The Factors Affecting Chemical Use in Aquaculture in the Central Coast Region of Vietnam

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Abstract

Using the econometric approach of Ordinary Least Squares (OLS), this study has identified the key factors affecting the use of inorganic chemicals in coastal aquaculture in South Central Vietnam. These factors included the amount of training and support policies for extensions and the level of participation by cooperative groups in aquaculture activities. The greatest impact factor to the use of inorganic chemicals in aquaculture was 'Fishery Extension Support Policy Group' by -0.747. This value means that if the remaining variables do not change and this variable increased by 1 unit (meaning that an increasing in support including capital, machinery, the consultants , seed for aquaculture farmers), the use of chemicals in aquaculture sector will decrease 0.747 units. In contrast, the level of "participation in cooperative groups" in aquaculture in Vietnam was directly proportional, extended to the use of inorganic chemicals with a coefficient by 0.706. This result suggests that households participating in "cooperative group" aquaculture will tend to use more 70.6% inorganic chemicals than non-participating households. This suggests the need for corresponding policies to limit the usage of inorganic chemicals and antibiotics in aquaculture in the region in order to achieve the development goals of green growth and sustainability.

2

1. Introduction

The South Central region (SCR) of Vietnam is an area with a high degree of potential in the aquaculture sector relative to the country as a whole. With a total farming area of approximately 27,000 hectares, the region's total output of aquaculture products reached 86,364 tonne im 2015 (the prawn farming area accounted for 51% of the total area farmed, producing 56,459 tonne). Aquaculture production in the region during the 2005–2014 period was consistently higher than the national average yield, increasing from 2,495 tonne/ha in 2005 (compared to the national yield of 1,552 tonne/ha) to 4,095 tonne/ha in 2014 (when the nationwide yield reached 3,239 tonne/ha). Given the extra income generated by aquaculture work, proponents argue that the sector produces high socio-economic gains and contributes to the economic development of coastal rural areas, thereby creating jobs, raising revenue, and contributing to poverty reduction in the coastal areas of the SCR.

Despite its achievements, the aquaculture sector in the SCR still confronts a variety of drawbacks, namely, (1) environmental pollution issues caused by the overuse of antibiotics and inorganic chemicals, (2) instability in aquaculture output due to antibiotic redundancy in the harvested product and (3) the unpredictability and large scale of disease occurrence. The primary reason for these problems can be found in a common aquaculture practice: the use of inorganic chemicals from the time of ponding to the time of harvest. Many chemicals are used, including lime, chlorine, iodine, saphonine, microbial enzymes, rice bran, molasses and dolomite lime. The use of antibiotics such as flophenicol and oxytetraciline is also growing. The significant concern with such practices is that many of the aquaculturists administering these antibiotics do not possess a sufficient understanding of these drugs to be able to prevent and treat diseases on a large scale. Moreover, they tend to administer higher doses of the antibiotics than is allowed. These poor practices result in increased antibiotic resistance, the entry of antibiotic residue into animal farms, environmental pollution and effects on the health of consumers.

Faced with this urgent situation, it is necessary to study the factors that influence aquaculturists in their decision to use inorganic chemicals in coastal areas of the SCR. With these factors in mind, it will be possible to determine the best measures by which the use of drugs and other inorganic chemicals can be restricted, thereby facilitating the development of green aquaculture towards the objective of environmental protection.

2. Theoretical and analytical frameworks

Pillay (1990) defined aquaculture as a concept that refers to all forms of cultivation of aquatic plants and animals in fresh, brackish and salty waters. According to the Food and Agriculture Organisation of the United Nations (FAO, 2008), aquaculture is a form of rearing aquatic species, including fish, molluscs, crustaceans and aquatic plants, that applies certain breeding techniques in order to improve productivity owned individually or collectively.

2.1 Factors affecting the use of inorganic chemicals in aquaculture in the South Central region

The researchers engaged in a thorough review of the extant literature on the use of inorganic chemicals in aquaculture in order to determine the factors that have been found to exert the most influence on chemical use, it includes seven factors:

Educational background: Educational background negatively impacts the amount of antibiotics used in aquaculture (Serrano, 2005). The farmers with higher educational attainment easily adapt to new technologies, and they tend to be more aware of environmental pollution and the negative effects on animal health caused by antibiotics. Therefore, these farmers will tend to use a lower volume of toxic antibiotics compared to people with less education.

