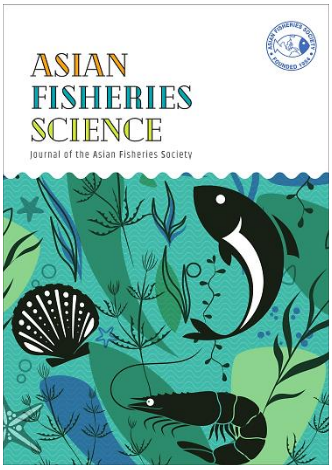

Adoption of Vietnamese Good Agricultural Practices (VietGAP) in Aquaculture: Evidence From Small-Scale Shrimp Farming

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Abstract

The increasing demand by international customers for high-quality shrimp products has led to the introduction of various certificates of traceability intended to validate quality products in Vietnam. The Vietnamese good agricultural practices (VietGAP), better known in aquaculture as the Vietnamese good aquaculture practices, has emerged as a reliable certificate for small-scale farmers and a prerequisite for international certification. This study investigates factors affecting applications for VietGAP by small-scale shrimp farmers in Vietnam. Cost-benefit analysis and binary logistic regression approaches were used to categorise shrimp farms with and without VietGAP certification. Findings indicated that while the adoption of VietGAP raised production costs by 14.5 %, it could increase net profit by up to 22 %. The increase in net profit is from increased productivity and antibiotics and chemical-free products in shrimp farming, helped fetch better prices. The results also revealed three factors that positively influenced the farmers' decision to acquire VietGAP; education, farm size, and production system. Shrimp farmers with longer schooling years, larger farms, and those who possess cooperative/farming cluster membership are more likely to acquire VietGAP certification. The results imply that the VietGAP certification should be better promoted to cooperative production forms of farming, by strengthening the schooling year of farmers and increasing awareness of VietGAP certification to farmers who operate shrimp farms of 5,000–9,000 m^2.

Keywords: binary logistic regression, cost-benefit analysis, GAP-certification, VietGAP, *Panenus vannamei*

Introduction

Aquaculture constitutes almost half of the world's seafood supplies. As one of the fastest-growing production methods in the global food supply system, aquaculture accounted for 17 % of the global population's intake of animal proteins in 2017, creating employment for more than 59 million people (FAO, 2020). Such increasing demands have called for the propagation of "Blue Revolution", an initiative that advocates the substitution of aquaculture in the place of capture fishery causing significant concerns about its social and environmental impacts (Bush and Oosterveer, 2012; UNEP; 2016). In light of these developments, there is pressing demand for traceability of alternative certifications to meet the increasing consumer awareness of sustainability, legality, safety, and quality issues.

Vietnam's commercial shrimp farming industry started in the late 1990s after its economic reform policies that brought about trade liberalisation, and economic restructuring by increasing private sector involvement (UNEP, 2016; Suzuki and Nam, 2018). By 2019, the nation's total shrimp production reached 750,000 metric tonnes (MT), and shrimp products from Vietnam were consumed in 91 countries, corresponding with USD3.6 billion of the country's export value (VASEP, 2020). The black tiger shrimp (*Penaeus monodon* Fabricius, 1798), and whiteleg shrimp (*Penaeus vannamei* Boone, 1931), are the main species of brackishwater aquaculture in Vietnam. The production volume of the whiteleg shrimp was significantly higher than black tiger shrimp, which was

480,000 MT and 270,000 MT, respectively, in 2019. The Mekong Delta (MD), covering 12 provinces and one city in Southern Vietnam, made up more than 93 % of the dedicated shrimp farm area and about 85 % of the total production of the country, providing a livelihood for thousands of local people (Vietnam Institute of Economics and Planning, 2015).

Shrimp production in Vietnam is dominated by small-scale producers who make up approximately 80–95 % of the farming area and contribute to two-thirds of the total shrimp production (Suzuki and Nam, 2018; Quyen et al., 2020a). Traditional small-scale improved extensive shrimp farming relies on farming practices such as additional seed stocking, feeding and management inputs. Feeding, in this case, is minimal and involves almost no antibiotics or chemicals.

