FACILITATING AQUACULTURE PRODUCTIVITY IN VIETNAM: PERSPECTIVES FROM AWARENESS OF HOUSEHOLDS AND THE CLIMATE CHANGE

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Abstract

Aquaculture is promoted for food security and poverty alleviation in developing countries. The objective of this study was to identify key potential factors that affect aquaculture productivity among smallholder farmers in South Central region of Vietnam. The field survey was randomly conducted at two sites with 200 respondents, using a pre-tested interview schedule. OLS econometric method was used to address determinants in contributing to successful aquaculture sector in Vietnam. Empirical estimates of striking hurdle revealed that awareness of aquaculture households; climate change, capital investment and environmental sustainability in the region are statistically significant variables that affect the probability of performance and productivity of aquaculture. Implications for policies to improve productivity of aquaculture in the region towards green growth and sustainability were also highlighted.

Key words: *Aquaculture productivity, climate change, awareness, Vietnam*

1. BACKGROUND

A continuous and dramatic growth in global aquaculture production has been observed since the 1950s, and is expected to continue in the new millennium (Karim, M., Keus, H. J., Ullah, M. H., Kassam, L., Phillips, M., & Beveridge, M, 2016). Aquaculture does not only bridge the supply and demand gap of aquatic food, but also generates employment, and alleviates poverty (Irz et al., 2007; Subasinghe et al., 2009; Srinivasan et al., 2010; Soto-Zarazúa et al., 2011). The increased knowledge and awareness of human nutritional requirements for healthy growth have focused increasing attention on the unique roles of seafood farming/production/aquaculture in human development (FAO, 2007; FAO, 2008). Agricultural research plays a significant role in the improvement of agricultural productivity via the introduction of technologies geared towards increasing yields (Alene et al., 2009) and aquaculture currently is the fastest growing agricultural industry and continue to grow to meet the world's increasing demand for seafood as seafood is the most traded food, as 39% is actually traded and 77% is exposed to trade competition (Asche, F.et al, 2015; Tveteras et al., 2012). It is clear that productivity growth and innovation at all levels in enhanced technologies and the supply chain contribute to successful aquaculture industries.

A plenty of research has conducted focusing on productivity evaluation of different crops, livestock on the fisheries as well as aquaculture sector (Paraguas, F. J., & Dey, M. 2006), adopting the total factor productivity (TFP) framework to measure the productivity. Ultimately, we are interested in gains in total factor productivity (TFP), as a major determinant of long-term price trends - most productivity increases have been ultimately passed on to consumers through lower prices. TFP is a measure of output in relation to the aggregate of all inputs, whereby changes in agricultural production are decomposed into the component relating to changes in inputs, and a change due to productivity growth. Hence, the central to most of these TFP studies are (i) evaluation of the performance of the production system and sustainability of the growth process, (ii) assessment of the quantitative effects over time of agricultural research, extension, irrigation, and other public and private investments on productivity, and (iii) examination of factors accounting to TFP growth and estimation of the marginal economic rates of return to public and private investments (Paraguas, F. J et al, 2006). At some extent, the 'behavioural approach' in rural studies focusing on attitudes and awareness of the fisher/farmer/households' on the productivity and its determinants from their aspects also plays

important to address and capture the differentials towards farmer response to policy initiatives in the industry.

With the potential and advantages of aquaculture, especially producing aquatic organisms inhabiting salty and brackish water, provinces and cities in the South Central Vietnam have recently focused on the development of the aquaculture industry. According to Pillay (1990), the concept of 'aquaculture' refers to all forms of farming aquatic plants and animals in fresh, brackish, and salt water environments. Aquaculture is the farming of fish, crustaceans, and aquatic plants and other aquatic organisms, applying the techniques of the breeding process to improve productivity for individual or collective ownership (Food and Agriculture Organization of the United Nations [FAO], 2008). In 2014, this area used for aquaculture in the region reached approximately 27 thousand hectares; the total aquaculture output reached 86,364 tonnes (in which shrimp farming accounted for 51%, corresponding to 56,459 tonnes of output). Aquaculture production in the region during the 2005–2014 period was consistently higher than the national average yield, increasing from 2,495 tonne/hectare in 2005 (compared to the national yield of 1,552 tonne/hectare) to 4,095 tonne/hectare in 2014 (when the nationwide yield reached 3,239 tonne/hectare). Aquaculture has created jobs, raised income, and reduced poverty in the region.