The price of inorganic chemicals: According to the law of supply and demand, when prices rise, market demand will decrease. Compared to the value of the products harvested in aquaculture, the prices for antibiotics and other inorganic chemicals are

4

relatively high. Therefore, an increase in the selling prices of inorganic chemicals can be expected to lead to more limited dosing in aquaculture (Mariyono and Baattharai, 2009).

Farmers' awareness of the production process: According to a study by Pathak et al. (2000), in general, if farmers are unaware of aquaculture processes and scientific standards, they will not be able to understand the nature or aetiology of the diseases affecting their stock, and they may more easily fall prey to errant advice when epidemic diseases occur. This leads to the indiscriminate use of toxic chemicals, which can cause great damage to the environment and strengthen antibiotic resistance in aquatic animals and plants.

Farmers' awareness of the harmful effects of inorganic chemicals: Due to the massive environmental and health-related consequences caused by antibiotic use, regulations on the use of antibiotics are very strict, and only a few types are allowed for use in aquaculture. Many countries have defined maximum residue limits (MRL) for aquaculture products. Therefore, it is important to require that aquaculturists be aware of the harmful effects caused by antibiotics and other inorganic chemicals. This may help reduce the use of drugs and keep doses within permitted levels (Romero and Navarrete, 2012).

Training policies for extensions: According to Pathak et al. (2000), in order to restrict the use of hazardous chemicals and antibiotics in aquaculture, farmers should be instilled with a high degree of awareness about their practices. To this end, measures should be taken by local authorities or centres specialised in the field of aquaculture. In these centres, scientific tests are conducted to improve the rearing process of aquaculture products in the region. These centres also support experts in guiding the application of new technical processes and in restricting the use of hazardous substances during rearing. Efforts to reduce the use of antibiotics will be more effective when aquaculture operations are placed under the strict supervision of the central agencies managing

5

aquaculture developments. For example, the facilities that provide agricultural materials should only sell antibiotics to those who have a prescription issued by the local veterinary department (Grave et al., 1999, 1996; Lillehaug et al., 2003; Markestad and Grave, 1997; Sorum, 2006, 2000).

Support policies for extensions: In addition to supporting training in aquaculture using scientific methods, government agencies need to implement strict regulations on chemical use in order to reduce the risk of abuse. Moreover, there is a pressing need to build diagnostic laboratories in areas focusing on aquaculture development and to support the use of preventive and curative medicines that are safe for the environment. Furthermore, the government needs to create favourable conditions, funding support and facilities so that aquaculture businesses are better prepared to improve practices, apply new farming models, operate in an environmentally safe manner and remain within the allowed levels of antibiotic residue (Pathak et al., 2000).

Cooperative groups: According to Serrano (2005), communication and community relations between households within a given area play an important role in influencing aquaculturists' behaviour in administering antibiotics. Specifically, households engaged in aquaculture activities tend to communicate, learn from experiences and follow the antibiotic dosing behaviour of the majority of households within their community. In coastal areas of the SCR, the cooperative group is a unique model that creates links between aquaculturists. When participating in cooperative groups, members have the opportunity to share their experiences and knowledge of rearing in order to help each other during the feeding process. This can affect both the behaviour of the farmers and the level of antibiotic dosing used in the region.

