Australian Journal of Crop Science AJCS

Aust J Crop Sci. 19(01):52-59 (2025) | ISSN:1835-2707
https://doi.org/10.21475/ajcs.25.19.01.p175

Impacts of successful implementation of good agricultural practices in field latex rubber production in Thailand: A quantitative study

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Received: *14/04/2024*

Revised: *16/09/2024*

Accepted: *24/10/2024*

Abstract: This research aims to identify the factors that influence the successful adoption of GAP (Good Agricultural Practices) standards in the production of field latex among rubber farmers in the Southern region of Thailand. The study also focuses on the outcomes of successful implementation of GAP standards in field latex rubber production in the country. To fulfill the study objectives, a cross-sectional survey was conducted in three districts, namely, Langu, Khuan Khanun, and Tha Phae of the Satun Province in Thailand. A structured questionnaire was used to collect primary data from a total of 372 small rubber farmers. A Probit model was employed to identify the factors influencing the successful implementation of GAP among the field latex rubber farmers, while the extent of implementation was analyzed using a Tobit model. The study found that 43.5% of farmers adopted GAP standards in field latex rubber production. Factors influencing both the adoption and the level of implementation of GAP standards included type of labor, group membership, number of training provided, and marketing channels for the rubber products. It was also revealed that, particularly, the farmers who have a secondary occupation adopt GAP standards. If the outcomes of implementing GAP are taken into consideration, it was revealed that 90%of the farmers achieved clean field latex during the harvesting period. In addition, the farmers reported that adulteration decreased by 3.1%, dry rubber content (DRC) and yield per rai increased by 10.6% and 8.8%, respectively due to successful implementation of GAP. It was also revealed that the adherence to GAP standards yielded other benefits such as reducing yield losses, extending tapping intervals, and reducing working hours. Therefore, this study recommends implementing more effective policies to promote the successful adoption of GAP standards among rubber farmers through collaborative efforts between the Rubber Authority of Thailand and farmer institutions.

Keywords: Good agricultural Practices (GAP), Implementation, Rubber, Field latex, Thailand.
Abbreviations: APO_Affront to their Practices; ACKS_ Agricultural Commodity and Food Standards; DRC_Dry Rubber Content; FAO_Food and Agriculture Organization; FSC_ Forest Strewardship Council; GAP_ Good Agricultural Practices; OAE_ Office Agricultural Economics.

Introduction

Good agricultural practices (GAP) are the principles and standards that are required for quality productions and products (Preprame & Buncha, 2023). The principles and standards under GAP were developed by the Food and Agriculture Organization (FAO). GAP addresses environmental, economic, and social sustainability for on-farm processes, and safety and quality of both food and non-food agricultural products (FAO 2010; Olaniran et.al, 2023). Effective management strategies and good practices can boost yields, improve the latex preservation process, and make it possible to harvest latex for an extended period (Kangpisadan, 2006; Gohet et al., 2016; Preprame and Buncha, 2023). Three groups are benefited from the implementation of GAP: a) farmers and their families are able to ensure their nutrition and well-being by obtaining nutritious and high-quality food; b) the GAP enhances the value of their products, allow them to reach markets more effectively; c) The final category consists of consumers who may gain from better and safer food quality as a result of sustainable production, along with the general population, which will benefit from a better environment (FAO 2007). However, many farmers and agricultural practitioners all over the world have difficulty understanding the GAP standards that have been set by national authorities, international agencies, or retailers. Their first impression of GAP standards or GAP schemes is simply of prohibitions on many of their farm activities. In addition, numerous farmers who use traditional farming methods opine that GAP is an affront to their practices (APO, 2016).

In Thailand, certain products receive global GAP certification. (Holzapfel & Hampel-Milagrosa,2020). The majority of both food and non-food crops adhere to Thailand's own certified standards. The ministry of agriculture and cooperatives oversees this process and employs the Q-GAP symbol on certified items, indicating quality and safety at the farm or production level. The national bureau of agricultural commodity and food standards (ACFS) collaborates with relevant agencies, including the Department of Agriculture, Department of Agricultural Extension, Department of Livestock Development, Department of Fisheries, Department of rice, Department of Sericulture, and Rubber Authority of Thailand (RAOT). Currently, the ACFS has established standards for over 400 agricultural products, encompassing food crops like vegetables, fruits, herbs, spices, as well as animals and non-plant products such as silk and rubber (ACFS 2021). In 2018, RAOT realized the importance of the quality standards for field latex and cup lump rubber, which are utilize as starting materials for the production of blocks rubber and crepes rubber. Because of this, standards for agricultural

products relating to good agricultural practices for rubber have been defined, and criteria for good agricultural practices for rubber have been developed to manufacture field latex and cup lump rubber (TAS 5908-2019). Good agricultural practices for rubber for the production of cup lump rubber (TAS 5910-2020) and good practices for field latex collection centers (TAS 5911-2021) (ACFS, 2021).