International customers are often concerned about the uncertainty of food safety, quality, and equity of the products in question (Mohan, 2013), and in addition, the Vietnamese shrimp industry is challenged by technical and commercial drawbacks and harsh global competition (Lap et al., 2015; UNEP, 2016). Upon coming to terms with the failure to control food safety and quality in the 1990s, certification schemes were encouraged as a market-based incentive to promote sustainable aquaculture. Voluntary third-party certifications covering a wide range of criteria have also mushroomed, e.g., Aquaculture Stewardship Council (ASC) certification, global good aquaculture practices (Global GAP), best aquaculture practices (BAP), and VietGAP (UNEP, 2016; FAO, 2018). These voluntary certifications could potentially have trade-enhancing effect on developing countries since they provide validation that certified farmers produce high-end products and might be recognised in several international markets. Among the three main import markets of Vietnamese shrimp products, the European Union (EU) prefers the ASC, the United States of America (USA) prefers the Global GAP and Japan prefers all eco-label products with food safety tests (Nabeshima et al., 2015; Quyen et al., 2020b). This suggests that certification schemes can be perceived as a highly appropriate strategy for the aquaculture sector to achieve sustainable development. In Vietnam, sustainable certifications for aquaculture have been introduced on several platforms since 1996, often with the support of non-governmental organisations (NGOs) such as the Worldwide Fund for Nature in Vietnam (WWF-VN), the International Collaborating Centre for Aquaculture and Fisheries Sustainability (ICAFIS) as well as other charitable entities. Recent local certifications like Metro GAP and VietGAP have also been promoted by the government and the private sector (Nabeshima et al., 2015; UNEP, 2016; Quyen et al., 2020a). Though initially devised to target domestic consumption, these local certifications work just as effectively for food safety and disease control; and facilitate international certifications. National accreditation has always been considered an appropriate starting point for farmers to familiarise themselves with global market requirements (Quyen et al., 2020a). Currently, most credible certification standards are adopted only by large and advanced companies. Smaller farms, cooperatives, and individual households have difficulty acquiring and adopting such certifications due to the high investment cost involved and the limitation they face in accessing relevant information. The adoption approach relies upon the analysis employing probability models such as logit and probit. In addition, the study adopted the comparison cost, efficiency and economic results between adopters and non-adopters (Ullah et al., 2015; Duyen et al., 2019). In light of the above issues, this study attempts to understand the factors influencing Vietnamese farmers' choices of adopting the VietGAP certificate-ion.

Materials and Methods

Data collection

A household survey was conducted in the MD provinces known for small-scale monoculture shrimp farming (General Statistics Organisation, 2021). The Mekong River that crosses the lower basin of MD is divided into two main rivers, Tien River and Hau River, separating the area into two regions. The first region includes six provinces, i.e., Long An, Dong Thap, Vinh Long, Tien Giang, Ben Tre and Tra Vinh (Fig. 1), of which Ben Tre ranks high in shrimp production by volume and value (72,090 MT of shrimp in 2019) (General Statistics Organisation, 2021).

Fig. 1. Selected provinces for the study on adopting Vietnamese good agricultural practices; Ben Tre and Soc Trang (circled), in the Mekong Delta region (Adapted from: Vietnam Institute of Economics and Planning, 2015).

The second region includes six provinces and one city, i.e., An Giang, Kien Giang, Can Tho, Hau Giang, Ca Mau, Bac Lieu and Soc Trang. Soc Trang is the second-largest commercial shrimp producer in the MD after Ca Mau, having produced 167,755 MT in 2019 (General Statistics Organisation, 2021), whereas Ca Mau diversifies its farming models, i.e., mangrove shrimp, rice-shrimp rotation, and extensive farming systems. Since the small-scale intensive shrimp farming model dominates in Soc Trang (People Committee of Soc Trang, 2020), Soc Trang and Ben Tre were selected for sampling, and this is also because they represent locations from both sides of the MD, thus typically representing the whole MD region.

The targeted group of farmers in this study were small-scale intensive shrimp farmers, who have family-owned farms and manage and operate over a small farming area. The typical harvesting areas are less than 2 hectares, and these farmers mainly employ family labour and use their own land to optimise their capital (De Silva and Davy, 2010; Edwards, 2013).

A survey was carried out from January until September 2019. Two interviews were conducted with selected respondents from the two provinces using a structured questionnaire. The first interview was conducted between January and March 2019 with the key informant panel (KIP) of senior specialists from the Department of Fishery. They were interviewed using a list of open-ended questions (semi-structured interview) to collect secondary data on their shrimp farming status and details of their VietGAP certification adoption. The first interview involved a pilot test (accounted for 10 % of the total shrimp farmers) to revise and validate the questionnaire for the second interview. The second interview was carried out from April to September 2019, after the shrimps were harvested. In the second interview, combinations of two sampling methods were applied. First, the two provincial DoF compiled a list of farmers in these regions for the study. After that, the stratified random sampling method was employed. Two groups of farmers were interviewed, including 101 farmers who adopted VietGAP and 111 farmers from the non-GAP compliance category. The questionnaire was designed with information on household characteristics, production operation practices and finance, including investment and production costs with their structure and economic returns. The survey data allowed researchers to quantify factual differences between farmers' adoption and non-adoption of the VietGAP standard.

Data analysis

The collected primary data were refined and processed using Statistical Package for Social Sciences (SPSS) version 20. Data analysis and processing included descriptive statistics, i.e., mean, standard deviation, frequency, and percentage. Financial benefit indicators such as production costs, unit prices, revenue, net profit, and profit margin were also calculated and compared. These quantitative variables were assessed using independent sample t-test to identify significant differences between VietGAP adopters and non-GAP adopters ($P < 0.01$). Finally, the regression model was applied to identify factors affecting farmers' adoption of VietGAP with a detailed description in the section "Binary logistic regression analysis".