Based on the above analytical framework and survey results detailing the current situation of aquaculture in the SCR, Figure 1 displays the factors affecting the use of inorganic chemicals in aquaculture.
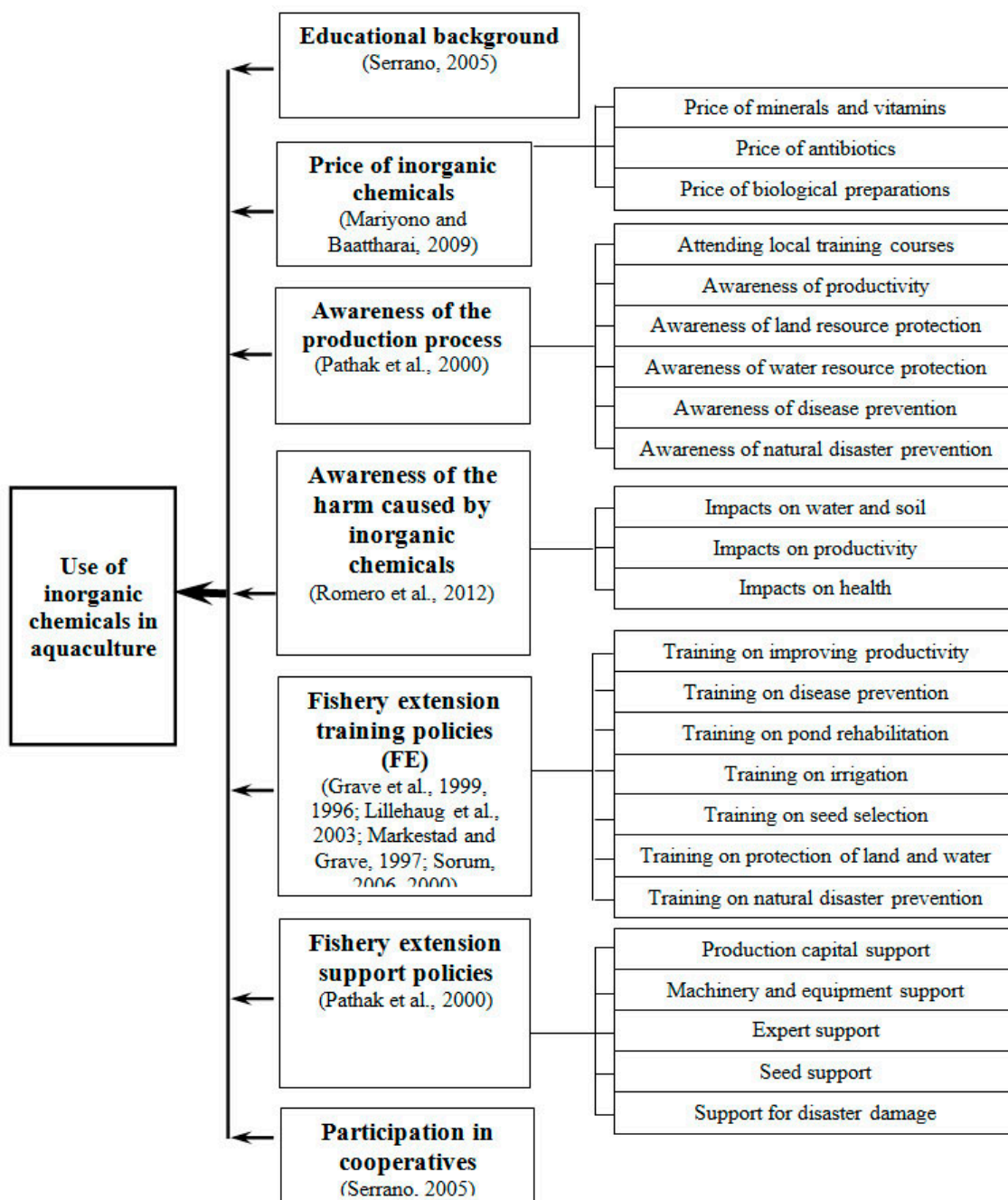
6

Figure 1: Researchers' model of the factors affecting the use of inorganic chemicals in coastal aquaculture in the South Central region.

2.2 Establishing the research model: *explanation of variables*

The dependent variable

The dependent variable is the amount of inorganic chemicals used by an aquaculture site. The various inorganic chemicals used in coastal aquaculture can be divided into the following main groups: antibiotics, vitamins, minerals, food additives, disinfectants, lime fertiliser, ferrous drugs and anaesthetics (Pathak et al., 2000). Each type of chemical has its own specific characteristics and effects, and each serves a different function during the rearing process.

However, abuses in the use of some inorganic chemicals can lead to adverse impacts on the health of farmed animals and consumers, as well as on the environment. Currently, the list of banned or restricted chemicals in aquaculture in many countries includes: antibiotics, stimulating additives in foods with a high metal content, disinfectants and products for polymerisation (Les Burridge et al., 2008).

The objective of this study was to identify the factors that limit the use of inorganic chemicals. Thus, the dependent variable, the amount of inorganic chemical use, was determined by the following formula:

The amount of inorganic chemical used (kg / rod) [3] = Average weight of antibiotics + Average weight of additives + Average weight of disinfectants

The researchers used the following inclusive criteria in determining the formula's inputs:

1) In determining the average weight of additives, the researchers included the additives that adversely affect animal health and the farming environment, such as hormones, minerals and vitamins, which are mixed into feeds that have a high metal content (Les Burridge et al., 2008).