Rubber is an economic crop that plays an important role in the economic and social development of Thailand. Thailand is the greatest producer and exporter of rubber in the world (Leepromrath et al, 2021). It has a market share of over 41.09%. Rubber is a source of income, employment and added value from the rubber product industry. This Represents an economic value of 400 billion baht per year. In 2022, Thailand has rubber plantation areas of over 24.09 million rai, with a production volume of 4.82 million tons, a yield of 217 kilograms per year. The southern region of Thailand is an important rubber growing area. 2.85 million tons of rubber are produced annually from 13.88 million rai of rubber plantations (OAE, 2022). During the period 2016-2022, the southern region's rubber plantation areas expanded by 1.33% per year while the amount of production expanded by 1.77% per year but the yield tends to continuously decrease by 1.33% per year. In the rubber processing industry, a circular economy combined with effective management techniques can boost output, add value, and lower pollution (Preprame and Buncha, 2023). Similarly, the availability of clean filed latex is a significant factor in achieving economic sustainability in this industry. The cytoplasm of Hevea brasiliensis plants produces cis-polyisoprene particles, which are then disseminated in an aqueous solution to make natural rubber latex (NRL) (Boonrasri, 2020). When natural rubber latex is harvested from rubber trees and kept free of impurities such as dirt, leaves, bark, and other debris, it is referred to as clean field latex (Boonrasri, 2020). Clean field latex is extracted from rubber trees by gently tapping them, followed by a controlled bark incision that allows the latex to flow into fresh collection containers. The farmers in southern Thailand produce a substantial amount of rubber latex (Kongmanee et al., 2023). However, they are at risk from sustainable production standards and traceability from buyers. To address the above-mentioned issues, adopting good agricultural practices for rubber or GAP standards for field latex production is a necessary option to improve production efficiency, reduce production costs, and produce quality rubber that meets market demands.

GAP standards for field latex production cover management in plantations post-harvest management and agricultural product standards that can be used as guidelines for sustainable development of the rubber industry (Zou et al., 2024). GAP standards for field latex production is a general standard established by the agricultural commodity standards act 2008 (TAS 5908-2019), to provide farmers with good practice guidelines for producing quality field latex as a raw material for product processing GAP standards for field latex production consider cost-effectiveness, sustainability, environment, health and safety of farmers. The regulations cover everything from planting plot to post-harvest operations. The collection of produce and transportation of field latex were divided into 8 parts: (1) planting area (2) agricultural hazardous substances (3) production factors (4) pre-harvest management (5) harvest and post-harvest treatment (6) transportation (7) personnel and (8) data recording (ACFS, 2021).

Adopting GAP standards results in increased yield per rai, increased dry rubber content, reduced production costs, reduced yield loss, increased income from rubber plantations, and traceability find a production source (Chanthuma, 2020) as well as certifies important production standards in order to reach international production or traceability standards. In 2023, there are 3,540 cases certified with GAP standards, with a total area of 52,695 rai, classified as GAP certified field latex 58 cases, rubber plantation area 10,662 rai and GAP standard certification for cup lump rubber, totaling 3,482 cases, for a rubber plantation area of 42,033 rai. The rubber plantation area certified with the GAP standard is very small comparison to the entire country's rubber plantation area, which has a productive area of more than 22 million rais (RAOT, 2022) reflecting that the drive to expand GAP standard rubber plantation areas may have limitations in terms of the government's driving mechanism and the conditions of rubber plantation farmers.

Therefore, this study aims to identify the factors that influence the successful implementation of GAP standards in the production of field latex in Southern Thailand. The study also examines the impacts of implementation of GAP standards in the field latex production in the country. The findings of this study might be useful to farmers' institutions in planning and promoting the adoption of GAP standards for field latex production, as well as being beneficial to the Rubber Authority of Thailand and related agencies to be used as information in planning, promoting, supporting, and advising rubber farmers in applying GAP standards for the production of field latex.

Results

Socio-demographic profile of the respondents

The results of data collection from 372 rubber farmers found that 162 farmers (43.5%) had adopted GAP standards, and 210 rubber farmers had not adopted GAP standards (56.5%). Table 1 presents social and economic variables, which is used to analyze the factors affecting the decision to adopt GAP standards and the factors affecting the level of compliance with GAP standards. The analysis of independent t-test and chi-square test found a significant differences ($p< 0.01$ and $p < 0.05$) between farmers who adopted GAP standards and those who did not. Similarly, rubber farmers who applied GAP standards and did not adopt GAP standards were significantly different ($\rho < 0.01$ and $\rho < 0.05$) regarding variables including gender, agricultural income, secondary occupation, type of labor, farmer institution membership, number of rubber training, and marketing channels.

Determinants of farmers' participation in good agricultural practices (GAP) for field latex

The probit model analysis revealed a significant model with a log likelihood ratio chi-square statistic value of 316.95 ($p<0.01$) (Table 2). The Pseudo R-square score of 0.622 shows that the independent variables account for 62.2% of the variation. The findings indicate that having a secondary occupation, type of labor, membership in farmers' institutions, rubber training program, and marketing channels are all significant factors influencing the farmers' the decision to adopt GAP standards in field latex rubber farming (Table 2).

Determinants of farmer's extent in good agricultural practices (GAP) for field latex

Table 3 shows the summary findings of the Tobit model analysis related to the determinants of farmer's extent in good agricultural practices (GAP) for field latex. The Tobit model analysis and model accuracy test (Goodness-of-Fit) revealed a log likelihood ratio chi-square statistic score of 393.43 with statistical significance ($\rho < 0.01$). The findings indicate that the type of labor, group membership, number of training, and marketing channels are the factors that have a statistically significant impact on GAP compliance (Table 3).