Despite the benefits, some disadvantages remain in the region's aquaculture industry. In particular, research 'Green Agriculture Development in the South Central Region of Vietnam' conducted by Institute of Social Sciences of the Central Region, Vietnam using a two-stage survey in 2015, from April 1 to April 14 and from May 11 to May 15, to investigate performance of 211 shrimp farming households indicated that the region's aquaculture industry was encountering problems with environmental pollution, use of inorganic chemicals not prescribed, and a lack of systems to treat water before and after production. The failure to treat water before its use and then after its release into common irrigation systems or rivers polluted the water resources, causing disease outbreaks and losses in aquaculture productivity. The other concern is that climate change is expected to have a wide-ranging effect on the agriculture and aquaculture with the fact that Vietnam is identified to be in the top 5 developing nations which are impressionably susceptible to the impacts of climate change (Yusuf and Francisco, 2010; Bates et al., 2008).

Additionally, studies of industry performance and higher productivity are important, the performance of an industry is the sum of the individual farmer's awareness/ behavior and natural environment. In particular, aquaculture productivity will not only depend upon advances in the genetics and nutrition, and improvements in culture system design and management but also highlights the importance of knowledge and awareness from fisheries/farmers on its practices and performance management models with respect to how biophysical factors influence the production productivity (Aasheim et al., 2011; Nielsen, 2011), including how this is influenced by climate change (Bruckner, M.,2012;.Hermansen & Heen, 2012). In fact, the challenges and factors affecting aquaculture productivity posed by climate change require a holistic and strategic approach to linking knowledge with action. Key elements of this are greater interactions between decision-makers and researchers in all sectors, greater collaboration among climate, agriculture, aquaculture and consideration of interdependencies across whole food systems and landscapes.

A plenty of research on determinants of aquaculture productivity mentioned different perspectives. For example, according to Paraguas, F. J., & Dey, M (2006), increasing productivity output depended on five factors: the quality of labour, the changing demand for goods and services, the changing capital structure, economic structure changes, and the application of science and technology processes. Furthermore, research on analysis of factors affecting the development of aquaculture and their use in forecasting production" (The FAO, 2008) showed that aquaculture practices based on traditional methods have a large impact on the environment; these problems include overdosing inorganic chemicals and destroying biodiversity with used bottles and other rubbish discarded next to ponds. On the other hand, if households are aware of environmental problems, the pressure of pollution on aquaculture will be reduced, thus increasing productivity and reducing the risk of diseases. In some cases, the lack of knowledge about aquaculture skills, including the methods for protecting and maintaining water supplies and aquaculture tanks, leads to negative impacts on productivity.

Understanding the different aspects and influencing impacts on household productivity is important if investments into aquaculture development are to be effective (Barman et al., 2002). Therefore, taking account for these discussions, the research aims to investigate factors affecting aquaculture productivity in southern central Vietnam context and understand the influence of associated factors such as awareness of training on aquaculture productivity and profitability and the climate change to provide valuable insights for future investments in aquaculture development initiatives.

2. METHODS

The conceptual framework for this research was based on research questions, gaps from literature on the determinants of aquaculture productivity. In particular, in order to have a solid conceptual framework, the preliminary stage to explore the validity of variables from the interviews and pilot ones conducted with farmers/fisher households was adopted in southern central Vietnam context. Factors affecting aquaculture productivity were evaluated using multiple regression analysis. 24 items from 10 variables were used in the model including Education, Labour, Total Capital Investment, Production Area, Safety of the Aquaculture Environment, Household Awareness, Years of Experience, Climate change, Participation in Cooperatives; Inorganic Chemicals use. The conceptual framework was explicitly expressed as below:

A multiple regression equation was used to measure the factors affecting the productivity of coastal aquaculture in the South Central region below:

Ln AP (Aquaculture productivity) = $\alpha 0 + \alpha 1\ Ln$ Ed (Education) + $\alpha 2\ Ln\ \alpha 3\ Ln$ (Labour) + $\alpha 3\ Ln$ CI (Total Capital Investment) + $\alpha 4\ Ln$ YE (Years of Experience) + $\alpha 5\ Ln$ HA(Household Awareness) + $\alpha 6\ Ln$ PA(Production Area) + $\alpha 7\ Ln$ CC(Climate change) + $\alpha 8\ Ln($PC (Participation in Cooperatives) + $\alpha 9\ Ln$ SAE (Safety of the Aquaculture Environment) + $\alpha 10\ Ln$ IC(Inorganic Chemicals) + ei.