Cost-benefit analysis

Differences in cost-benefit between VietGAP-compliant farms and non-VietGAP-compliant farms were explored using descriptive statistics. The cost-benefit analysis includes item cost analysis, which was divided into production cost, post-harvest cost and returns (Islam et al., 2012). However, UNEP (2016) and Quyen et al. (2020a) stated that small-scale shrimp farming features in the MD are considered costs incurred towards the end of the harvest and post-harvest costs such as transportation, marketing, sales, and distribution are the responsibilities of the buyers. Nhuong et al. (2013) affirmed that the Vietnamese global value chain of commercial shrimps is buyer-driven. This means the buyers, e.g., collectors, traders, wholesalers and processing enterprises, are responsible for harvest, transportation and sales. Therefore, the cost analysis does not include post-harvest costs. Comparisons were made between cost items, including investment, fixed, variable, and their structures.

Estimation model for the binary logistic regression

Basic binary logistic regression (BLR) model

The basic binary logistic regression (BLR) model, known as a nonlinear regression model, was used to describe the relationship between a dependent variable (dummy variable) and multiple independent variables (Ozdemir, 2011; Pourghasemi et al., 2013). The logistic regression algorithm applies maximum likelihood estimation after transforming the dependent variable into a logic variable, representing the natural logarithm of the probability of occurrence of the dependent (Bai et al., 2010; Pourghasemi et al., 2013). As logistic regression model, the generalised linear model extends the linear regression model by linking the range of real numbers to the range 0–1.

The basic logistic regression model is formed as follows:

$$P(Y = 1) = \frac{e^z}{1 + e^z} \quad (1)$$

and $P(Y = 0) = 1 - P(Y = 1) = 1 - \frac{e^z}{1 + e^z}$

where P is the probability that the n^{th} case will adopt VietGAP and z is the value of the non-observed variable for n^{th} case. Therefore, the model assumes that z is linear regression related to the X_n predictors.

Thus $z = B_0 + B_1X_1 + \cdots .. + B_nX_n + u$ (2)

where z is the n[th] value of the dependent variable, or the farmer's participation in the VietGAP certification *(0 = Non-GAP application; 1 = VietGAP application)*; B_0 is a constant; X_n is n[th] value of independent variables explaining the correlation with the dependent variable; and the term u is the error of the model; B_n indicates the slope regression coefficients. The B_n is correlated to marginal effects $Exp(B_n)$ directly under the equation:

$$Exp(B_n) = \frac{\partial\,(Y=1/X)}{\partial X} = P(1-P)B_n$$

The SPSS automatically computes the value of $Exp(B_n)$ through an iterative maximum likelihood method when running the BLR where *n* is the number of independent variables.

Empirical model of BRL

In this study, the BRL was employed to analyse the factors influencing farmers' decisions to adopt the VietGAP certification. Because there were two categories for the dependent variable, employing the BLR model for the analysis was deemed preferable.

A farmer can be described as someone who is able to participate in the VietGAP certification based on the probability of P (Y = 1) being greater than 0.5. Conversely, if P (Y = 1) is less than 0.5, they are deemed ineligible to participate in VietGAP certification.

Hensher and Greene (2003) proposed the following factors that possibly influenced the shrimp farmers' choice to participate in the VietGAP certification. The factors as to why a farm household chooses to participate in VietGAP application depends on many explanatory variables, which could be classified into two groups: i) demographic and social profile of the surveyed farmers, e.g. educational level of the head of the household, shrimp farming experience, the number of workers in the household, age of head of the household, and ii) farm operation information, e.g. the farming area, and the production system, i.e. extensive or intensive. Therefore, the following model was used to predict the adoption of VietGAP applicants. The description of the model variables is given in Table 3.

$$Log_e\left[\frac{P\,(Y=1)}{P\,(Y=o)}\right] =$$

$$B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + u \quad (3)$$

Results

Cost-benefit analysis of VietGAP and non-VietGAP application at shrimp farms

The research result shows that the application of VietGAP certifications at the study site has not been fully understood and appreciated by the farmers, as more than 50 % of the surveyed shrimp farmers have not attempted to apply for or adopt VetGAP. Moreover, only 7 % of the shrimp farms with VietGAP appear to have renewed the certificate (Fig. 2).

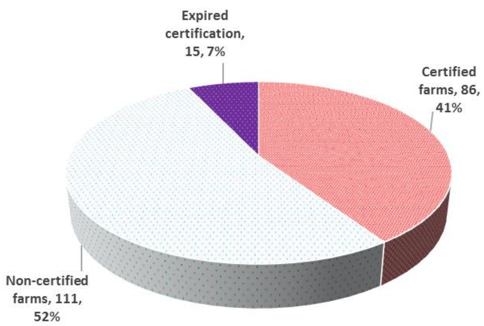

Fig. 2. Distribution of shrimp farms audited for adoption of Vietnamese good agricultural practices (VietGAP) certification in Ben Tre and Soc Trang.