Impacts of the implementation of GAP standards

Table 4 provides a comparative scenario on the field latex production between 2020 and 2021. The findings indicate that the adoption of GAP standards resulted in significant increases in latex quality and productivity. Most of the farmers began by implementing minor requirements that had immediate effects, such as screening latex and changing tapping systems. The perceived benefits and the impact of the learning ecosystem within the community drove continued adoption and compliance with GAP standards.

Table 1. Socio-demographic profile of the respondents.

Variable	participant GAP (n=162)	non-participant GAP (n=210)	t-test
	mean	mean	
Age	53.66	52.76	-0.741
Agricultural income	16,334.96	12,773.31	-2.966**
Non-agricultural income	4,042.59	4,428.25	0.409
Experience in rubber plantation	26.51	25.61	-0.704
Size of agricultural land	15.71	13.61	-1.823
Number of training	4.05	1.48	-7.034**
Rubber tree age	16.06	15.64	-0.763
Variable	**Percent**	**Percent**	**χ^2 value**
Gender			
- male	55.6	42.9	5.905*
- female	44.4	57.1	
Secondary occupation			
- yes	60.5	46.2	7.501**
- no	39.5	53.8	
Education			
- more than primary school	39.5	43.3	0.551
- less than primary school	60.5	56.7	
Type of labor			
- household labor	40.1	82.9	72.706**
- hired labor	59.9	17.1	
Farmer institution membership			
- yes	98.8	69.0	54.694**
- no	1.2	31.0	
Debt			
- yes	62.3	57.1	1.027
- no	37.7	42.8	
Market channels			
- cooperatives/farmer institutions	99.4	24.3	210.410**
- local market	0.6	75.7	

Note: ** $p \leq 0.01$, and * $p \leq 0.05$

Table 2. Probit model results for determinants of farmers' participation in good agricultural practices (GAP) for field latex.

Variables	Coefficient	Std. Err.	Marginal Effect	Z	P > |z|
gen	0.0520	0.2121	0.0152	0.24	0.807
age	0.0004	0.0094	0.0001	0.04	0.966
secoc	**0.5202***	0.2235	**0.1507**	2.33	0.020
edu	-0.4446	0.2463	-0.1265	-1.81	0.070
aincome	0.00000043	0.000010	0.00000012	0.04	0.968
nfincome	0.00000049	0.000012	0.00000014	0.04	0.967
exp	0.0023	0.0090	0.0006	0.26	0.795
landz	-0.0161	0.0113	-0.0047	-1.40	0.162
labor	**-0.9264****	0.2312	**-0.2930**	-3.64	0.000
member	**1.2915****	0.4716	**0.2585**	3.90	0.000
agerub	-0.0007	0.0208	-0.0002	-0.04	0.969
tran	**0.1376****	0.0495	**0.0404**	2.59	0.010
debt	0.3310	0.2295	0.0947	1.45	0.148
market	**3.0128****	0.4196	**0.6900**	14.80	0.000
Constant	-3.473**	0.9640			

LR chi2 (14) = 316.95; Prob > chi2 = 0.0000; log likelihood = -96.272; Pseudo R^2 = 0.6221; Note: ** $p \leq 0.01$, and * $p \leq 0.05$.

Discussions

The present study attempted to compare the socio-demographic profile of the small farmers who adopt GAP standards with the farmers who do not adopt GAP standards. It was found that the rubber farmers who adopt GAP standards have a higher income from agriculture and receive a greater number of rubber training sessions than that of rubber farmers who do not adopt GAP standards. In addition, rubber farmers who adopt GAP standards are more likely to be men, engage with secondary occupation, employ hired labor, be members of farmer organizations, and sell a larger portion of their goods to farmer groups than that of the farmers who do not implement GAP standards.

The current study provided efforts to identify the critical factors that influence small farmers to implement GAP standards in field latex rubber production in Thailand. The analyses show that secondary occupation has a positive effect on the likelihood of deciding to adopt GAP ($\rho \leq 0.05$). The marginal effect shows that rubber farmers with secondary occupations have a 15.0% increased chance of deciding to adopt GAP. Rubber farmers who adopt GAP have a higher proportion of secondary occupations than rubber farmers who do not adopt GAP. Other agriculture (diversified agriculture) is the most common secondary occupation. Rubber farmers with experience and knowledge from various farming practices have a positive attitude and higher opportunity to learn and develop, are willing to do experiment, and have the courage to change behavior or farm management styles and new production systems. Several previous studies observed almost similar findings. The study by Kongmanee, et al. (2023) revealed that rubber farmers need to employ a variety of risk management strategies to increase productivity. Especially during the COVID-10 pendemic, a

Table 3. Tobit model results for determinants of farmer's extent in good agricultural practices (GAP) for field latex.

