land utilization, and so on. The farm structure and management influenced the quality of mangosteen. The income from mangosteen fluctuated according to local market prices and quality of products. Adoption of GAP might affect the farmers' farm structure, costs and earnings.

Table 1. Respondents socio-economic background

Contents	Frequencies			Total (percent)
	District			
	Makham	*Khlung*	*Tha Mai*	
Gender				
Male	19	20	14	53 (47.3)
Female	14	26	19	59 (52.6)
Age (years)				
22 – 31	12	3	-	15 (13.3)
32 – 41	14	8	8	30 (26.7)
42 – 51	3	14	13	30 (26.7)
52 – 61	2	15	12	29 (25.8)
> 61	2	6	-	8 (7.1)
Mean	*36.5*	*49.1*	*47.7*	*45.0*
S.D.	*11.6*	*10.8*	*7.6*	*11.5*
Education				
Pre-primary school	9	18	12	39 (34.8)
Primary school	7	19	14	40 (35.7)
Junior high school	5	7	7	19 (16.9)
High school	10	2	-	12 (10.7)
Vocational school	2	-	-	2 (1.7)
Number of family members				
2 – 3	10	8	5	23 (20.5)
4 – 5	20	29	25	74 (66.0)
6 – 7	3	7	3	13 (11.6)
> 7	-	2	-	2 (1.7)
Mean	*4.2*	*4.7*	*4.3*	*4.4*
S.D.	*1.1*	*1.4*	*0.9*	*1.2*
Fruit cultivation experiences (years)				
1 – 10	13	4	6	23 (20.5)
11 – 20	8	10	7	25 (22.3)
21 – 30	8	16	14	38 (33.9)
31 – 40	3	11	6	20 (17.8)
41 – 50	1	5	0	6 (5.3)
Mean	*17.2*	*27.1*	*23.4*	*23.1*
S.D.	*12.1*	*11.5*	*10.3*	*12.0*
Experience on GAP (years)				
1 – 2	7	4	4	15 (13.4)
3 – 4	3	1	1	5 (4.4)
5 – 6	8	4	2	14 (12.5)
7 – 8	15	37	26	78 (69.6)
Mean	*5.7*	*7.1*	*7.0*	*6.7*
S.D.	*2.4*	*1.8*	*2.0*	*2.1*
Mangosteen cultivated area (rai)				
5 – 10	1	8	5	14 (12.5)
11 – 20	19	31	25	75 (66.9)
21 – 30	9	7	3	19 (16.9)
31 – 40	4	-	-	4 (3.6)
Mean	*21.3*	*15.4*	*14.5*	*16.9*
S.D.	*7.8*	*5.1*	*4.4*	*6.5*
Mangosteen income / rai (THB)				
< 15,000	0	8	0	8 (7.1)
15,000 – 20,000	7	18	25	50 (44.6)
20,001 – 25,000	17	20	8	45 (40.1)
25,000 – 30,000	9	0	0	9 (8.0)
Mean	*23,415.9*	*19,124.0*	*18,251.1*	*20,131.4*
S.D.	*3,102.9*	*3,463.3*	*2,624.5*	*3,781.9*
Total	**33**	**46**	**33**	**112 (100.0)**

5. Results of the Study

1. Current GAP understanding among mangosteen farmers

This study revealed that mangosteen farmers moderately understood (mean = 1.6) the overall GAP contents (Table 2). GAP standard is promoted to increase the reliability of agricultural products in the overseas markets. Nonetheless, GAP presented difficulty and complexity for practical farming. Consequently, GAP inspection services often had to compromise to give a better opportunity for the farmers to apply for the GAP certificate. However, they still needed to keep their food safety production practices, such as input selection, as the minimum requirement for certificate qualifications.

GAP farmers could not automatically get higher prices for their produce even with their GAP certificates. However, higher prices can be expected from higher fruit quality whether they have GAP certificate or not. Because GAP certification usually result to better fruit quality, the cooperatives actively campaign for GAP system. The local cooperatives tried to promote GAP system in collaboration with the government institutions and export company through campaigns, such as "*the farmers who showed their GAP certificate can get free electric fan*". After the farmers implemented GAP on their orchards, they realized that GAP can improve their farm management to increase the proportion of high-quality mangosteen production. Therefore, the farmers who wanted to obtain more income needed to learn and understand GAP contents for their eventual GAP certification.