Of the total of 212 surveyed shrimp farms, the average size of all stocking ponds that had applied for the VietGAP certification was 8,601 m^2 household^{-1}, which was 40.2 % higher than farms that did not apply for the certification.

These two systems' cost and benefit comparisons were made using an identical unit, namely USD.ha^{-1} cycle^{-1}. The farms that had applied for VietGAP had invested USD34,348 ha^{-1} as a start-up, which was 23.9 % higher than non-certified farms. The production costs of the VietGAP-certified farms were USD20,244 ha^{-1}, which was 14.5 % higher than those of the non-VietGAP certified farms in the same production cycle. The higher cost was used to improve the farm's capacity towards meeting VietGAP standards of infrastructures, particularly in the areas for digging deeper ponds, building separate reservoirs, and developing irrigation and waste treatment systems. Meanwhile, the fixed cost in a VietGAP applied system was 23.6 % higher than a non-VietGAP. In contrast, the variable cost using the VietGAP system was 13.3 % lower than that of the non-VietGAP one. The lower cost for VietGAP certified farms was due to the 10 % to 15 % discount offered for materials from the supplier. There was no difference in the labour cost as VietGAP required neither additional paperwork nor complex management processes. Therefore, the productivity of VietGAP farms was 0.8 mt ha^{-1} cycle^{-1} higher than those of non-VietGAP farms (See Table 1).

Figure 3 shows the distribution of shrimp products and indicates that 68 % of shrimp products from the

Table 1. Comparison of production cost and cost of variable structure between Vietnamese good agricultural practices (VietGAP) and a non-VietGAP shrimp farm.

Cost items	Non-VietGAP Average ± SD; n = 111	VietGAP Average ± SD; n = 101
Average size of active ponds (m^2 $farm^{-1}$)	4,906.8 ±1.813***	8,601.1 ± 2,499***
1. Initial investment cost (USD.ha^{-1} $cycle^{-1}$)	26,130.4 ± 5,260.8***	34,347.8 ± 9,391.3***
2. Depreciation cost (USD.ha^{-1} $cycle^{-1}$)	3,621.7 ± 2,304.3***	4,739.1 ± 2,434.8***
• Structure of depreciation costs (%)	100	100
• Construction depreciation	42.5	43.2
• Equipment depreciation	28.8	29.8
• Warehouse depreciation	8.5	8.9
• Small boats and other tools depreciation	20.2	18.1
3. Variable cost (USD.ha^{-1} $cycle^{-1}$)	356.5 ± 93.5***	314.7 ± 89.8***
• Structure of variable costs (%)	100	100
• Feed	57.6	58.1
• Shrimp post larvae	25.8	23.9
• Fuel/electricity	5.9	6.1
• Drugs/chemical compound	5.1	8.0
• Labour	2.8	0.6
• Water treatment, pond renovation	1.8	0.8
• Food safety test at the processing before harvesting	0.4	1.6
• Loan interest	0.3	0.7
• Transportation of inputs	0.2	0.1
• Phone costs for transaction in production stage	0.1	0.1
4. Total cost (2+3)(USD.ha^{-1} $cycle^{-1}$)	17,304.4 ± 765.2***	20,243.5 ± 669.6***
5. Productivity (MT.ha^{-1} $cycle^{-1}$)	5.3 ±1.4***	6.1 ± 1.7***
6. Average production cost (USD.kg^{-1})	3.29 ± 0.61	3.39 ± 0.53

USD1 = VND23,000 (2020).
*** denotes statistical significance at 1 % using independent sample t-test to compare means.

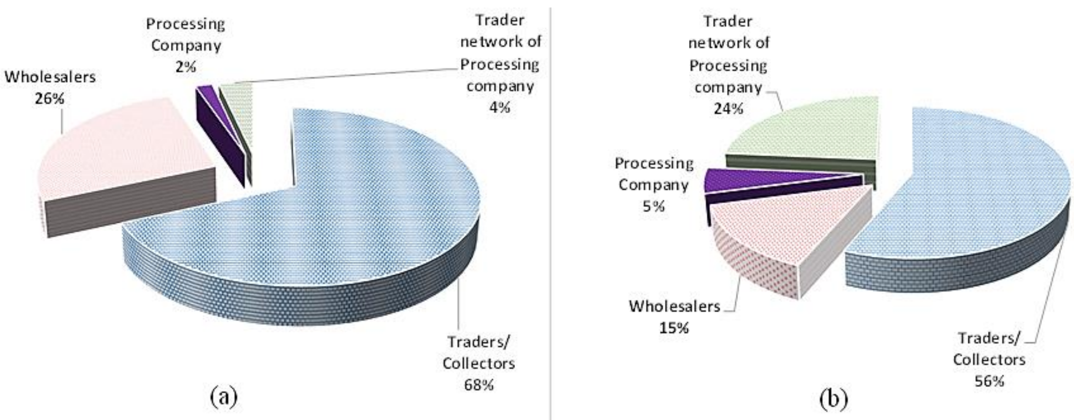

Fig. 3. Shrimp sales distribution of non-Vietnamese good agricultural practices (VietGAP) (a) and VietGAP certified commercial shrimps (b) in Ben Tre and Soc Trang.

