Factors affecting the adoption of climate-smart aquaculture (CSAq) in the North Central Coast of Vietnam

Working Paper No. 269

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

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Abstract

Climate-smart aquaculture (CSAq) is considered an appropriate and effective adaptation approach for the coastal aquaculture sector under the climate change phenomenon. This study, applying probit model, aims to assess the influence of several factors on the farmers' decision to apply CSAq practices in extensive coastal shrimp farming. Data were collected from interviews with 200 households who have both already applied and have yet to apply CSAq practices in five coastal districts of Thanh Hoa Province. The results showed six key factors that influenced the decision of the farmers to apply CSAq practices: availability of household labor; access to information on CSAq practices; market price of products applying CSAq practices; economic efficiency; ability to ensure food security; and improved pond environment when applying CSAq practices. These factors explained 69.41% of their decision to apply CSAq, among which economic efficiency had the greatest impact (30.2%). Market prices and access to information about CSAq are also important factors with respective levels of influence at 16.0% and 14.9%. The result implies that strengthening access to CSAq information and improving technical understanding of CSAq practices are important solutions to upscale CSAq in the North Central Coast of Vietnam.

Keywords

Climate-smart aquaculture (CSAq), adoption, affecting factors, tilapia.

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Acronyms

CC	climate change
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CSAq	climate-smart aquaculture
FCR	feed conversion ratio
LPM	linear probability model
FGD	focus group discussion
NCC	North Central Coast
PRA	participatory rapid assessment
VIFEP	Vietnam Institute for Fisheries Economics and Planning

Introduction

Aquaculture in the North Central Coast (NCC), especially in Thanh Hoa Province in Vietnam, plays a crucial role in the socioeconomic development of the people. Specifically, it is one of the most important livelihoods of coastal communities. This livelihood, however, is now facing many risks due to the negative impacts of climate change.

Weather abnormalities such as prolonged heatwaves, irregular annual rainfall patterns, and large fluctuations in salinity levels affect the survival rates and growth potential of cultured species, especially the economically important black tiger shrimp (*Penaeus monodon*). By applying risk management strategies such as diversification of farmed species and technical interventions like CSAq, these farms can become more resilient under climate change, ensure food security and economic stability, and mitigate the adverse impacts of climate change.

To help aquaculture farmers improve their farming practices and cope with climate change, a project under the support of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) was implemented by the Vietnam Institute for Fisheries Economics and Planning (VIFEP), WorldFish, and Thanh Hoa Agriculture Extension Centre. The pilot project entitled “Enhancing community resilience to climate change by promoting smart aquaculture practices along the coastal areas of North Central Vietnam (ECO-SAMP)" was implemented in Hoang Phong Commune in Thanh Hoa Province from 2015 to 2017.

The project tested a new approach of integrating *tilapia* (amongst other brackish water fish species) into existing extensive shrimp and seaweed aquaculture systems. This integrated aquaculture approach is recognized as a potential climate-smart aquaculture (CSAq) practice. In 2015, on-farm trials of this practice were first completed on five farming households in Hoang Phong Commune.

Initial results showed that farmers gained a substantial increase in their household’s income-about 12%- and pond environment was better when applying this integrated aquaculture approach. In 2016, the CSAq trial was expanded to 25 aquaculture farmers in Hoang Phong Commune for replication purposes. Although the production value from the 2016 trials was lower in comparision with 2015, average income of the participating households and pond bed/water environment quality were still better than those maintain the conventional practice (VIFEP, 2016). Autonomous scaling out of the CSAq was also observed in the project area and neighboring communes.