2) The average weight of antibiotics included the class of drugs commonly used in aquaculture, such as oxytetraciline, flophenicol, chloramphenicol, sulfonamides, fluoroquinolones and erythromycin (Charles & Benbrook, 2002).

8

3) The average weight of disinfectant included popular chemicals such as chlorine
    and formaldehyde (Pathak et al., 2000).

The independent variables

A multiple regression equation was used to measure the factors that affect the decision to
use inorganic chemicals in aquaculture. The scales are specified in table 1. The following
production function was used:

$$Ln(SDHC) = \beta_0 + \beta_1 Ln(HV) + \beta_2 Ln(G) + \beta_3 Ln(NT) + \beta_4 Ln(TD)$$
$$+ \beta_5 Ln(KNHL) + \beta_6 Ln(KNHT) + \beta_7 Ln(THT) + e_i$$

Table 1: The dependent variable and the independent variables included in the model,
along with their symbols and measurement units.

Number	Symbol	Variable definition	Unit	Expectations marked *
	SDHC	Dependent variable: chemical use	kg / rod / farming season	
I	HV	Education level	Encoded from 0 to 16 with 0: preschool and 16: Postgraduate	-
II	G	Price of inorganic chemicals		-
	G1	Price of minerals, vitamins	Likert scale with 1: very low and 5: very high	
	G2	Price of antibiotics	Likert scale with 1: very low and 5: very high	
	G3	Price of probiotics	Likert scale with 1: very low and 5: very high	
III	NT	Awareness of the production process		-
	NT1	Attending local training courses	Likert scale with 1: absolutely not, and 5: lot	
	NT2	Awareness of productivity	Likert scale with 1: absolutely not, and 5: lot	

9

	NT3	Awareness of land resource protection	Likert scale with 1: absolutely not, and 5: lot	
	NT4	Awareness of water resource protection	Likert scale with 1: absolutely not, and 5: lot	
	NT5	Awareness of disease prevention	Likert scale with 1: absolutely not, and 5: lot	
	NT6	Awareness of natural disaster prevention	Likert scale with 1: absolutely not, and 5: lot	
IV	TD	Awareness of the harm caused by inorganic chemicals		-
	TD1	Impacts on water and soil	Likert scale with 1: absolutely not, and 5: lot	
	TD2	Impacts on productivity	Likert scale with 1: absolutely not, and 5: lot	
	TD3	Impacts on health	Likert scale with 1: absolutely not, and 5: lot	
V	KNHL	Fishery extension training policies		+/-
	KN1	Training on improving productivity	Likert scale with 1: absolutely not, and 5: lot	
	KN2	Training on disease prevention	Likert scale with 1: absolutely not, and 5: lot	
	KN3	Training on pond rehabilitation	Likert scale with 1: absolutely not, and 5: lot	
	KN4	Training on irrigation	Likert scale with 1: absolutely not, and 5: lot	
	KN5	Training on seed selection	Likert scale with 1: absolutely not, and 5: lot	
	KN6	Training on protection of land and water	Likert scale with 1: absolutely not, and 5: lot	
	KN7	Training on natural disaster prevention	Likert scale with 1: absolutely not, and 5: lot	
VI	KNHT	Fishery extension support policies		+/-

10

	KN8	Production capital support	Likert scale with 1: absolutely not, and 5: lot	
	KN9	Machinery and equipment support	Likert scale with 1: absolutely not, and 5: lot	
	KN10	Expert support	Likert scale with 1: absolutely not, and 5: lot	
	KN11	Seed support	Likert scale with 1: absolutely not, and 5: lot	
	KN12	Support for natural disaster damage	Likert scale with 1: absolutely not, and 5: lot	
VII	THT	Participation in cooperatives	Likert scale with 1: absolutely not, and 5: lot	+/-

* + Expected to increase; - Expected to drop

3. Research methods and data

3.1 Research methodology

Quantitative research of the aquaculture model including shrimp, fish, along with the integration of green agriculture criteria, was used to design an initial research model, as well as the scale of the variables and content for the survey. The Delphi method and a preliminary survey were used to adjust the scale and aid in the design of the questionnaires. The official survey questionnaire was distributed in representative provinces in the SCR. The sample was randomly selected.