Variables	Coefficient	Std. Err.	t	P > |t|
gen	0.3927	2.3028	0.17	0.865
age	0.0238	0.1022	0.23	0.815
secoc	4.7034	2.4048	1.96	0.051
edu	-4.2403	2.5427	-1.67	0.096
aincome	0.0000405	0.000104	0.39	0.698
nfincome	0.0000106	0.000128	0.08	0.935
exp	0.0101	0.0951	0.11	0.915
landz	-0.2146	0.1178	-1.82	0.069
labor	**-9.7313****	2.3858	-4.08	0.000
member	**19.6246****	6.2460	3.14	0.002
agerub	0.0168	0.2130	0.08	0.937
tran	**0.7917****	0.2648	2.99	0.003
debt	2.3277	2.4786	0.94	0.348
market	**52.8221****	5.5556	9.51	0.000
Constant	-49.4326**	11.4375	-4.32	0.000
Sigma	16.0122	0.9696		

LR chi2 (14) = 393.43; Prob > chi2 = 0.0000; Pseudo R^2 = 0.2102; Note: ** $p \leq 0.01$, and * $p \leq 0.05$

Table 4. Comparison on field latex production between 2020 and 2021.

Variable	January 2020	January 2021	% y/y
% Dry rubber content	32	33	3.1
Dry rubber (kg./rai/day)	2.07	2.29	10.6
Tapping day (day/year)	120	118	-
Productivity (kg./rai/year)	248.4	270.2	8.8

substantial livelihood and behavioral transformation occurs among rubber-related producers (Kongmanee & Ahmed, 2021) and also in whole business strategy (Kongmanee & Ahmed, 2022).

However, the study reveals that the type of labor has a negative effect on the likelihood of deciding to adopt GAP ($\rho \leq 0.00$). The marginal effect shows that rubber farmers who use household labor are 29.3% less likely to adopt GAP. Rubber farmers who do not adopt GAP use more household labor than who adopt GAP because rubber farmers will not have time to take the opportunity to adopt GAP but if they use hired labor, they will have time to study, observe and participate in activities related to GAP standards organized by the farmers' institution, educational institution and government agencies. All of these provide rubber farmers more opportunities to adopt GAP standards, which is consistent with the study of Lioutas, et al. (2010) indicating that lack of time is one of the factors hindering the farmers' participation in GAP implementation.

The study findings indicate that membership in the farmers' institution has a positive effect on the likelihood of deciding to adopt GAP ($\rho \leq 0.00$). The Marginal effect shows that rubber farmers who are members of the farmers' institution, the possibility of deciding to adopt GAP increased by 25.9%. The majority of farmers who adopted GAP were members of farmer institution. Being a member of the farmers' institution results in having access to information, attending training courses and practices, and participating in various government promotion and support projects related to GAP standards through group processes. As a result, a member of the farmers' institution has more opportunities to apply GAP standards. Similarly, several previous studies found that membership was one of the main factors influencing farmers' participation in conservation agriculture (Bunclark and Lankford, 2011; Bekabil and Bedemo, 2015). In addition, farmer organizations can provide important platforms for capacity building, information exchange, and innovation in rural settings (Bingen et al., 2003).

The present study also reveals that number of agriculture training has a positive effect on the likelihood of deciding to adopt GAP ($\rho \leq 0.00$). The marginal effect shows that rubber farmers who join several training sessions about rubber had a 4.04% higher possibility of deciding to adopt GAP. Rubber farmers who adopted GAP received more training about rubber farming (such as fertilizer and soil management, tapping system, rubber plantation management, diseases and pests, use of agricultural chemicals, agricultural standards, etc) than farmers who did not adopt GAP. The training allows rubber farmers to gain knowledge, advice, and ideas on how to practice and earn the benefits from rubber plantations according to GAP standards, resulting in an increased possibility to decide to adopt GAP.

Similarly, the current study reveals that marketing channels have a positive effect on the likelihood of deciding to adopt GAP ($\rho \leq 0.00$). The marginal effect shows that rubber farmers who sell their products to farmer institution, there is an increased chance of deciding to apply GAP by 69.0%. One of the reasons is that the farmers' institution follows Good Manufacturing Practice (GMP) standards and is under the supervision of the Rubber Authority of Thailand (RAOT). There is a standard process for purchasing field latex, but the quality of field latex must start from the rubber plantation. Therefore, rubber farmers utilize several strategies to boost productivity and income (Longpichai et al., 2023). If rubber farmers who sell their products to farmers' institutions comply with GAP requirements, it will make the quality of field latex meet the factory's needs and affect the price and increase income. In addition, GAP standards are agricultural product standards that manage environmental issues and reduce the impact of rubber plantation management on the environment. For example, rubber plantation areas must have the documents for land use rights, do not encroach on forests and conservation areas, reduce and control the use of hazardous agricultural raw materials and so on. This is in line with international standards such as the Forest Stewardship Council (FSC) which is a standard that countries follow in rubber and rubber products, use as a condition for purchasing products. It maintains the existing market and has the opportunity to open new markets.

The present study focused on the significant determinants of farmer's extent in good agricultural practices (GAP) for field latex. The findings show that type of labor has a negative impact on the level of compliance with GAP standards ($\rho \leq 0.00$). The coefficient shows that rubber farmers who use household labor compliance with GAP requirements is reduced. Compliance with GAP requires time to study and understand and adjust the production process. If rubber farmers use household labor in rubber plantations, they may not have enough time to fully apply the GAP requirements.