Preliminary surveys and pilot are used to adjust the measuring scale and complete the questionnaire. The field survey was conducted using structured questionnaires to households in the South Central provinces at Núi Thành and Thăng Bình in Quang Nam Province and Huyện Ninh Hải, huyện Ninh Phước in Ninh Thuan; The samples were selected using the random method. The valid sample was 200 respondents from households.

The collected data were analysed using descriptive statistical analysis. Following the analysis, the data were filtered and used in factor analysis incorporating the ordinary least squares (OLS) method to determine the scale of the factors affecting the productivity of coastal aquaculture in the South Central region.

3. RESULTS AND DISCUSSIONS

After testing the scale variables using the Cronbach's alpha method and exploratory factor analysis, the variable *use of inorganic chemicals* was excluded from the model, having a Cronbach's alpha coefficient < 0.6. This is consistent with research by Phillips (2000); inorganic chemicals do not affect aquaculture productivity. In the correlation analysis, the variable labour was excluded from the model because this variable has no significant correlation with the examined *aquaculture productivity* (Sig. 2-tailed = 0.891> 0.5).

Table 1. Model summary

Model	Correlation coefficient R multiples	R^2	Edited R^2	Standard error of the estimation	Durbin-Watson
1	.755[a]	.677	.606	.80999	1.784

Ln AP (Aquaculture productivity) = $\alpha 0 + \alpha 1\ Ln$ Ed (Education) + $\alpha 2\ Ln\ \alpha 3\ Ln$ (Labour) + $\alpha 3\ Ln$ CI (Total Capital Investment) + $\alpha 4\ Ln$ YE (Years of Experience) + $\alpha 5\ Ln$ HA(Household Awareness) + $\alpha 6\ Ln$ PA(Production Area) + $\alpha 7\ Ln$ CC(Climate change) + $\alpha 8\ Ln($PC (Participation in Cooperatives) + $\alpha 9\ Ln$ SAE (Safety of the Aquaculture Environment) + $\alpha 10\ Ln$ IC(Inorganic Chemicals) + ei.

Table 2. Coefficient[b]

Model	Uncoded B coefficient		Coded Coefficient	Value (t)	Significance level (Sig.)	Multi-line inspection	
	B	Standard error	Beta			Acceptability	VIF
(Constant)	-1.143	0.552		-2.070	0.040		
Ln Ed	0.165	0.137	0.079	1.200	0.232	0.916	1.091
LnCI	0.317***	0.056	0.450	5.662	0.000	0.630	1.588
LnPA	0.059	0.067	0.059	0.876	0.382	0.871	1.148
Ln YE	0.056	0.076	0.053	0.735	0.463	0.751	1.331
LnHA	0.490**	0.251	0.129	1.947	0.042	0.911	1.098
LnSAE	0.323***	0.128	0.162	2.523	0.008	0.967	1.034
LnCC	-0.237**	0.118	0.135	-2.007	0.046	0.887	1.128
LnPC	-0.266	0.181	-0.101	-1.467	0.144	0.848	1.179

a. Independent Variable: (Constant), LnEL, LnCI, LnPA, LnEX, LnHA, LnAE, LnND, LnAE.

b. Dependent Variable: LnAP.

Note: *,**, and *** correspond to the levels of statistical significance 10%, 5%, and 1%, respectively.

Multivariate regression results using the OLS method show that the coefficient of determination R^2 is 0.677. This means that the value of the independent variables explained 67.7% of the variability of aquaculture productivity. The T value has statistical value. The inspection of multi-collinearity VIF coefficients <2 show no multi-collinearity phenomenon.

Table 3. Analysis of variance (ANOVA) of the factor model, analysing key factors affecting coastal aquaculture productivity of the South Central region.