Despite this success, the diffusion of this promising CSAq practice is still at a slow pace and has not been directed or supported by relevant aquaculture development policies at both central and provincial levels. Several key barriers to CSAq adoption in coastal aquaculture communities were discussed in a previous working paper (VIFEP, 2016), which included credit, technological, marketing, and institutional factors. So far, no aquaculture policies, strategies, plans or programs directly advocate or recognize the three-pilars of the CSAq approach and CSAq scaling-up in sustainable aquaculture development. Typically, the concept of sustainable aquaculture is cited as an adaptation to climate change, without mention of CSAq. Lack of attention among aquaculture managers and decision makers at both central and provincial levels is another key barrier to mainstreaming CSAq in sustainable aquaculture management policies.

A deep analysis to delve into the factors affecting the CSAq adoption and scaling up must then be conducted to provide empirical evidence of crucial factors affecting the diffusion of CSAq across coastal communities. This includes testimony on multiple stakeholders including CSAq end-users (local aquaculture farmers) and CSAq advocates (central and local aquaculture managers, policy makers, local extension workers, international agencies, NGOs, and credit providers, among others) in NCC. This study therefore aims to determine such factors and how they influence the adoption of CSAq among smallholder farmers.

Nature of Climate-Smart Aquaculture

Vietnam, as well as its NCC specifically, has been experiencing climate change for the last 50 years, based on meteorological observations (IMHEN, 2011). Recent changes on the climate brought negative impacts on the coastal aquaculture system in Hoang Phong. Climate data shows that rainfall patterns in Thanh Hoa changed by decreasing frequency but increasing intensity. This led to greater fluctuations on pond water environments (i.e. salinity, pH). Furthermore, with ‘Tieu Man’ flooding frequently occurring in June, pond salinity sharply declines and drops to its lowest level (about 2-3%) during the period of September-October (VIFEP, 2013) (Figure 1).

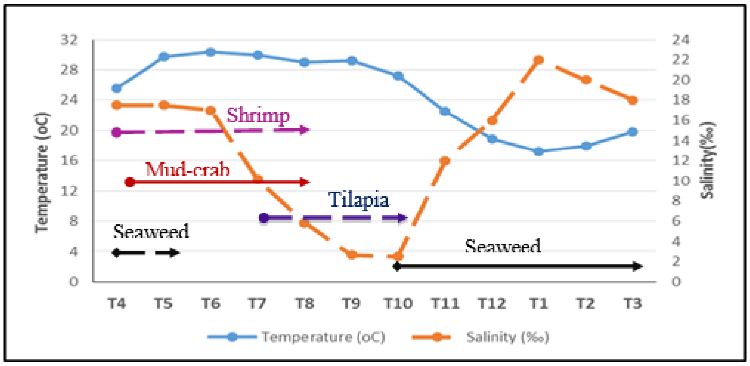

Figure 1. Fluctuations in pond salinity and temperature in Hoang Phong area

Note: T1, T2, T3, T4, T5... T12 means Jan, Feb, Mar, Apr,...

Low salinity means shrimp and mud-crabs are more vulnerable to climate change impacts during this period. Increasing temperature and high variations between day and night temperatures also cause shocks to cultured species, especially environmentally sensitive species such as shrimp, increasing its risks of mortality. Leaving the pond empty during this period is the current solution and response of most local farmers in Hoang Phong commune to minimize their risks.

This adaptation solution, however, reduces the farmers' income. Alternatively, suitable cultured species and/or farming practices must be developed to help local farmers adapt to climate change, reduce production risks, and sustainably increase their income. Mono-sex *tilapia* was selected for culture during the rainy season from July to October in Hoang Phong. The purpose of CSAq research and practice is to diversify farmed species to improve resilience against climate risks, providing a stable source of income that is less vulnerable to production loss.

By gradually domesticating *tilapia* species into brackish water farming systems, the integration of shrimp, *tilapia*, crab and seaweed as a CSAq practice in NCC brings higher economic gains and reduces feed uses, pond preparation costs and improves pond environmental quality. Moreover, this practice improves food accessibility of local farmers more than non-integrative practices do. Despite this success, adoption and scaling up of CSAq practices in the region still face several issues and require necessary support measures.