In contrast, farmer institution membership, number of training and marketing channels have a positive impact on the level of compliance with GAP standards ($\rho \leq 0.00$). Coefficient shows that rubber farmers who are members of the farmers institution usually participate in training on rubber and GAP standards and sell GAP field latex products to farmer institutions. Consequently, these factors increase farmers' ability to comply with GAP requirements. In addition, most of rubber farmers participate in the replanting program initiated by the Rubber Authority of Thailand (RAOT). This program also supports the initial budget for planting. The concerned officers from the RAOT office make periodic auditing visits to the farms so as to verify the proper use of funds. If the visiting officers discover some irregularities or some sort of difficulties at farm level, they issue direct instruction to the farmers for betterment. In this case, the concerned farmers are obliged to correct the outcomes before receiving the next payment. Under this program, farmers receive knowledge, transfer/rubber plantation technology, training, practice and follow up on replanting. From the first year of planting up to 6.5 years, they can pay for replacement planting in 8 installments. During this period, the RAOT officials monitor, control and assess the effects of replacement planting quite closely. In the 6th and 7th years since tapping began, the RAOT prepares farmers in terms of tapping skills and post-tapping management. However, it is worthwhile to mention that once the rubber farmers complete their harvesting, the management of rubber plantations and the selection of rubber plantation technology are not monitored, controlled, and evaluated for the use of technology by relevant agencies. It is one factor that influences the acceleration and spread of technology change on a wide scale. Therefore, farmers are encouraged to adopt the standards. GAP should require farmers to comply with GAP standards from the beginning of rubber plantation and continuously monitor compliance with GAP standards throughout the rubber harvesting period, which will increase the efficiency of rubber plantations in a sustainable way.

Finally, the present study provided efforts to identify the significant impacts of implementation of GAP standards in field latex in Thailand. The findings reveal that most of the rubber farmers start adopting GAP from simple requirements that yield immediate results, such as filtering the latex with a latex strainer, drawing lines to line the front and back slits, which most farmers observe and measure the preliminary results within 3 months, such as percent of dry rubber content (DRC), increasing yield, increasing the time spent using the tapping surface, reducing working time, and so on. In addition, rubber farmers apply additional requirements; some choose to apply all requirements, while others choose to apply some of the requirements flexibly based on farm conditions. GAP deployment continuation is based on empirical benefits and enhancing the power and efficiency of the learning ecosystem in the community. For some requirements that rubber farmers do not apply, it depends on the conditions/restrictions of the farm, such as biophysical factors, rubber trees, time, economy, culture, institutions, etc. and may be applied after success by fellow farmers in the community. Although the requirements for overall GAP standards are simple, and have the possibility of adapting but some practices are difficult to implement. This is a gap between the old practice and the GAP field latex standard. Some of the farmers opine that the GAP standards create difficulties in their work.

The current study revealed that the implementation of the GAP standards resulted in a significant improvement in field latex production in Thailand. It was found that 90% of the farmers received clean latex with reduced foreign matter, proportion (%) of dry rubber content (DRC) increased by 3.1%, production of dry rubber in per rai increased by 10.6%, and the productivity in per rai increased by 8.8% (Table 4). These findings suggest that implementation of Gap standards not only improves rubber quality but also increases overall production. It also enhances farmers' revenue, adding to the long-term sustainability of the rubber farming industry in Thailand. In line with the findings of the present study, Chanthuma (2020) revealed that adoption of GAP standards results in increased yield per rai, increased dry rubber content, reduced production costs, and reduced yield losses further validating the effectiveness of GAP in agricultural sector. Similarly, Preprame and Buncha (2023) found that implementing GAP in field latex rubber production resulted in significant improvements in farmers' knowledge and practice.

The present study also revealed that compliance with GAP standards has other benefits including 1) reducing yield loss 2) increasing the time of using the tapping surface due to using the tapping system recommended according to academic principles, less shell consumption, no damage to the rubber surface makes the new shell completely regenerate and can be re-tap more efficiently 3) reduce working time from adjusting the tapping system according to the instructions with less frequency but it does not affect the amount of yield.

In addition, one of the important achievements include two rubber plantation farmers passed the GAP certification examination to develop mentor farmer leaders and create a GAP learning ecosystem in the community which influences significantly the continuation of GAP expansion in Satun Province by the RAOT. However, the successful implementation of GAP is not without difficulties. The likelihood of GAP adoption is influenced by several constraints, including the types of labor, the accessibility of tanning, and the membership of farmers in various institutions. Farmers with an additional occupation and involvement in farming organizations are more likely to adopt and adhere to GAP standards, but those who depend on domestic labor are less likely to do so due to time constraints. Furthermore, the lack of participation of target groups in all stages of the agricultural program leads to its failure or low adoption (Douglah and Sicilima, 1997). Therefore, the present study emphasized that more support and resources should be provided to farmers to help them overcome these hurdles, such as providing flexible training alternatives or encouraging farm group membership. Similarly, the study by Cristóvão et al. (2009) reported that the success of an agricultural program requires the cooperation among farmers, extension agents, scientists and other stakeholders.