non-VietGAP farms were distributed by traders and small-time collectors residing in nearby communes. These traders collect the shrimps and pack them in containers and shipped to processing companies. Only 2 % of the high-volume farms could sell shrimps directly to processing companies, while 26 % sold to wholesale buyers. Under the VietGAP system, approximately 56 % of the harvested shrimps were sold to small traders or collectors. This is a simple system where shrimps are collected and stored for several days in a container until they reach full capacity. They are then shipped to local markets for retail or to processing companies for export. The above methods of shrimp distribution are mainly used for domestic consumption rather than export.

Farms with VietGAP certification or contracted ones can sell their shrimps directly to the processing companies or via the companies' trader network (29 % of the harvested shrimps). The others sell their products to wholesalers when high volumes are harvested. In some cases, contracted farmers sold the shrimps to collectors and wholesalers due to difficulties in executing contracts between Vietnamese farmers and processing companies. This has resulted in a higher proportion of VietGAP shrimps being exported from such companies than non-VietGAP products (5 % and 2 %, respectively), at a higher price of USD4.67 kg^{-1} for the former and USD4.57 kg^{-1} for the latter. Direct sales to companies tend to fetch a higher price and promise higher quality due to a shorter production line, faster processing, and fewer distribution joints (Suzuki and Nam, 2018; Quyen et al., 2020a).

The price of VietGAP-certified shrimps was 2 % higher than that of non-VietGAP-certified ones. During the incubation stage of VietGAP certification, the Vietnamese government proposed that they would guarantee the prices of certified products and keep them higher than those of the un-certified counterparts. However, since the economic target of the VietGAP is beyond the scope of the VietGAP scheme, the premium price, in reality, is not officially regulated in paper (MARD, 2015; Quyen et al., 2020a). UNEP (2016), Amundsen et al. (2019) and Quyen et al. (2020a) confirmed that the certification does not determine the premium price of VietGAP certified products but instead is the outcome of passing food safety tests at the processing companies, which have gained a sound reputation for their stringent and reliable processing standards.

The research results demonstrated in Table 2 show that the application of VietGAP brought about economic benefits at USD1,517 ha^{-1} $cycle^{-1}$ to the farmers. In other words, the profit.kg^{-1} of households that had acquired VietGAP was USD1.28 kg^{-1} compared to USD1.17 kg^{-1}. The difference came from the higher revenue and the higher selling price as shown in the analysis above (USD28,570 ha^{-1} $cycle^{-1}$ of households that acquired VietGAP compared to 24,117 USD28,570 ha^{-1} $cycle^{-1}$ of households which had not acquired VietGAP). Along with the costs analysed in the previous section, the VietGAP label brings higher economic benefits to those who had acquired it. Additionally, VietGAP provides insurance against loss up to 15 % resulting in 80 % of the VietGAP- compliant farms seeing a successful harvest compared to 65 % of the non-GAP ones. VietGAP practices also prevented farmers from significant losses from unsuccessful harvests such as early harvesting due to unexpected diseases and in cases where farmers could only harvest small-size shrimps, which would fetch lower revenue than usual. However, in such situations with similar conditions of risk and uncertainties in both categories of the farms, despite the income being insufficient to compensate for the production cost, the loss of a VietGAP system was considerably lower than a non-VietGAP.

The results in Table 2 show that the VietGAP practices led to higher financial returns. Profit margins for the VietGAP-compliant farms were 4.57 % higher than those of their non-VietGAP counterparts. The increase in selling price, the net profit and the successful harvest ratio indicate that VietGAP provided farmers with considerable economic benefits. Almost all financial indicators of VietGAP-compliant farms were higher than those of their counterparts.

Binary logistic regression analysis

Description of variable in the regression

The description of all variables for processing BLR are shown in Table 3. The descriptive statistics indicate that the educational levels of the household heads/representatives of VietGAP farms were higher than that of non-VietGAP counterparts, which were 7.87 and 6.16 years, respectively. In addition, farmers in the VietGAP system had at least 5 years of shrimp farming experience compared to the non-VietGAP

Table 2. Change of financial indicators of Vietnamese good agricultural practices (VietGAP) versus non-VietsGAP system.