Source	Total squared	Degrees of freedom	Square means	F	Sig.
Between groups (ESS)	52.068	5	10.414	5.554	0.000[a]
Individual group (RSS)	367.464	196	1.875		
Sum (TSS)	419.532	201			

a. The independent variables: (Constant), LnEL, LnCI, LnPA, LnEX, LnHA, LnSAE, LnCC, LnAE.

Using the method of testing the P-value of F, we investigated the value of Sig. F in ANOVA Table 3: Sig. F = 0.000. Because, in Table 3, Sig. F = 0.000 < α = 0.05, we rejected H_0 and accepted H_1. This means that the regression model selected was appropriate.

Hypothesis testing was conducted according to the regression results, the variables with no statistical significance were eliminated, and generalized regression factors affecting aquaculture productivity with a significance level of 5% and a confidence level of 95 percent were obtained as follows:

$$\boldsymbol{LnNS = -1.143 + 0.317LnCI + 0.49LnHA + 0.323LnSAE – 0.237LnCC + ei}$$

The regression results confirm the role of these factors: the total investment, the awareness of farmers, low levels of environmental pollution, and the impact of climate change natural disasters on the yield of aquaculture in the South Central provinces. The remaining factors were excluded from the model because there is no correlation with the dependent variable or are of low reliability.

The signs of the regression coefficients are consistent with the initial prediction of the model and maintain compliance with the principles of technical analysis and statistics. According to the above results, the productivity of aquaculture in this model was found to be affected by new factors such as the environment and awareness among aquaculture households — these are the factors that affect the long-term sustainability of productivity.

The factor with the strongest impact on *aquaculture productivity* in the South Central provinces is *household awareness* (+49%). Household awareness on training skills, land & water protection, disease prevention could impact other factors affecting farming productivity. The results of this study highlight the key role played by farmer training in achieving these outcomes. Training has a stronger effect on productivity than others alone to increase. Aquaculture practices based on traditional methods have a large impact on the environment; these problems include overdosing inorganic chemicals and destroying biodiversity with used bottles and other rubbish discarded next to ponds. Awareness on aquaculture practices at the household level has been shown to be an important factor in implementing and managing productivity (Karim et al., 2014). Training on agricultural technology has also showed significant positive impacts on agricultural production in Uganda and is likely to have a stronger impact for those who are already more productive (Pender et al., 2004; Turongruang and Demaine, 2002). Additionally, if households are aware of environmental problems, the pressure of pollution on aquaculture will be reduced, thus increasing productivity and reducing the risk of diseases. When the awareness of households increases, it can enable farmers study and transfer new technologies, voluntarily participate in training courses, and apply suitable aquaculture models or new production methods to bring greater efficiency and less environmental pollution. Farmers that are aware of best practices can also spread the skills, experience, and advanced manufacturing methods to other aquaculture households around the community to improve the environment, thereby reducing the

spread of disease and increasing productivity. Actually, Climate Change + Inappropriate Agricultural Practices = Environmental Disaster

The second-most influential factor is *the safety of aquaculture environment*, with a coefficient of +32.3%. Aquaculture production is strongly influenced by the water environment, the soil environment, the exchange of oxygen, and the availability of food for aquatic plants and animals. Therefore, environmental factors directly affect the health and survival of aquatic animals and plants in the aquaculture habitat. If the aquaculture environment is safe, the risk of disease will be reduced and animals and plants will be in good health and gain weight rapidly, contributing to a stable harvest yield. In contrast, water pollution will create conditions for harmful bacteria and viruses, triggering diseases among farmed animals and plants, including liver disease, pancreatic necrosis, opaque body, or yellow head disease. These are often difficult to treat once incurred, causing death among aquaculture animals and plants on a large scale. Productivity deteriorates, and sometimes the entire crop is lost. In some South Central provinces, most water pollution affecting aquaculture is due to:

(1) water sources that are unsafe; no water treatment system operates before and after planting;

(2) aquaculture areas being created spontaneously and without planning, which increases the pressure on the environment and creates sources of water pollution;

(3) indiscriminate use of toxic antibiotics and chemicals such as chlorine, pesticides, or chloramphenicol. These pollute the water sources and then are discharged into the environment—and this water is collected by households into the lake to feed the next crop; and

(4) chemical packaging and other garbage that litters farming area shorelines, triggering water pollution.