Materials and Method

Study area and data collection

This study conducted a cross-sectional survey to collect primary data to fulfill its objectives from farmers who participate and not participate in good agricultural practices (GAP) for field for latex production. According to the report published by European Forest Institute (2024), Thailand is the largest natural rubber producing country in the world. It was also reported that the country produced over 4.7 million tons of rubber accounting for roughly one-third of global production in 2022. The biggest portion of rubber production in Thailand occurs in the southern region, mainly Songkhla, Satun, Surat Thani, Trang, and Patthalung provinces. Particularly, the province of Satun is considered as a rubber production hub in Thailand. The province is heavily dependent on rubber production for its socio-economic development. It can be mentioned that nearly 83.42% of total farming households in the Satun province are engaged with rubber production. It is worth mentioning that the three districts, namely, Langu, Khuan Khanun, and Tha Phae of the Satun Province contribute significantly to rubber production in the southern region. Therefore, the survey was conducted in these three districts to get the most representative samples of the study. Figure 1 shows the schematic map of the survey area of the current study. During the survey, a total of 372 small rubber farmers were selected randomly as the sample of the study. A standardized and structured questionnaire was distributed among the selected respondents and invited them to participate in the survey. The respondents provided their free and unbiased responses.

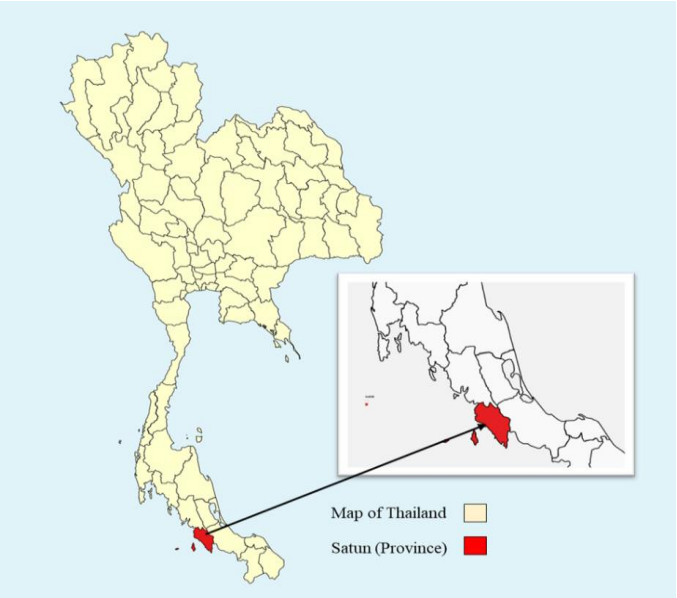

Figure 1. Survey area of the study.

Table 5. Description of variables used in the model.

Variable	Description	Type	Measurement	Expected sign
Dependent variable				
ID	Decision to implementation	Dummy	1 if implemented, 0 otherwise	N.A.
IP	Extent of implementation	Continuous	score of implemented GAP standards	N.A.
Independent variable				
gen	gender	Dummy	1=male, 0 = female	+/-
age	age of rubber farmers	Continuous	years	+/-
secoc	secondary occupation	Dummy	1=yes, 0 = no	+/-
edu	education	Dummy	1= at least primary school 0 = less than primary school	+
aincome	agricultural income	Continuous	Baht/month	+
nfincome	non-agricultural income	Continuous	Baht/month	+
exp	experience in rubber plantation	Continuous	years	+
landz	size of agricultural land	Continuous	size of agricultural land hold (rai)	+
labor	type of labor	Dummy	1=household labor, 0 = hired labor	+/-
member	Farmer institution membership	Dummy	1=yes, 0 = no	+
agerub	rubber tree age	Continuous	years	+/-
tran	number of training	Continuous	times/year	+
debt	debt	Dummy	1=yes, 0 = no	+/-
market	market channels	Dummy	1= cooperatives/farmer groups 0 = local market	+

Data Analysis

Data were analyzed using descriptive statistics and econometric modeling. To compare the socioeconomic status of the sampled rubber farmers, descriptive statistics were used, including means, percentages, ratios, standard deviation, an independent t-test, and a chi-square test.

Determinant of participation and impact implementation of good agricultural practices (GAP) for field latex

Probit and Tobit models were used in determining the factors that influence rubber farmers participation in good agricultural practices for field latex (GAP) and the extent of their involvement in good agricultural practices for field latex (GAP), respectively.

Determinants of farmers' participation in good agricultural practices (GAP)for field latex

This study represents a correlation between good agricultural practices (GAP) for field latex participation decisions and socioeconomic factors such as the households and farm characteristics. Due to the ordinal nature of the response outcomes, an ordered response model was applied in this study (Ye, F. and Lord, D. 2014) Farmer's decision to participate in good agricultural practices for field latex (GAP) was considered as a two-level ordinate response (yes/no).

To calculate the effect of socioeconomic and farm characteristics on a farmer's decision to participate in practices GAP, a propensity function or collective GAP participation decision function is defined according to Eq. 1.

$$Y^* = \beta^1 x + \varepsilon \qquad \text{Eq. 1.}$$

Where,

Y^*= the unobserved propensity variable,

β= the vector of the estimated parameters,

x= the vector for independent variables,

ε = the randomly distributed error term (assumed to be normally distributed with zero mean and unit variance).