Financial indicators	Non-VietGAP Average ± SD; n = 111	VietGAP Average ± SD; n = 101	Differences
Selling price (USD.kg^{-1})	4.57 ± 1.10	4.67 ± 1.14	0.1
Revenue (USD.ha^{-1} $cycle^{-1}$)	24,117 ± 8,322	28,570 ± 11,856	4,453
Average production cost (USD.ha^{-1} $cycle^{-1}$)	17,304.4 ± 765.2	20,243.5 ± 669.6	2,939.1
Net profit (USD.ha^{-1} $cycle^{-1}$)	6,813 ± 5,817	8,330 ± 6,987	1,517
Net profit (USD.kg^{-1})	1.27 ± 1.01	1.28 ± 1.20	0.01
Successful harvest ratio (%)	65	80	15
Losing among (USD.ha^{-1} $cycle^{-1}$)	2,370.2 ± 1,167	530.9 ± 265.67	-1,839.1
Profit margin	0.394	0.412	0.018

USD1 = VND23,000 (2020).

Table 3. Descriptive statistic of independent variables in a binary logistic regression model used for predicting farmers' application to Vietnamese good agricultural practices (VietGAP) certification.

Variable	Description	Non-VietGAP	VietGAP
		Average ± SD	
Education level of the household head[a] (X_1)	Schooling years (Years)	6.12 ± 2.87**	7.87 ± 3.2**
Shrimp farming experience (X_2)	Number of years of shrimp farming (Years)	11.08 ± 7.2***	16.63 ± 6.45***
Family labour.ha^{-1} (X_3)	The no. of people in the family under labour age involved in shrimp farming (Person)[b]	1.35 ± 0.57***	2.43 ± 0.80***
Age of household's head (X_4)	Age of household's head (Years old)	49.42 ± 9.8	50.30 ± 10.75
Farming area (X_5)	Total land used for shrimp farming, including sub-construction (m^2)	4,441.4 ± 3,402.5***	11,137.6 ± 9,145.3***
Production forms (X_6)	Production organisation forms (N (%)) 0 = individual farms 1 = collective form	97 (87.4 %) 14 (12.6 %)	21 (20.8 %) 80 (79.2 %)

USD1 = VND23,000 (2020).
N = number of observations.
[a] household's head could be the husband or the wife who makes decisions of major activities in shrimp farming; classification of education is based on the K-12 system in Vietnam, where basic education is from grade (or year) 1 to 12, higher education includes undergraduate and graduate education; [b] labour age ranges from 15 to 60 years old for male and from 15 to 55 years old for female.
***, ** denotes statistical significance of the explanatory variables and dependent variable at 1 and 5 % under independent sample t-test.

ones. The average number of workers was 1.35 workers.ha^{-1} in a VietGAP farm compared to 2.43 workers.ha^{-1} in a non-VietGAP one. VietGAP farmers cultivated an area of 1.1 ha.farm^{-1} as compared to 0.44 ha.farm^{-1} by non-VietGAP farmers. The survey also shows that 94 % of farms had constructed reservoirs necessary for areas with high water turbidity or overcrowded farms. The reservoirs aimed at improving the water quality were monitored to meet VietGAP standards, which require that the area of reservoirs occupy at least 15 % of the farm size (MARD, 2015). Meanwhile, 70 % of the non-VietGAP farms ended up constructing smaller reservoirs. In this study, most farmers in the VietGAP system were members of cooperatives or farming clusters, where they could receive training, agricultural extension subsidies (e.g., toolkits and infrastructure upgrading), and partial financial support to comply with VietGAP's criteria. The remaining 20.8 % of farmers in the VietGAP system was from individual farms. It was also noted that of all the members of collective farming forms in compliance with VietGAP, 11.9 % were from farming clusters as compared to non-VietGAP farms were individual primarily (87.4 %).

Overall model fitting

According to Yanagihara et al. (2003) and Trong and Ngoc (2008), independent variables included in the logit regression model should be coded into dummy variables or ordinal variables. Therefore, the quartile function was applied to grouping to explain the scale variables. Various trials of the models were progressed from six suggested independent variables above. The measure of the model's goodness of fit was based on the information of Akaike Information Criteria (AIC) (Bozdogan, 1987; Yanagihara et al., 2003). The AIC is a measure of goodness of fit and can be produced in relation to mean Log-Likelihood by the equation:

$$AIC = -2 \times Log\ Likelihood + 2 \times k = 2(k - Log\ Likelihood)$$

In this study, the model measured the goodness of fit by clarifying the differences in *-2 Log Likelihood* and *AIC* amongst the different trial models. The smaller the statistics were, the better the model became. The results of the model are presented in Table 4.

The common assessment of the overall model fitting in logistic regression models was based on the Chi-square value in the Hosmer and Lemeshow test (Hosmer and Lemeshow, 2000; Zewude and Ashine, 2016). The Chi-square value in the Hosmer and Lemeshow test was greater than 0.01, so the overall logistic regression model was a good fit. The result of Cox and Snell R^2 and Nagelkerke R^2 was greater than

Table 4. Model summary and goodness of fit in the regression model.