The agricultural cooperatives had an important role to encourage the farmers to produce GAP-based mangosteen. Without any support from extension officers and the cooperative's staff, mangosteen farmers could hardly prepare for necessary data and figures required by the GAP system. Therefore, each agricultural cooperative prepared un-official GAP procedures for its member-farmers which would be tested by the GAP inspectors. Although these roles were not normally expected from cooperatives, they were continuously implemented by them rather than by government sectors.

After the farmers learned the GAP procedures and contents, their GAP practices affected the level of understanding about pre-harvest management methods, especially on the aspects related to improve the product quality more than the others contents (mean = 1.9). Only 31 farmers (27.6%) kept their cultivation records at least for 2 years. This was because these respondents participated in the program provided by the local cooperatives.

Table 2. Current GAP understanding of mangosteen farmers categorized by GAP elements

Content	Yes (2)	No (1)	Mean	S.D.	Level*
Water source			**1.7**	**0.2**	**High**
Farm used water that was not contaminated by substances	103	9	1.9	0.2	High
Treatment was needed before using water on farm	96	16	1.8	0.3	High
Post harvested used water was same quality as drinking water	65	47	1.5	0.4	Moderate
Cultivation site			**1.5**	**0.3**	**Moderate**
Cultivation site should not be polluted by the substances	74	38	1.6	0.4	High
High risk site should treated to reduce risks	60	52	1.5	0.5	Moderate
Cultivation should be legal	55	57	1.4	0.5	Moderate
Use of agricultural hazardous substance			**1.6**	**0.3**	**High**
Agro-chemical must be used under DOA instruction	74	38	1.6	0.4	High
DOAprohibited agro-chemicals were not used	66	46	1.5	0.4	Moderate
Agro-chemical equipment must be clean after use every time	86	26	1.7	0.4	High
Pre-harvesting management			**1.6**	**0.2**	**High**
Keeping on record of the cultivation input methods	65	47	1.5	0.4	Moderate
Solid waste from humans must not be used on the farm	64	48	1.5	0.4	Moderate
Cultivation plan must follow the traders' requirement	100	12	1.8	0.3	High
Harvesting management			**1.6**	**0.2**	**High**
Cultivation methods must follow the traders' requirement	106	6	1.9	0.2	High
Cultivation methods must be done for food security	58	54	1.5	0.5	Moderate
Cultivation equipment indirectcontact with the products must be clean	59	53	1.5	0.5	Moderate
Product storage and on-site transportation			**1.5**	**0.2**	**Moderate**
Product harvesting must be done for the food security	58	54	1.5	0.5	Moderate
Product storage should be provided without hazardous substance	71	41	1.6	0.4	Moderate
Truck/cart must be clean and provided without contamination	57	55	1.5	0.5	Moderate
Workers Health			**1.6**	**0.2**	**High**
Workers who directly handle the product must be cleared	69	43	1.6	0.4	Moderate
Workers must be trained/educated on food safety production method	71	41	1.6	0.4	Moderate
Workers must check their health every year	89	23	1.7	0.4	High
Data recording			**1.4**	**0.4**	**Moderate**
Recording on cultivation methods, input, and management is needed	65	47	1.5	0.4	Moderate
Do you have any note books?	47	65	1.4	0.4	Moderate
Do you keep record for at least 2 years?	31	81	1.2	0.4	Low
Total mangosteen farmers' GAP understanding			**1.6**	**0.1**	**Moderate**

*level of farmers understanding were justified into 3 levels (Low = 1 – 1.33; Moderate = 1.34 - 1.66; High = 1.67 – 2.00).

The farmers' GAP understanding varied with their background, practices, market environment, and extension efficiency, and so on. There is a difference as regards to level of farmers' understanding among the three districts, being significant at 1% level of confidence (Table 3). The farmers in Makham district had the highest GAP understanding (mean = 1.8) among the three districts. Farmers in Makham district had superior competition in the export market. GAP certified-farmers always searched for lucrative market channels that activated the movements of the local farmers' organization to connect between producers and satisfied market. Makham agricultural cooperative had a contract with a large exporter who provided small purchasing stations to support its members. However, to produce high-quality mangosteen, farmers needed to conduct specific methods rather than conventional ones, such as regulating the use of chemicals and harvesting only after rainfall. These methods are defined under the GAP system. Of course, the majority of mangosteen farmers familiar with conventional methods can produce only a small proportion of high quality mangosteen. Local purchasers exporting high-quality mangosteen preferred to have a business link with GAP-certified farmers, rather than with non-certified farmers since GAP certificate was a requirement in the export market. The farmers in Makham district had more chances to access the valuable market because they followed GAP methods.