Methodology

Data collection

Data for the study were collected from both secondary sources and field surveys on the five coastal districts in Thanh Hoa Province: Hau Loc, Hoang Hoa, Nga Son, Nong Cong and Quang Xuong. Participatory rapid assessment (PRA) methods, focus group discussions (FGDs), and direct household interviews, which followed a structured questionnaire were applied. Field survey data was supplemented by secondary data for further verification.

Random sampling method was applied to select aquaculture households in the five coastal districts. The minimum number of samples was calculated by the formula, n = 50 + 8m, in which m refers to the number of independent variables used in the econometrics model (Hair et al., 2006). A total of 200 improved extensive aquaculture farms with and without tilapia integration were covered in the study from August-October 2018. After cleaning and removing unsatisfactory questionaires, 182 samples remained for this study.

Data analysis

Qualitative data collected from PRA and FGDs were compiled, summarized, and analyzed for general assessment. The surveyed data of households were analyzed by descriptive statistical method and probit model with STATA 12 and SPSS 16.

Research framework

Kumar (2018) reviewed several factors that influenced the adoption-related decisions of farmers on aquaculture technologies from a number of studies and summarized them as follows: (1) method of information transfer; (2) characteristics of the technology; (3) farm characteristics; (4) economic factors; and (5) sociodemographic and institutional factors. These factors revealed that the main modes of information transfer to farmers were based on two major channels, the Extension Approach and Media and Training.

In terms of the characteristics of the new technique, factors affecting adoption decisions were the perceived benefits of the new technique compared to previous techniques such as improvements in productivity (Batz et al., 1999), reduction of used input (Feder et al., 1985), cost effectiveness (Katiha et al., 2005), and decrease in market price and yield risks, (Tsur et al., 1990). The degree of compatibility with the needs of potential adopters and the complexity of new technologies for farmers' understanding and use were also influential in their decision making (Rogers, 1995).

Moreover, several economic factors such as profitability (Griliches, 1957), market price of the product (Feder et al., 1985), availability of capital (Salter, 1960), and availability of labor (Binswanger and Rosenzweig, 1986) serve as major influences in the adoption of a new technology.

For farm characteristics, factors such as farm size (Globerman, 1975), ownership, and tenure are suggested to influence the adoption decisions of farmers. For household characteristics, age both has a positive effect (Shields, 1993) and a negative effect (Roger, 1995) to farmers' decision. Meanwhile, factors such as the level of education, technology, and experience of farmers have positive impacts on decision making (Spenser and Byerlee, 1976). Geographical distance wherein the new technology is being developed also has certain effects on adoption outcomes.

Samuel (2017) studies factors affecting adoption and degree of adoption of soybean in Ilu-Ababora Zone in southwestern Ethiopia by considering household characteristics (age of household head, education level, number of labors), characteristics of production areas (farm size, distance to market, distance to cooperatives, distance to local extension station), attendance in training sessions, and use of soy food at home. The results of the econometric model indicated that attendance on training on soybean production and use of soy food at home affects adoption positively and significantly. However, the age of the household head and distance to main market have negative and equally significant impacts.

Chuchird et al. (2017) assessed the influencing factors of adoption of three agricultural irrigation technologies in Thailand including demographic factors (gender, age, educational level, experience, labor of households), socio-economic factors (land holding size, farm income), location (upstream or downstream, distance to irrigation systems), policy institutions (skills training courses, water use association membership, information access, degree of participation), and the level of perceived fairness of the water allocation.

Based on the overview of the above studies in relation to the CSAq systems in Thanh Hoa Province, household characteristics (age of household head, gender, aquaculture experience, education level, number of available labors, farmers' knowledge about CSAq) and aquaculture characteristics (farm size, cooperatives or not, aquaculture revenue) may affect the adoption decision of farmers.