The ordered probit model can be expressed according to Eq. 2, based on the observed ordinal collective GAP participation decision data.

$$Y = \begin{cases} 0 & Y^* \leq 0 \\ 1 & Y^* > 0 \end{cases} \qquad \text{Eq. 2.}$$

Eq. 3 is then used to compute the probability of collective marketing participation for a given X (Christoforou *et al* 2010) Provided that ε is normally distributed with a zero mean and a unit variance.

$$\Pr(Y = 0|1X| = \phi(-\beta' X)$$
$$\Pr(Y = 1|X| = 1 - \phi(-\beta' X) \quad \text{Eq. 3.}$$

Where;
ϕ = the standard normal cumulative distribution function,
$Y = 0$ non (non-participant), $(Y = 1|X)$ indicates yes (participant).
Therefore, marginal effects were calculated to identify the direction effects where positive or negative is unclear. For continuous variables, the marginal effects were estimated using Eq. 1. However, for indicator variables, the marginal effects were calculated as the difference in the estimated probabilities with the indicator variables changing from 0 to 1 (Washington et al, 2010).

Determinants of farmer's extent in good agricultural practices (GAP) for field latex

The Tobit model is a regression model in which dependent variables can be either left or right censored (Tobin, 1985). In this study, the data was left-censored with clustering at zero because the extent of participation may not have been observed in all farmers during the observation. A Tobit model using a left-censored limit of zero can be expressed according to Eq. 4.

$$Y^* = \beta' x_i + \varepsilon_i \qquad i = 1,2,3.....n \quad \text{Eq. 4.}$$
$$Y = \begin{cases} 0 & Y^*_i > 0 \\ 1 & Y^*_i \leq 0 \end{cases}$$

Where;
n = the sample size'
Y^*_i = the dependent variable,
x_i = a vector of the independent variable,
β = a vector of estimable parameters and
ε_i = the error term (normally and independently distributed with zero mean and constant variance σ^2)
From Eq. 2 above, there is an implicit stochastic index which is equal to Y^*which is observed only when positive. Thus, the corresponding likelihood function of the Tobit model can be expressed as shown by Eq. 3.
Where ϕ is the standard normal distribution function ϕ is the standard normal density function (for review, please refer to (Anastasopoulos et al., 2008). Table 1 presents the description of the variables used in this study.

Conclusion and policy recommendation

The GAP standard for field latex production covers from management in plantations to post-harvest management and is one of the agricultural product standards that can be used as a guideline for sustainable development of the rubber industry. GAP standards are created as good practices for farmers to follow in order to get quality field latex. However, there are very few rubber plantations certified to GAP standards. Therefore, this study aimed to investigate factor affecting the implementation and impacts of GAP adoption. The results of the study found that around 57% of rubber farmer were reluctant to implement GAP for field latex. The findings show that membership of farmer organization, training about rubber, and sales channels increased both the implementation and level of implementation. The Farmers Institute has a role in organizing training on rubber and being a source for purchasing produce from farmers. Therefore, the role of farmer institutions should be increased in driving the adoption of GAP standards. Farmers who are members of farming institutions should undergo training and comply with GAP standards. They may be motivated by dividends, credits and support for production factors. In requesting subsidy for replanting, The Rubber Authority of Thailand should require farmers to comply with GAP standards from the beginning of rubber plantation and continuously monitor compliance with GAP standards throughout the rubber plantation harvest period. However, the type of labor that uses household labor in rubber plantations will reduce the opportunity to adapt and level of adoption of GAP standards. Having a secondary occupation affects the likelihood of adopting GAP but does not affect the level of adoption.
Most of the farmers have implemented GAP regulations in areas that are consistent with previous practices; however, few farmers have implemented them in areas which conflict with previous practices. Therefore, training and knowledge to understand and be aware of farmers of the application of various regulations is still necessary. In addition, there should be a study of the problems and limitations in applying GAP standards. The study may cover geographic characteristics, rubber varieties, production systems, and rubber plantation technology that are academic recommendations. To adjust or develop GAP field latex specification criteria to be up to date and promote wider adoption by farmers.

Acknowledgement

The authors are thankful to the rubber farmers in the three districts, namely, Langu, Khuan Khanun, and Tha Phae of the Satun Province in Thailand to participate willingly in the survey without any financial and other forms of benefits.