Hosmer and Lemeshow	Chi-square	df	Sig.
	5.094	8	0.747***
Model summary	-2 Log Likelihood	Cox and Snell R Square	Nagelkerke R Square
	116.8	0.565	0.754
Akaike information criterion (AIC)			211.16

*** denote the statistical significance of the model at 1 %; Hosmer and Lemeshow (chi-square value) show the test of the model; the Cox and Snell or Nagelkerke R square is an analogous statistic in logistic regression to the coefficient of determination R^2 in linear regression; -2 Log Likelihood and AIC are criteria to measure the model's goodness of fit.

0.5 (0.56), whereas that of Nagelkerke R^2 was 0.754, getting close to 1. This means that the model is assumed to be good (Zewude and Ashine, 2016; Behera, 2019). The results of -2 Log-Likelihood and AIC showed that these two figures, at 116.8 and 211.16, were respectively the smallest amongst different models with variables. Therefore, the final regression model with the lowest -2 Log-Likelihood and AIC included four independent variables: Educational level (X1), farming experience (X2), farming area (X5), and production forms (X6) (see Table 5).

A good model should have a minimal opportunity of misclassification (Hosmer and Lemeshow, 2000; Trong and Ngoc; 2008). In the 111 observed non-VietGAP cases, the model predicted 100 cases accurately, which accounted for 90.1 %. Simultaneously, the model accurately predicted that 89 out of 101 cases were VietGAP (88.1 %). Therefore, the total accuracy percentage was 89.2 %, which indicates that it is indeed a good model (Table 5).

Logistic regression represents the marginal contribution of each independent variable, evaluated at the sample mean and associated with the odds ratio. The results of this model are in line with the broad argument that multiple independent variables influence the decision to participate.

The mathematical model is re-written as:

$$Log_e\left[\frac{P\,(Y=1)}{P\,(Y=o}\right] = -5.161 + 0.182X_1^{***} + 0.445X_2 + 0.605X_5^{***} + 2.803X_6^{***} \quad (4)$$

in which:
X_1: Education level (years)
X_2: Shrimp farming experience (years)
X_5: Farming area (m^2); (1 = 5,000 – 9,000 m^2; 0 = others)
X_6: Production system (0=individual farms; 1=member of cooperative/farming cluster)

Regression result analysis

Of the four regressors, three were found to be statistically significant: Educational level (X_1), farming area (X_5), and production forms (X_6) (Table 5). The estimated coefficients (B_j) measure the change in predicted log odds of participation in the VietGAP certification when independent variables change for a unit.

As seen from Table 5 and equation (4), the educational level of the head of the household (X_1) positively impacts the probability of participating in the VietGAP system. Better educated farmers had better awareness of the VietGAP certification. Therefore, it is logical to expect that if farmers possessed a higher level of education, they would be able to help increase awareness of VietGAP and facilitate the application of VietGAP successfully. A one-year increase of schooling results in a 1.2-time increase in the probability of adopting VietGAP.

Another vital factor affecting the decision of acquiring VietGAP that was positively significant is the farming area (X_5). The probability of VietGAP application increased with the farming area. Specifically, the marginal impact level of the farming area was 1.831 times in line with a threshold unit increase of the farming area. Shrimp farms with farming areas ranging between 5,000 and 9,000 m^2 had a higher probability of applying VietGAP.

Production forms (X_6) significantly contributed to the probability of farmers adopting VietGAP. VietGAP application requires more support from collective forms in terms of training program and contracted input-supply (Ha et al., 2013; Quyen at el., 2020a). Likewise, a member of a collective economic organisation, i.e., cooperative (Hợp tác xã) or farming clusters (Tổ hợp tác), is also more likely to apply for VietGAP at the marginal impact level of 15.439 times.

Discussion

The study has considered the cost-benefit of VietGAP to prove the significance of the certification. Nabeshima et al. (2015) and UNEP (2016) revealed that most certified products were processed by larger and more advanced companies because smaller farms and households faced challenges when conforming to the high standard criteria. The total cost, including registration, audit, and preparation, to obtain an international certification ranges from USD5,000 to USD10,000 $farm^{-1}$, making it impossible for most

Table 5. Variables in the equation of binary logistic regression and probability of farmers' application to Vietnamese good agricultural practices (VietGAP).

Variables	B_j	SE	Wald	Df	Sig.	Exp(B)
Educational level (X_1)	0.182	0.067	7.498	1	0.006***	1.200
Shrimp farming experience (X_2)	0.445	0.196	5.153	1	0.317	1.560
Farming area (X_5)	0.605	0.194	9.682	1	0.002***	1.831
Production forms (X_6)	2.803	0.413	30.503	1	0.000***	15.439
Constant	-5.161	0.907	17.938	1	0.000	0.006
			No	Yes	Percentage correct	
VietGAP	No		100	11	90.1	
	Yes		12	89	88.1	
Overall percentage						89.2
N						212

The B_j is the parameter of the eight explanatory variables in regression model as described in the text; *** denotes the statistical significance of the explanatory variables at *P*-value = 1 %; df = degree of freedom; Exp (B) is the marginal effects; N = the included number of observations in the model.

small-scale farmers to apply for the certification (Quyen et al., 2020b; Dong et al., 2021). Not surprisingly, only a few small-scale shrimp farms could afford international certifications. VietGAP is a much more reasonable alternative, with the total cost ranging from USD1,500 to USD2,000 farm^{-1}. In 2013, a national program was initiated in the MD to make the VietGAP certification more popular for shrimp products. By 2016, 130 shrimp farms covering over 64 hectares had been certified (VASEP, 2020). The VietGAP certificate is valid for 2 years and can be extended to 3 months if the holders need more time to re-audit the farm (MARD, 2015). In fact, due to financial burdens, many farmers could not undergo re-audit exercises to renew VietGAP unless there was external financial support for the audit costs. It explains why only a smaller number of farmers re-audited for VietGAP when it expired.