Currently, communication of climate-smart agriculture and CSAq through mass media systems is still limited all over Vietnam. This is specifically evident in Thanh Hoa Province. The farmers can access technical information mainly through local extension system. Therefore, technical information access from aquaculture extension services are considered to affect adoption decision more than others. Regarding perceived benefits, according to Quyen et al. (2017), expected benefits of CSAq system are economic efficiency, food security, reduced feed conversion ratio (FCR), and improved environmental ponds. In addition, market price of CSAq products may affect farmers' decisions for adoption. The analytical framework is shown below:

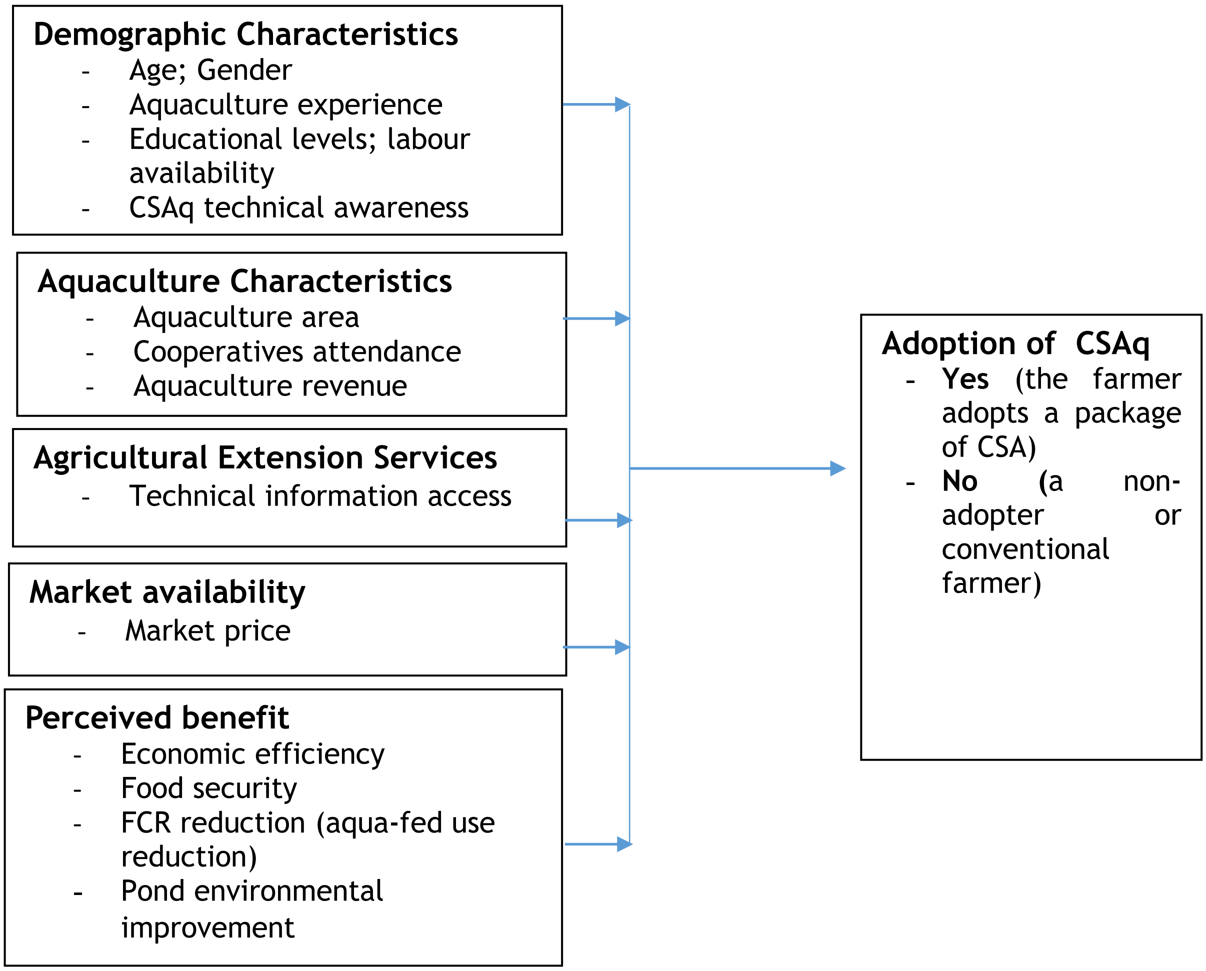

Figure 2. Analytical framework for factors affecting CSAq adoption decision of farmers