Depending on the extent of these poor practices, the risks in aquaculture are different in each region. Some are stable and obtain high yields (e.g. Phuoc Dinh district, NinhThuan); some suffer continuous losses due to severe pollution, lowering income and causing debt (e.g. Son Tinh district, QuangNgai province). On the other hand, Sustainability of aquaculture supply/productivity is predicated on the environmental sustainability of production, the state and function of ecosystems that support production, and the economic and social sustainability of production and processing methods and supply chains. Risks to environmental sustainability come from the direct and indirect impacts of production systems and supply chains on the environment (Jennings, S., Stentiford, G. D., Leocadio, A. M., Jeffery, K. R., Metcalfe, J. D., Katsiadaki, I., & Peeler, E. J, 2016). Environmental sustainability has direct and indirect impacts to the production systems and productivity of aquaculture.

The third-most influential factor is total capital investment capital investments (provincial capital investment, capital investment of owners), with the coefficient +31.7%. Investment capital is an input factor with an important role in aquaculture. With increases in capital, households will have access to improved machinery, new processes such as Biofloc6 technology, VietGAP7 standards, and good seeds, all of which improve aquaculture environment safety, reduce disease, and increase productivity. Capital investments, over the medium and long terms that depend on entrepreneurial strategies present a particularly unpredictable nature of risks to aquaculture (Sgroi et al., 2014; Volpato, 2000; Schotter, 1995).

Results showed that factors that impact negatively on the productivity of aquaculture include impact of climate change in terms of natural disasters, with the coefficient –23.7%. Climate change is predicted to have a range of serious consequences, some of which will have impact over the longer term, like spread of disease and sea level rise, while some have immediately obvious impacts, such as intense rain and flooding (Gallina, V., Torresan, S., Critto, A., Sperotto, A., Glade, T., & Marcomini, A, 2016). Typically, four main categories of natural disaster are distinguished (Bruckner, M., 2012): geophysical (such as earthquakes and volcanoes), meteorological (storms), hydrological (such as floods) and climatological (such as drought, heat waves and cold waves). In this research, the South Central provinces are affected by natural disaster such as droughts, tropical storms, and floods more than other areas of the country. Aquaculture facilities – which operate seasonally with two to three

crops per year, 2.5 to 3 months per season – are close to rivers and the sea. Disasters such as tropical storms and floods can easily break down embankments, destroying ponds. Even a sudden change in pH of the water environment (e.g. acid rain) can kill shrimp and fish. Moreover, in recent years, the phenomenon of desertification is increasingly obvious in provinces like Ninh Thuan and Binh Thuan, causing lake water levels to suddenly drop and severe water shortages in the dry months. This leads to stagnation in aquaculture activities because of inadequate safe water sources. Climate change reduces the efficiency of producing commodities in coastal waters. Similar recent research on aquaculture in Bangladesh survey revealed that different climatic variables including flood, drought, rainfall variation and temperature fluctuation have had adverse effects on pond-fish culture (Ahmed, N., & Diana, J. S.,2016).These climatic variables have detrimental effects on the ecosystem of ponds and thus affect survival, growth and production of fish. Changes in climatic variables have adverse effects on aquaculture reproduction, grow-out operation, parasite infestation and disease occurrence (Savo, V., Morton, C., & Lepofsky, D, 2017).

Thus, econometric models using the factor analysis method and the OLS results showed that aquaculture productivity in the South Central provinces is mainly driven by these factors: total capital investment, household awareness, the safety of the aquaculture environment, and the impact of climate change/natural disasters. The impact of each factor in the model has a high coefficient of productivity; thus, improving aquaculture productivity in a sustainable way in the future should focus on implementing policies that affect these factors.

4. POLICY IMPLICATIONS

Result findings have been significant in contributing addressing and proposing policies that enables the aquaculture productivity and the development of green agriculture in the South Central region.