Table 3. Difference of farmers GAP understanding in three districts

GAP elements	Average farmers' GAP understanding (level)			t-value	p-value
	Makham	*Khlung*	*Tha Mai*		
Water source	1.8 (H)	1.7 (H)	1.7 (H)	4.2	0.1
Cultivation site	1.8 (H)	1.4 (M)	1.3 (L)	30.2	0.0**
Use of agricultural hazardous substance	1.8 (H)	1.5 (M)	1.5 (M)	15.2	0.0**
Pre-harvesting management	1.8 (H)	1.6 (M)	1.5 (M)	24.3	0.0**
Harvesting management	1.7 (H)	1.6 (M)	1.6 (M)	0.7	0.4
Product storage and on-site transportation	1.5 (M)	1.5 (M)	1.5 (M)	0.0	0.9
Worker health	1.7 (H)	1.6 (M)	1.6 (M)	3.6	0.0**
Data recording	1.8 (H)	1.3 (L)	1.1 (L)	42.7	0.0**
Total farmers' GAP understanding	1.8 (H)	1.5 (M)	1.5 (M)	76.5	0.0**

**significant at 1% level of confidence.

2. Farmers' GAP economic incentives (cost effectiveness)

GAP certified farmers were satisfied with income from their investment more than the ordinary farmers (cost efficiency = 1.74 and 1.27, respectively). However, the production cost per rai was 11,554.7 THB/rai, higher than the ordinary farmers' cost (7,007.9 THB/rai) (Table 4). The production methods required the farmers to manage their farms, but extensive labor needed to be factored into the production cost.

Table 4. Economic incentive comparison between Chanthaburi GAP-based and ordinary farmers

Contents	Chanthaburi farmers*	Chanthaburi GAP-based farmers	Practical GAP economic incentive advantages (%)
Average production cost / rai (THB)	7,007.9	11,554.7	- 4546.8 (64.8)
Average cost / rai / Kg. (THB)	14.1	15.6	- 1.5 (10.6)
Average production / rai (Kg.)	585	522	- 63 (10.7)
Average income / rai / Kg. (THB)**	8,968.0	20,131.4	+ 11,163.4 (124.4)
Average income / rai / Kg. (THB)	15.3	38.5	+23.2 (151.6)
Average cost efficiency / rai	1.27	1.74	+ 0.47 (37.0)

**Source* Chanthaburi provincial Department of Agriculture Extension survey, 2014

**Mangosteen prices for the farmers were fluctuated due to the product quality, and period of purchasing.

Meanwhile, mangosteen market prices depended on quality. For example, peel of the mangosteen is one of the pricing criterion. The mangosteen with smooth skin which is highly appreciated in the market, was sold at 30 – 40 THB/Kg, while that with irregular skin was less than 20 THB/Kg. GAP farmers could sell their mangosteen at 38 THB/Kg on average, whereas the ordinary farmers realized only 15 THB/kg. There was not much difference as regards volume of production between GAP certified and ordinary farmers (-10.7%). As a result, the GAP farmers' income was more than the average farmer (124.4%).

Table 5. Comparative cost efficiency of different mangosteen planting density

Number of mangosteen per rai (trees)	Number of respondents	Average cost efficiency per rai	S.D.
20 – 25	34 (30.3%)	1.79	0.28
26 – 30	22 (19.6%)	1.57	0.22
31 – 35	14 (12.5%)	1.42	0.18
36 – 40	42 (37.5%)	1.60	0.23
Total	**112 (100.0%)**	**1.63**	**0.02**

ANOVA: F-change = 8.793, p-value =0.00

The density of mangosteen trees in an orchard was a good example affecting production outcome. In general, ordinary farmers believed that 30 – 40 trees / rai would bring more production and more income [5]. In sun-lit areas of their farms, the quality of mangosteen got better. GAP instructions guided farmers to reduce mangosteen density to 20 – 25 trees per rai. Farmers slowly adopted GAP on their farm by reducing the density of mangosteen trees per rai. The farmers who reduced the density of mangosteen to 20 – 25 trees per rai obtained the highest

economic benefit (cost efficiency ratio = 1.79) (Table 5). The most cost efficient density was 24 trees per rai, which was the same number as the DOA's GAP instruction concerning planting density.