Econometric model

Probit model

The decision on CSAq adoption of farmers is considered a dichotomous dependent variable measured as "yes" or "no". According to Aldrich (1987), the most popular econometric models in estimating the effects of such decision are linear probability models (LPMs), logit models, and probit models. However, LPM was not chosen for this study because of two limitations: that the estimated probabilities from LPM do not necessarily lie in the bound of 0 and 1 and also because LPM assumes that the probability of a positive response increases linearly with the level of the explanatory variable, which is counterintuitive (Domadar, 2011). On the other hand, logit and probit models generally give similar results; so in practice there is no compelling reason to choose one over the other and the choice between them depends on the availability of software and the ease of interpretation (Domadar, 2011).

Samuel (2017) used a logit model to evaluate factors affecting soybean adoption decisions in Ethiopia through consideration of above mentioned variables. Meanwhile, Chuchird (2017) applied a probit model to determine the factors impacting irrigation techniques decision of households.

Because there is no significant difference of results between the two logit and probit models, but rather basing on the availability of software and the ease of interpretation, in this study, the probit model is used to measure the determinants of CSAq adoption decision of farmers.

The probit model assesses the impact of an independent variable on probability of dichotomous dependent variable. The dependent variable gets a value of 1 if farmers make the CSAq adoption decision. Otherwise, the variable is given a 0 value. The probability of CSAq adoption decision is shown with the following equation:

$$P_i = \frac{e^{\beta_0+\beta_i X_i}}{1+e^{\beta_0+\beta_i X_i}}$$

In this equation, X_i refers to independent variables that are factors affecting to CSAq adoption decision of farmers; β_i are slope parameters. The associated latent variables are expressed as $F(X_i, \beta') = \beta_i' X_i + u_i$, in which u_i are error term and unobserved; hence, the $F(X_i, \beta')$ is also unobservable.

$$F(X_i, \beta') = \begin{Bmatrix} 0 \ if \ F(X_i, \beta') < 0, \ \text{Farmers don't adopt CSAq} \\ 1 \ if \ F(X_i, \beta') > 0, \ \text{Farmers adopt CSAq} \end{Bmatrix}$$

This means that the form of Probit is expressed as follows: P_i= E(Y_i=1/X_i) = F($\beta_i X_i$) $= \beta_i X_i + u_i$, in which P_i is probability when Yi = 1 (the farmer adopts a package of CSA); E is conditional expected probability; F is Cumulative Distribution Function:

$$\mathrm{F}(X_i\beta) = \int_{-\infty}^{Xi\beta} \frac{1}{\sqrt{2\pi}} e^{-(Xi\beta)^2/2}$$

The β_i parameters cannot be expressed by any direct formula of the F and X value in the observed data. In this model, the marginal effect of an independent variable is used to estimate the probability change P(Y=1/X=x) when a unit change of an independent variable occurs. It is expressed as follows:

$$\frac{\partial p}{\partial X} = f(X_i\beta)\widehat{\beta_i}$$

Description of independent variables

Factors affecting CSAq adoption decision of farmers in the above analytical framework are described in detail in table 1:

Table 1. Desciption of the independent variables

Name	Code	Description	Expected effects
Age of respondent	age	Age (years)	+/-
Gender of respondent	sex	1=male, 0=female	+/-
Aquaculture experience of respondent	exp	Number of aquaculture experiences (years)	+/-
Education	edu1 edu2 edu3	Non educated (1=yes, 0=no) Primary (1=yes, 0=no) Secondary(1=yes, 0=no)	+/- +/- +/-
Labors of households	labour	Number of labors (person)	+/-
CSAq technical knowledge	tech	Households has known adequate technical of CSAq (1=agree, 0=disagree)	+
Pond area	area	Area of cultured pond (ha)	+/-
Cooperative member	cooper	1=yes, 0=no	+/-
Aquaculture revenue	TR	Total revenue from aquaculture (million dong)	+/-
Information access	info_access	Households has received adequate CSAq information from extension system (1=agree, 0=disagree)	+
Market price	price_inc	CSAq products has higher price (1=agree, 0=disagree)	+
Economic efficiency	eco_effi	CSAq system brings high economic efficiency (1=agree, 0=disagree)	+
Food security ensuring	food_ensur	CSAq system helps to ensure food security for households and communities (1=agree,	+

		0=disagree)	
Aqua-fed use (FCR) reduction	FCR_red	CSAq system helps to decrease used pellet feed for farming (1=agree, 0=disagree)	+
Waste reduction	waste_red	CSAq system helps to decrease organic waste in pond bed (1=agree, 0=disagree)	+

Results and discussion

Characteristics of coastal aquaculture households in Thanh Hoa Province

The main characteristics of aquaculture farmers in Thanh Hoa Province are described in Table 2, which shows that respondent age, labour of household, pond area of aquaculture, and aquaculture revenue are not different between CSAq adoption and non-CSAq (at 5% significant level). However, there is significant difference between those two in terms of aquaculture experience at 10% significant level. CSAq adopters have more aquaculture experiences (mean=16.74) than non-adopters with their average 14.35 years.

Table 2. Characteristics of coastal aquaculture households in Thanh Hoa Province

Items	CSAq adoption *(n=88)*	Non-CSAq adoption *(n=94)*	On average *(n=182)*	Sig. (*t-test*)
Age of respondent	50.16	49.31	49.72	0.53
Labors of households	4.77	4.34	4.55	0.07
Aquaculture experience of respondent	16.74	14.35	15.51	0.05
Pond area	2.48	3.15	2.83	0.15
Aquaculture revenue	216.86	226.82	222.0	0.76

Source: Field survey in 2018

Correlation between factors in the model

Before assessing the effects of these factors to CSAq adoption decision, Pearson correlation coefficients among independent variables and between independent variables and dependent variables were computed. The results showed that correlation between independent variables such as household characteristics (age, gender, aquaculture experience, education, number of labors), aquaculture characteristics (pond area, cooperatives member, aquaculture revenue), food security, aqua-fed use reduction and dependent variables are quite low with Pearson coefficient from 0.01 to 0.28. However, the remaining variables (including CSAq technical knowledge, information access, market price, economic efficiency, waste reduction) and the dependent variables have closer correlation with Pearson coefficients from above 0.3 to above 0.8 (Table 3). In addition, there are weak correlations among independent variables with Pearson coefficients less than 0.3, which indicates that it is possible to confirm that Multicollinearity does not exist.

Table 3. Pearson correlation coefficients between variables in the model

Variables	y1	age	sex	exp	edu1	edu2	edu3	labour	tech	area	cooper	tr	inf_access	price_inc	eco_effi	food_sur	FCR_red	waste_red
y1	1																	
age	0.05	1																
sex	-0.18	-0.21	1															
exp	0.14	0.39	-0.12	1														
edu1	0.01	-0.04	0.23	-0.03	1													
edu2	-0.09	0.04	0.04	0.01	-0.08	1												
edu3	0.01	0.13	-0.01	0.02	-0.22	-0.37	1											
labour	0.14	-0.06	-0.07	0.08	-0.02	0.00	-0.04	1										
tech	0.39	0.14	-0.17	0.04	-0.10	-0.08	-0.01	0.05	1									
area	-0.11	0.03	-0.06	0.14	-0.05	-0.10	0.00	0.11	-0.11	1								
cooper	0.28	0.14	-0.26	0.15	-0.14	-0.12	-0.01	0.13	0.31	-0.11	1							
tr	-0.02	0.06	-0.29	0.14	-0.06	-0.10	-0.03	0.14	0.01	0.56	-0.01	1						
inf_access	0.48	0.02	-0.17	0.25	-0.10	-0.05	-0.04	0.04	0.29	-0.10	0.34	0.10	1					
price_inc	0.55	0.17	-0.17	0.12	0.00	-0.13	0.09	-0.03	0.26	0.03	0.24	0.09	0.31	1				