Furthermore, the VietGAP application cost-benefit analysis results for intensive whiteleg shrimp shows an economic incentive for certified shrimp farms, which corresponds with previous studies conducted by Marschke and Wilkings (2014) and UNEP (2016). Although the national VetGAP label is not internationally recognised, it now serves as a springboard for farmers to achieve other international certifications such as ASC or GlobalGAP since they share similar criteria and standards (Nabeshima et al., 2015; Quyen et al., 2020a). It is therefore imperative that the incentives of VietGAP be made more prominent and the premium price is regulated in official legislation documents.

In this study, factors that influence the probability of respondents' decision to apply for the VietGAP certification was identified as farmers' educational level, farming area, and production forms. Educational level is an important determinant of farmers' decisions to adopt the VietGAP certification as this factor helps increase the awareness of aquaculture certification. In addition, it is also considerably easier to train educated farmers to understand and comply with VietGAP standards. These results are similar to the findings of Vieldstra et al. (2014) and Duyen et al. (2019). It is important to note that most of the farmers who participated in VietGAP certification had farms larger than 9,000 m^2 because one of the VietGAP criteria strictly requires the construction of reservoirs (MARD, 2015; Behera, 2019). The reservoir acts as a settling pond for remedial measures to prevent the transmission of diseases from the wild. Hence, only farms with a larger area could comply with the criteria. Nhuong et al. (2013) stated that the farmers with farming areas larger than 9,000 m^2 operate their farms less effectively than small-scale farm owners in Vietnam, which is also confirmed in this study (Nhuong et al., 2013; MARD, 2015). Also, the probability of applying for the VietGAP certification was higher for members of collective forms, concurring with findings in Quyen et al. (2020a). The farmers who joined cooperatives and farming clusters were sponsored for the audit costs by the government when they were audited for the first time. Dong et al. (2021) and Duyen et al. (2019) stated that the VietGAP certification could be obtained by individual and organised farmers, e.g., cooperatives or small-farming clusters. Therefore, being a member of collective forms provides farmers with a strong motivation to apply for the VietGAP certification (Bai et al., 2011; Ha et al., 2013).

Conclusion

Vietnamese good agricultural practices (VietGAP) is a key certification that provides Vietnamese shrimp farmers with better opportunities for growth in the global seafood market. This study analyses and compares the cost-benefits of shrimp farming selected VietGAP and non-VietGAP GAP adopters. The research result shows a 14.5 % increase in production cost; 2.2 % of the premium price and 22.27 % of net profit gained by acquiring VietGAP. Moreover, the practices help farmers increase the rate of successful harvests and prevent severe losses in case of unexpected disease outbreaks based on sound standards and criteria set by the certification. Generally, the cost-benefit analysis of VietGAP adoption illustrates that VietGAP adopters are more successful with better profits than non VietGAP farmers. It proves the need for the VietGAP scheme to be promoted extensively among small-scale shrimp farmers. This study also considered several factors, namely education level, size of farming area, and production forms in binary logistic regression (BLR) associated with the higher probability of VietGAP adoption. Among these factors, the production forms had the highest marginal effect on the possibility of VietGAP application.

Based on the results of the BLR, some policy suggestions have been made. Farmers with higher education levels, larger farming areas, and those organised under collective forms can better implement VietGAP. It can also be concluded that it would be beneficial to restructure the industry to facilitate an increase of VietGAP applicants. This would include re-organising the shrimp industry by forming cooperatives or farming clusters and targeting groups categorised by education level and farm size that will fit well for the adoption of VietGAP.

The authorities concerned should consider the present findings to promote more farmers into adopting VietGAP for a more advanced shrimp industry in Vietnam. This could also result in more farmers upgrading their practices to conform to international certifications in the future. Such benefits will lead to higher participation of Vietnamese shrimp products in the global markets. Nevertheless, further investigations into the breakdown of the forecasted values need to be conducted for better decision-making. Future studies should consider the investigation of comprehensive cost-benefit analysis of all stakeholders of the shrimp global value chain. Similarly, the prediction of VietGAP adoption using logit model in this study alone cannot provide grounds for changes. Other factors should also be considered, such as the linkages of specific benefits from the collaborative economy and the application costs for other certifications.

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