Reference

ACFS (National Bureau of Agricultural Commodity and Food Standards) (2021) Agricultural product standards according to the Agricultural Product Standards Act 2008. Bureau of Standards.
Anastasopoulos PC, Tarko A, Mannering FL (2008) Tobit analysis of vehicle accident rates on interstate highways. Accid. Anal. Prev. 40: 768–775.
APO (Asian Productivity Organization) (2016) Manual on Good Agricultural Practices (GAP). Available on the https://resources.peopleinneed.net/documents/119-apo-manual-on-gap-2016.pdf. Accessed on November 4, 2022.
Boonrasri S, Sae–Oui P, Chaiharn M, Rardniyom C (2020) Effects of chitosan contents on latex properties and physical properties of natural rubber latex/chitosan composites.
Bekabil U T, Bedemo A (2015) Dynamics of farmers'participation in conservation agriculture: Binary logistic regression analysis. JPID. 13: 74–83.
Bingen J, Serrano A, Howard J (2003) Linking farmers to markets: different approaches to human capital development. Food Policy. 28, 405-419.
Bunclark L, Lankford B (2011) Rainwater harvesting: A suitable poverty reduction strategy for small-scale farmers in developing countries. Waterlines. 30: 312–327.
Chanthuma P (2020) Increasing the productivity and income of farmers in Trang Province from rubber plantation according to GAP standards. Para Rubber Electronic Bulletin.41: 2-11.
Cristóvão A, Ferrão P, Madeira R, Tibério M L, Raínho M, Teixeira M S (2009) Circles and communities, sharing practices and learning: Looking at new extension education approaches. J Agric Ext. 15: 191–203.
Douglah M, Sicilima N (1997) A comparative study of farmers'participation in two agricultural extension approaches in Tanzania. JIAEE. 4: 38–46.
European Forest Institute (EFI) (2024) Thailand's natural rubber producers are preparing for new market requirements. European Forest Institute. https://efi.int/publications-bank/thailands-natural-rubber-producers-are-preparing-new-market-requirements
FAO (The Food and Agriculture Organization) (2007) Guidelines, Good Agricultural Practices for Family Agriculture. Available on the https://www.fao.org/3/a1193e/a1193e.pdf. Accessed on November 4, 2022.

FAO (The Food and Agriculture Organization) (2010) Good Agricultural Practices (GAP) on horticultural production for extension staff in Tanzania. Available on the http://www.fao.org/docrep/013/i1645e/i1645e00.pdf. Accessed on October 22, 2022.

Gohet E, Lacote R., Leconte A, Chapuset T, Rivano R, Chambon B (2016) Improving rubber smallholdings productivity and resilience through adoption of good agricultural practices [Conference presentation]. CRRI IRRDB Workshop on Transfer of Technology "Good Agricultural Practices, Reduced Wastages, Improved Quality, Productivity and Profitability" at Phnom Penh, Cambodia. https://agris.fao.org/agris-search/search. do?recordID=FR2019134326

Holzapfel S, Hampel-Milagrosa A (2020) Global and National Food Safety and Quality Standards: Implications and Impacts for Farmers in Thailand and India. Sustainability Standards and Global Governance: Experiences of Emerging Economies, 163-186.

Leepromrath S, Zhu J, Zhou J, Li T, Zhou D (2021) Rubber crop diversity and its influential factors in Thailand. J Rubber Res. 24(3): 461-473.

Kangpisadan N (2006) Fertilizers are recommended for rubber plantations. Rubber Journal. 30(3): 22-27.

Kongmanee C, Ahmed F, Longphichai O (2023) Identifying farm risk management strategies of rubber farmers: A study in Southern Thailand. Aust. J. Crop Sci.17(6): 498-506. https://doi:10.21475/ajcs.23.17.06.p3870

Kongmanee C, Ahmed F (2022) Pre and post Covid-19 scenario of Thai fresh latex traders. J. Manag. Inf. Decis. Sci. 25(S3): 1-15.

Kongmanee C, Ahmed F (2021) COVID-19 Impacts on Rubber Farmers in Thailand: A Study of Behavioral Change and Livelihoods. Univers. J. Agric. Res. 9(6): 277 - 288. https://DOI:10.13189/ujar.2021.090606

Lioutas E D, Tzimitra-Kalogianni I, Charatsari C (2010) Small ruminant producers' training needs and factors discouraging participation in agricultural education/training programs. Livestock Research for Rural Development. 22: 126.

Longpichai O, Kongmanee C, Ahmed F (2023) Income diversification strategies of rubber farmers in Southern Thailand: an empirical study. Aust. J. Crop Sci.17(6): 481-487. https://doi:10.21475/ajcs.23.17.06.p3800

OAE (Office of Agricultural Economics). (2022) Agricultural statistics of Thailand, year 2022. Available on https://www.oae.go.th/assets/portals/1/files/jounal/2566/yearbook2565.pdf. Accessed on September 4, 2022.

Olaniran AF, Taiwo AE, Iranloye YM, Okonkwo CE (2023) The Role of Good Agricultural Practices (GAPs) and Good Manufacturing Practices (GMPs) in Food Safety. Food Safety and Toxicology. De Gruyter. North America. USA.

Preprame T, Buncha S (2023) GAP rubber farming and a GMP latex collection center with a BCG economy model in Thailand. J. Sustainability Sci. Manage. 18 (8): 37-49

RAOT (Rubber Authority of Thailand) (2023) Project driven to increase the potential of rubber plantation management according to GAP principles. Journal Rubber Thailand. 45:31–35.

Tobin J (1958) Estimation of relationships for limited dependent variables. Econom J. Econom Soc: 24–36.

Washington S, Karlaftis MG, Mannering F (2010) Statistical and econometric methods for transportation data analysis.

Ye F, Lord D (2014) Comparing three commonly used crash severity models on sample size requirements: Multinomial logit ordred probit and mixed logit models. Analytic Methods in Accident Research. 1: 72-85.

Zou R, Sultan H, Muhamed SM, Khan MN, Liao W, Li Q, Nie L (2024) Sustainable integration of rubber plantations within agroforestry systems in China: current research and future directions. Plant Sci. Today: 11(3).