eco_effi	0.77	0.04	-0.18	0.12	-0.07	-0.10	0.06	0.13	0.29	-0.06	0.24	-0.05	0.25	0.29	1			
food_sur	-0.13	-0.02	-0.03	0.06	-0.09	0.05	0.01	-0.05	-0.09	0.18	-0.07	0.04	-0.02	-0.24	-0.17	1		
FCR_red	0.21	-0.03	-0.07	0.04	0.05	-0.06	-0.08	0.07	0.11	-0.01	0.09	0.05	0.13	0.22	0.29	-0.19	1	
waste_red	0.35	-0.09	0.07	-0.02	0.05	0.08	0.01	0.03	0.26	-0.28	0.05	-0.11	0.19	0.18	0.24	-0.25	0.26	1

Source: Field survey in 2018

Based on the above correlation analysis, independent variables will be used in the probit model, which include age of respondent (age), gender of respondent (sex), aquaculture experience of respondent (exp), education (edu1, edu2, edu3), labors of households (labour), technical knowledge on CSAq (tech), pond area (area), cooperative member (cooper), aquaculture revenue (tr), information access (inf_access), market price (price_inc), economic efficiency (eco_effi), food security ensuring (food_ensur), aqua-fed use reduction (FCR_red), waste reduction (waste_red).

Results

The results using Stata are presented in Table 4. Chi square index equals 174.99 with P-value = 0.00 and Log likehood = -38.56. These results show that the model is appropriate and the independent variables have impact on CSAq adoption decision. Pseudo R^2= 0.6941 shows that 69.41% of farmer's CSAq adoption behavior can be explained by independent variables in the model.

Table 4. Results of the probit model assessing impact of factors on CSAq adoption decision

Name	Code	β parameters	Marginal effect (*dy/dx*)
Age of respondent	**Age**	-0.008	-0.001
Gender of respondent	**sex**	-0.302	-0.035
Aquaculture experience of respondent	**exp**	-0.004	-0.000
Education	**edu1**	1.453	0.169
	edu2	0.146	0.017
	edu3	-0.093	-0.011
Labors of households	**labour**	0.177*	0.021*
CSAq technical knowledge	**tech**	0.542	0.063
Pond area	**area**	-0.080	-0.009
Cooperative member	**cooper**	0.084	0.010
Aquaculture revenue	**tr**	-0.000	-0.000
Information access	**inf_access**	1.278**	0.149**
Market price	**price_inc**	1.379**	0.160**
Economic efficiency	**eco_effi**	2.598**	0.302**
Food security ensuring	**food_sur**	0.888*	0.103*

Aqua-feed reduction	**FCR_red**	-0.533	-0.062
Waste reduction	**waste_red**	1.032**	0.120**
Intercept		-3,537	
Pro > Chi^2	0.000		
Pseudo R^2	0.6941		
LR Chi^2	174.99		
Log likehood	-38.56		

**; **: implies significance at 10% and 5% level* *Source: Field survey in 2018*

The result shows that there are six key influencing factors having statistically significant effect on CSAq adoption decision in Thanh Hoa Province at 10% and 5% level. Specifically, these 6 factors have a positive influence to adopting probability, including a number of household labours, CSAq information access, market price of CSAq products, economic efficiency, ensuring food security, and waste reduction. Among these factors, there are three main determinants with the most impact on farmer decision: economic efficiency, market price and CSAq information access from aquaculture extension system.