In Makham district, where farmers had the greatest understanding of GAP than those in other districts, they showed the highest cost efficiency ratio (Table 6). Since their production cost was the highest, they could also obtain the highest income among the three districts. Understanding of GAP might positively impact on the farmers' economic structure.

In Makham district, where the export mangosteen markethas seen stiff competition, mangosteen farmers deeply understood the importance of GAP. GAP certificates were also highly coveted among the farmers in this district. At the start of the GAP extension period, it was difficult for the farmers to adopt new knowledge to their conventional farming. However, the minimum requirement for accessing satisfactory market price needed the GAP certificates to be shown to the local export trader. Normally, farmers tend to adopt GAP requirements step by step with their conventional farming, such as sorting out the chemical storage and data recording. However, these issues were not enough to improve the quality of mangosteen for the export market. If the farmers needed to improve their product quality, they had to change their farm management according to the instruction of GAP.

Table 6. Practical GAP-based mangosteen production cost, income, and profitability

Content	District			F change	p-value
	Makham	*Khlung*	*Tha Mai*		
Average cost of mangosteen production/ rai (THB)	13,264.2	12,314.7	11,674.2	5.902	0.004
Average income from mangosteen producing/rai (THB)	23,415.9	19,124.0	18,251.1	26.496	0.000
Average cost efficiency ratio of mangosteen/rai	1.779	1.572	1.583	7.246	0.001

Comparing the proportion of cost investment, farmers in Makham district disbursed the largest amount of wage cost. (Table 7) This was probably because GAP processes needed complex cultivation techniques. In general, the farmers hired both permanent and seasonal workers for daily operations, such as tree clipping and watering. Careful pre-harvesting process could reduce costs of pesticides and fertilizing. Tree clipping reduced the branches density for farm chemical spraying, so the farmers might spend lesser costs of fertilizers and chemicals. Makham farmers spent the highest cost on wage during pre-harvesting period. On the other hand, those farmers in Khlung and Tha Mai did not pay much attention on wage cost. They disbursed other costs like insecticide during harvesting and post-harvesting periods. Farmers in Makham invested in the pre-harvesting management such as soil and plant preparation. These processes could add up to the overall cost; however, they might enable reduction of other costs for the farmers in order to produce high quality mangosteen.

Table 7. Practical GAP-based mangosteen investment categorized by main production costs

GAP-based farmers cost management	Cost investment in each area			Mean	S.D.
	Makham	*Khlung*	*Tha Mai*		
Three main cost of mangosteen production (THB)					
1. Insecticide	3.975.7	5,084.1	4,802.2	4,674.5*	917.6
2. Wage	4,689.1	4,993.7	4,109.7	4,643.5*	895.7
3. Fertilizer	3,907.5	1,476.9	2,002.2	2,347.8*	1,180.2
Cultivation process cost management (THB)					
4. Pre-harvest cost management	4,952.1	2,206.8	990.2	2,657.2*	161.4
5. Harvesting cost management	3,617.0	4,506.1	5,541.9	4,549.3*	1,119.2
6. Post-harvest cost management	3,935.0	4,841.7	4,381.9	4,439.1*	109.3
Total cost of GAP-based production	**12,504.2**	**11,554.7**	**10,914.2**	**11,645.8***	**1,976.2**

**p-value < 0.05*

3. Farmers' understanding of and cost effectiveness from GAP adoption

Simple linear regression analysis was performed to examine the modification of production cost (Y_1) and income (Y_2) among 112 farmers as a reflection of their understanding of each GAP element. As shown in Table 8 and Table 9, farmers' understanding on data recording procedure (X_8) had a positive and significant impact on their production cost (Y_1) (X_8: $\beta = 1{,}356.76$, $t = 2.63$, $p < 0.05$). The coefficient of determination revealed 15.6% variation in GAP production cost.