The collected data were analysed using descriptive statistical analysis. Following analysis, the data were filtered and used in factor analysis using the Ordinary Least Squares (OLS) method to determine the scale of the factors affecting the use of inorganic chemicals among aquaculture households.

3.2 Description of data

This study used data from the National Foundation for Science and Technology Development (NAFOSTED) project on "Green agriculture development in the South Central region". Randomised sampling method took place in two provinces with high aquaculture production, Quang Nam and Ninh Thuan. Total of 214 sample was randomly

11

selected based on the characteristics of participating aquaculture production. Data were collected by questionnaire surveys. Due to the distance of geography and time of a survey made up phase is 15 days, the survey was distributed in two phases; phase 1 took place in April 2015 in Quang Nam, and phase 2 took place in May 2015 in Ninh Thuan. The sample size was 214 households. Three of the questionnaires were found to be invalid; thus, the data from the 211 valid questionnaires were analysed. According to Bollen (1989), the recommended sample size for each observed variable is five samples. This study included 25 observed variables, so the minimum sample size should be 125. This study's sample size of 211 is, therefore, more than adequate to satisfy Bollen's criteria.

4. Results and discussion

4.1 Results of the regression analysis

Assessing the variable scale using Cronbach's alpha, the variable *awareness of the harm caused by inorganic chemicals* was removed because its Cronbach's alpha coefficient was 0.254 < 0.6.

In Exploratory Factor Analysis (EFA) factor analysis, the coefficient Kaiser-Meyer-Olkin (KMO) = 0.823 > 0.5 → The factor analysis of the data was relevant to the study.

In correlation analysis, the variable *education level* had Sig. (2-tailed) = 0.822 > 0.5, and the variable *Fishery extension support for natural disaster damage* had Sig. (2-tailed) = 0.982 > 0.5. This means that the variation in these two independent variables did not affect the outcome of the dependent variable, *chemical use*, and as such they were removed from the model.

The results of the regression models for the five remaining independent variables are shown in Table 2.

12

Table 2: Results from the regression of factors affecting the use of chemicals in the aquaculture model

Model summary[b]

Model	Multiple correlation coefficient R	R^2	Revised R^2	Standard error of the estimate	Durbin–Watson
1	0.652[a]	0.524	0.502	1.36924	1.881

Coefficient[b]

Model	Unstandardised coefficients B		Standardised coefficients	Value (t)	Level of significance (Sig.)	Multicollinearity inspection	
	B	Standard error	Beta			Acceptability	VIF
(Constant)	2.800***	1.027		2.727	0.007		
LnG	-0.271	0.505	-0.039	-0.536	0.593	0.845	1.183
LnNT	0.113	0.426	0.018	0.264	0.792	0.939	1.065
LnKNHL	-0.498***	0.175	-0.201	-2.837	0.005	0.888	1.126
LnKNHT	-0.747***	0.287	-0.196	-2.605	0.010	0.789	1.267
LnTHT	0.706**	0.322	0.151	2.194	0.029	0.946	1.057

a. The independent variables: (Constant), LnTHT, LnKNHL, LnG, LnNT, LnKNHT

b. The dependent variable: LnSDHC

The logistic regression in table 2 showed a coefficient of determination (R^2) value of 0.524. This shows that the level of variation in the use of inorganic chemicals in aquaculture due to the independent variables is 52.4%. This value indicates statistical significance. The multicollinearity inspection showed that the Variance Inflation Factor coefficients (VIF) < 2, so the variables did show multicollinearity.

When testing the hypothesis with a significance level of 5% and a confidence level of 95%, the variables that affected the level of inorganic chemical use in aquaculture were *fishery extension training policies* (-0.498), *fishery extension support policies* (-0.747) and *participation in cooperatives* (0.706).

13

4.2 Inspection of the existence of the model using ANOVA

Table 3: Analysis of Variance (ANOVA) of the factor model: impacts on inorganic chemical use in aquaculture

ANOVA[b]

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), LnTHT, LnHV, LnKNHL, LnG, LnNT, LnKNHT

b. The dependent variable: LnSDHC

To test the existence of a logistic regression model, we built the hypothesis–alternative hypothesis pair:

Hypothesis H0: $R^2 = 0$ (regression model mismatched)

Alternative hypothesis H1: $R^2 \neq 0$ (regression model fit the level of significance $\alpha = 5\%$)

Using the method of testing the P-value of F, we investigated the value of Sig. F in the ANOVA table 3: Sig. F = 0.000.