Specifically, when the farmers' behavior changes from economic inefficiency to economic efficiency in adopting CSAq, decision probability increases by 30.2% on average. This is consistent with other studies stating that economic efficiency is the first factor considered in the farmers' decision-making. This can then be related to aquaculture being an important household livelihood in NCC. When they perceive that CSAq model could bring more revenues than the normal, their adoption probability will increase. This entails that improving the economic efficiency of CSAq is crucial in expanding the farmers' application.

Likewise, when farmers perceive that the market price of CSAq products is higher than the price of non-CSAq products, their adoption decision probability increases by 16.0%. When farmers can easily access CSAq information from the aquaculture extension system, adopting decision probability increases by 14.9%.

In relation to pond environment improvement, when farmers perceive that this model helps reduce the amount of organic waste in pond bed, decision probability increases by 12.0% on average. Furthermore, when farmers see that CSAq ensures their daily meals and eventually food security for their households, probability of adopting decision increases to 10.3% on average. In this regard, when the household adds one more labor, adoption probability will increase by 2.1%. When farmers decide on CSAq adoption, they will consider spending more labour on buying seeds, stocking and harvesting than conventional practise.

Discussion

Based on these results, to widen CSAq adoption into the North Central Coast, the following activities can be implemented:

1. Support to improve economic efficiency of the CSAq model (such as reducing costs, increasing feed efficiency, disease management, etc.);
2. Develop training programs, increase awareness, or organize study tours for coastal people on CSAq, focusing on introducing CSAq economic efficiency and environmental improvement;
3. Promote communication from relevant stakeholders including aquaculture extension systems, radio stations, television programs, brochure, dialogue and farmers' associations to improve the quality of information channels, increase accessibility of coastal farmers to CSAq and climate change adaptive aquaculture techniques;
4. Develop linkages among actors in CSAq value chain, which helps to improve CSAq product quality and price; maintain a stable ouput market for CSAq products and create steady conditions for CSAq scaling out through aquaculture cooperative establish.

Conclusion

Despite the importance of aquaculture in the socioeconomic development of NCC and the entire Thanh Hoa Province, the local coastal aquaculture sector is facing many risks because of the negative impacts of climate change. A new approach is then necessary to minimize such risks. CSAq is considered a potential solution in brackishwater aquaculture. A CSAq model was tested in Thanh Hoa Province from 2015-2017, which brought initially positive economic and environmental results. However, after the testing, the number of CSAq adoption households still remained limited.

The study found six key factors with positive influence on the CSAq adoption behavior among farmers: the household’s labour availability (numbers of household’s members); economic efficiency of CSAq farming system; pond environment improvement (decrease of organic waste in pond bed); higher price of CSAq products; access to technical information; and food security for the farming household. The three factors with the most impact on farmer decisions are economic efficiency, market price, and CSAq information access from aquaculture extension systems.

Based on these results, the economic efficiency of CSA must be improved to successfully promote the outscaling of CSAq in the North Central Coast of Vietnam. This can be achieved through cost reduction, feed use efficiency, CSAq value chain linkage establishment and disease management among others. To raise the awareness of coastal farmers about CSAq, the Vietnam government must improve its communication with relevant stakeholders and develop feasible supportive policies to advocate for CSAq scaling out.

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Annex: Pictures of survey activities and integrated aquaculture/CSAq system in Thanh Hoa province (in NCC region)

Interview the head of Hoang Phong Aquaculture Service Cooperative in Thanh Hoa province

Interview local farmer in Thanh Hoa province

Ready for group discussion with local aquaculture community in Thanh Hoa province

Local extension officer checks farmed shrimp for local farmers in Thanh Hoa province.

Harvesting farmed tilapia in Hoang Phong Aquaculture Cooperative in Thanh Hoa province

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