Table 8. Relationship between farmers' GAP understanding and their production cost

Predictors (Farmers' GAP understanding)	Mean	S.D.	t-value	GAP-based cost of production (Y) Beta
X_1 Water source	1.78	0.24	0.22	180.63
X_2 Cultivation site	1.56	0.34	0.65	394.45
X_3 Use of agricultural hazardous substance	1.67	0.30	0.16	109.92
X_4 Pre-harvesting management	1.68	0.25	-0.00	-2.65
X_5 Harvesting management	1.66	0.24	-0.89	-672.32
X_6 Production storage and on-site transportation	1.55	0.27	-0.02	-15.59
X_7 Workers' welfare	1.68	0.28	1.94	1,369.36
X_8 Data recording	1.42	0.41	2.63	1,356.76*
F change = 2.387*, R^2 = 0.156, Adjust R^2 = 0.091				

**p < 0.05*

GAP farmers' income (Y_2) was also affected by their understanding (F-change = 7.838, $p < 0.01$) (Table 9). This result proved that pre-harvest management methods (X_4)(X_4: $\beta = 2{,}745.81$, $t = 1.98$, $p < 0.05$), worker welfare management (X_7) (X_7: $\beta = 3{,}215.97$, $t = 2.77$, $p < 0.01$), and data recording methods (X_8) (X_8: $\beta = 2{,}387.08$, $t = 2.82$, $p < 0.01$) positively influenced their income. Thus, the coefficient of determination revealed 37.8% variation inproduction cost among the farmers.

Table 9. Relationship between farmers' GAP understanding and farmers' income

Predictors (Farmers' GAP understanding)	Mean	S.D.	t-value	GAP-based farmers' income/rai (Y) Beta
X_1 Water source	1.78	0.24	-0.02	-26.72
X_2 Cultivation site	1.56	0.34	1.84	1,816.34
X_3 Use of agricultural hazardous substance	1.67	0.30	1.53	1,646.73
X_4 Pre-harvesting management	1.68	0.25	1.98	2,745.81*
X_5 Harvesting management	1.66	0.24	-0.25	-310.83
X_6 Production storage and on-site transportation	1.55	0.27	-0.78	-856.30
X_7 Workers' welfare	1.68	0.28	2.77	3,215.97**
X_8 Data recording	1.42	0.41	2.82	2,387.08**
F change = 7.838**, $R^2 = 0.378$, Adjust $R^2 = 0.330$				

*$p < 0.05$, **$p < 0.01$

Even if farmers' understanding of GAP elements was relatively sufficient, their production costs were not reduced. On the other hand, they could obtain more income through adapting GAP production methods. This is because GAP products are lucratively marketed and farmers can increase their income from sales. If the farmers had a higher level of GAP understanding, their GAP-based production cost possibly be increased to 1,356.7 THB/rai or 11.6%, and their income could also be increased to 8,348.7 THB/rai or 41.4% from their farmer total income. The explanation of 3 GAP elements that influenced the economic structure of farmers are shown below:

1. *Data recording methods*: Recording data allows the farmers to manage their decision of input selection. This will improve planning of farming and post-harvest. However, a systematic farm arrangement can possibly increase cost of production but improving their product quality.
2. *Pre-harvest management*: The farmers' income increased due to the improvement of their understanding of this issue. Crop preparation following the GAP instruction enhanced the farmers' cultivation processes. For example, diversification of crop control improved product quality. Although the GAP-based production was lower than those from conventional farming methods, the product quality might be better than the conventional production. Thus, the GAP farmers could receive more income than the ordinary farmers.
3. *Workers' welfare management*: During harvesting season, extensive labor is much needed and desired but the shortage of laborers is always an impediment. Farmers needed to maintain relationship with their workers to assure sufficient number of laborers for the next harvesting season. An increasing demand for seasonal workers during harvest season raised the wage levels. For the example, temporarily hired seasonal workers' wage was 7 THB/kg., but farmers spent only 200 THB/day for their permanent workers. A days' harvest of mangosteen can yield as much as 100 Kgs per worker. This is advantageous to seasonal workers who work hard but are not guaranteed permanent employment. For permanent workers receiving fixed daily wage regardless of harvest quantity, the only benefit would be job security. These permanent farm workers perform other tasks aside from fruit harvesting especially during the off-season such as watering, chemical spraying and tree clipping. GAP social aspects which focused on the improvement of workers' welfare indirectly influenced the farm owners to contribute towards better conditions for their workers. Therefore, the farmers' understanding of this aspect helped maintain product quality through the efficient supply of farm workers.