4.1 Capital support policies

The significant role of the government's policies that should extend an unsecured credit program to aquaculture farmers with loans for investment in aquaculture development, upgrading machinery, and the application of new processes. At present, investments in the development of aquaculture in South Central households mainly come from real estate mortgage loans provided by commercial banks. Loans from local policy banks often have little value, are available only to poor households, and are not enough to invest in an environmental safety model with adequate machinery and water treatment facilities. According to Decree 41/2010/ND-CP on Credit Policies for Agricultural and Rural Development, even if a household can fully meet the requirements of conditionality, the banks can only lend for a short term of 6 months, while it takes from 5 to 7 years for the invested money to be fully depreciated. Therefore, the government should dismantle obstacles that prevent farmers from having access to capital at preferential interest rates.

Another way to create favourable conditions is for enterprises to cooperate with aquaculture farmers from input to output through contracts that aim to build aquaculture development models with high standards and high yields. Farmers will have to commit to seed application, cleanliness standards, and selling harvested products to businesses according to contractual commitments. This will strengthen the value chain in a sustainable way, reducing the risks in aquaculture.

4.2 Policies to raise awareness of farm households

For a policy or a development model to work in accordance with guidelines, farmers must be trained to ensure that the entire population is aware of the benefits of that policy or that new model. Awareness aims at training skills, land & water protection, disease prevention that could impact other factors affecting farming productivity and this enables citizens to contribute to the policy's development. In particular, the first step toward creating sustainability in the development of the

aquaculture industry is therefore, to raise awareness of sustainable agricultural practices of a green, clean, and safe environment.

To raise awareness among aquaculture farmers, the government and local stakeholders need to improve training courses and training models for farming that bring high yields in a safe environment. Currently, training in aquaculture is carried out mostly by businesses that sell seed, chemicals, and other necessities. Their aim is to integrate their products (i.e. chemical agents, antibiotics, or probiotics) into the current method of farming to increase sales. To turn aquaculture practices in the right direction, local inspection bodies should be established to manage the operation of these training programs. Also, the government should increase the budget for extension work to educate aquaculture farmers.

4.3 Environmental protection policy

To address pollution problems, the authors offer the following policy recommendations:

(1) Authorities should plan irrigation systems that channel the water supply and drainage in a reasonable manner for short distances to farming areas, using safe water, and encourage aquaculture households to reserve one to two acres of land for an aquaculture pond to be used before and after breeding. In Thuan Nam district, Ninh Thuan, the government has invested more than 2 billion VND for an irrigation canal to supply water for the farming region. The canal was built and completed from years 2013. However, it has not been put to use because it is too far from the farming areas and no funds are set aside for maintaining it, leading to signs of deterioration—cracks, landslides, and sea sand cover. Government authorities should carefully consider cost and usability before investing in irrigation facilities.

(2) Local authorities should encourage aquaculture farmers to cultivate in areas that are already planned for this use, close to water sources and away from residential areas. Ponds that are not covered in the plan and are ineffective in production should be relocated to reduce pressure on the environment. Provisions should be made for vocational guidance and different jobs for those who engage in inefficient aquaculture businesses.

(3) Regulatory authorities should monitor more effectively the volume of antibiotics and toxic chemicals used in aquaculture.

(4) Gathering points (e.g. thick bags or garbage bins) for wastes such as antibiotics bottles should be made available on pond shores. Campaigns to clean up canals and aquaculture water sources are also needed.

4.4 Disaster-defence policy

Local authorities need to continuously integrate disaster prevention guidelines in the training program that is given two to three times each year by the extension centre for aquaculture farmers. Disaster prevention and climate change elimination are not only the tasks of the local government, but also farmers. The solution is guiding the aquaculture farmers to build dikes using proper methods, helping to ensure the safety of tanks against the effects of acid rain, floods, and droughts. One suggestion to help curb the rate of high risk inherent in the aquaculture industry due to natural disasters is to implement insurance schemes for local capital. This has been successfully piloted in Ben Tre, SocTrang, TraVinh, Bac Lieu, and Ca Mau by decision No. 315/QD-TTg on the pilot implementation of the agricultural insurance period 2011–2013. According to a survey of this pilot, 75% of households are willing to participate in an insurance scheme if one is available in their local area.

Overall, the results of this paper indicate the important potential aquaculture roles and influencing factors in the development of the aquaculture sector in Southern central Vietnam and suggest that further investments into homestead aquaculture provide a potentially important pathway to increased income generation, food security and poverty reduction in Vietnam.

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