6. Conclusion

GAP has been chosen as asustainable cultivation standard by most Thai fruit exporters. The farmers adopt GAP together with their conventional farming techniques to improve their product quality. It is a reliable standard for producing high-quality fruit for the overseas markets. The MOAC has encouraged those farmers cultivating export-oriented commodities to follow the instruction of GAP since 2004. However, in the study areas, farmers were still confused and encountered many constraints for implementing it. However, farmers engaged with GAP practical implementation, such as data recording methods can expect influences for their farm improvement. In collaboration with local cooperatives and exporters in Makham district, the farmers can access export markets. They practiced GAP with their conventional farming methods for greater market access. This situation further brought up their GAP understanding. Moreover, market incentives positively enhanced the farmers' GAP understanding.

Adopting GAP production methods can increase farmers' income more than the conventional farming methods. The farmers produced high-quality mangosteen which are sold at a higher price. However, those farmers adopting GAP methods cannot bring down production cost, and they have to deal with higher costs. The farmers' GAP understanding positively affected both their production cost and income. Therefore, GAP standards can provide sustainable farming techniques which are regarded as non-economic incentives. This non-economic incentive brings satisfactory market price to the farmers which is a form of economic incentive. Conversely, the market price motivates the farmers' willingness to

embrace the new GAP knowledge. It is a relational development cycle between non-economic and economic incentives for sustainable development of GAP in the long term (Figure 2).

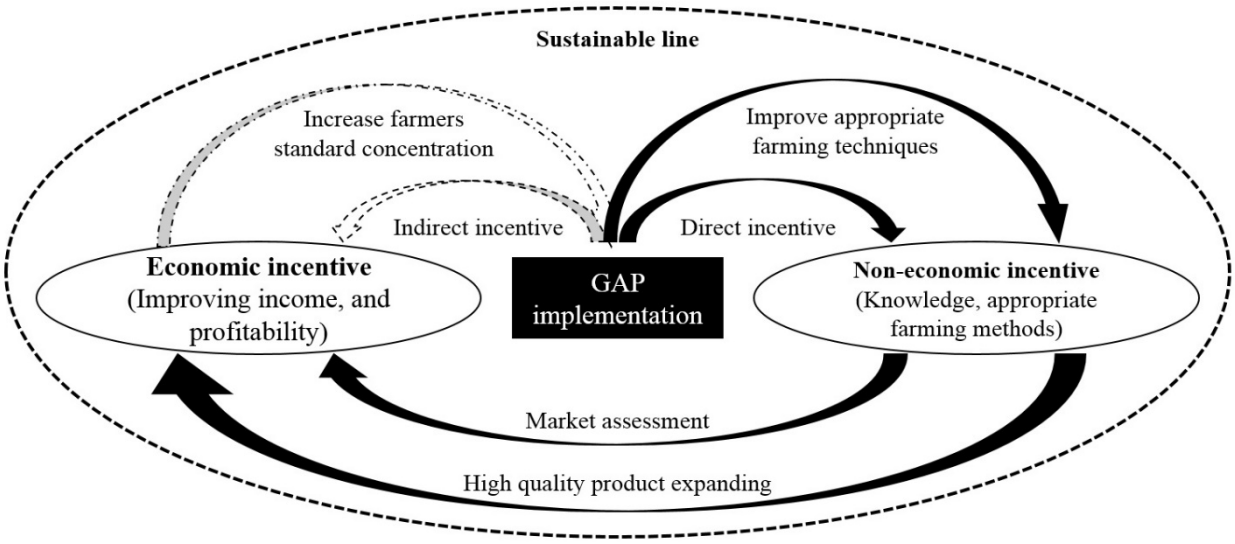

Figure 2. Farmers' practical incentive and linkage for farmers' sustainability

The GAP standard itself provides direct incentive through its knowledge and appropriate farming techniques which are classified as non-economic incentives. The proportion of high-quality mangosteen can be increased if the farmers effectively practice GAP on their farms. This situation is essential for the farmers to adopt additional GAP criteria on their farming practices. The relationship between direct and indirect incentives motivates and expands the cycles into the expected goal of sustainable development arising from GAP implementation. QGAP certificates were less attractive for farmers in practice because there was no direct market for them after implementing GAP.

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