Because, in table 3 Sig. F = 0.000 < α = 0.05, we rejected H0 and accepted H1. This means that the regression model selected was appropriate.

4.3 Comments and discussion

According to the regression results described above, after testing the hypotheses and excluding statistically insignificant variables, the generalised regression function of the factors that affect inorganic chemical use in aquaculture was obtained through the following function, using a significance level of 5% and a confidence level of 95%:

14

LnSDHC = 2.8 – 0.498LnKNHL – 0.706LnTHT + 0.747LnKNHT + ei

The regression results confirm the influential role of the following factors in determining inorganic chemical use in aquaculture in the South Central provinces: fishery extension training policies, fishery extension support policies, and the level of participation in cooperatives. The remaining factors were excluded from the model because they had no correlation with the dependent variable or showed low reliability. Regression coefficients are consistent with the initial prediction of the model and ensure the model's compliance with statistical principles and techniques.

The variable that had the greatest impact on the use of inorganic chemicals in aquaculture was *fishery extension support policies*, which had a correlation value of -0.747. This value means that if all other variables remained unchanged, with every one unit of increase in the support offered by fishery extensions to aquaculture farmers (e.g., through capital support, machinery, expert advice and seeds), the use of chemicals decreased by 0.747 units. It was found that in the South Central provinces, support for capital investment, seeds, materials and expert advice is usually only provided to aquaculture farmers upon the implementation of programmes and projects funded by foreign organisations or government sources. To receive this assistance, aquaculture households must often commit to applying the advanced models advocated by the project and are placed under the supervision of the implementing organisations. The majority of these models use fewer inorganic chemicals and antibiotics than the more intensive traditional farming model.

Therefore, the survey data from the households that received assistance from the local government showed less use of inorganic chemicals than the data from the households that did not receive support. For example, in the cage polyculture model of ecological farming used by Vung Ro and Song Cau lakes as part of a project in Phu Yen funded by the World Bank (WB), the monitoring results of the provincial fishery extension centres showed that though households received support for using this model in the short term, the profit rate was no greater than for the model of intensive Vannamei shrimp farming.

15

Moreover, in the medium and long term, the stability level of the cage polyculture model is much higher, and the rate of risk due to disease is lower because of the model's improvements to the aquatic environment. The root cause of this result is that these ecological models have focused more on developing environmentally beneficial practices for farming processes, such as the proper handling of water inputs and outputs, limits in the use of chemicals and inspection for animal disease. Ecological farming models also encourage the incorporation of multiple aquatic species (such as tiger prawn, rabbit fish, mullet, milkfish and grouper) into the same aquaculture system in order to reduce the pressure on the environment, handle waste products using natural methods and limit the occurrence of diseases. However, upon the completion of such a project, the participating households were no longer under the supervision of the implementing organisations and received no further support. At that point, many farming households returned to intensive, high-density farming, using antibiotics and other inorganic chemicals once again with the expectation of higher profits. This proves that people's awareness of environmental safety remains low and that people find environmental considerations to be less important than the farm's overall yield.

The variable that was found to have had the second greatest impact was *participation in cooperative groups*, which had a correlation value of 0.706. This value means that if the other variables remained constant, with every one unit of increase in household engagement in cooperative groups (with such participation assigned a value of 1), the use of chemicals increased by 0.706 units. A cooperative group is a typical model found in the aquaculture industry, similar to the cooperative model found in crop farming and animal husbandry. Cooperative group members tend to learn from each other's experiences, and most share similar farming models and techniques. In the SCR provinces investigated in this study, the households participating in cooperative groups tended to use more antibiotics and inorganic chemicals than did the non-participating households. This can be explained by the fact that the level of environmental awareness among aquaculture households remains low, and as such, their level of inorganic chemical use is high. Cooperative members tend to display a sort of 'herd mentality': If an epidemic occurs, the first line of treatment is to use antibiotics to treat the problem in

16

the same way the surrounding households do. This, in effect, leads to widespread pollution. This is similar to the situation that can be found in the Son Tinh District of Quang Ngai Province. In 2000, the district had four cooperative groups. However, because the group members abused the use of antibiotics and inorganic chemicals in their farming processes, widespread environmental pollution occurred, leading to livestock losses in the ensuing years and the eventual cessation in aquaculture production in the district.

The variable that had the third greatest impact was the *fishery extension support policies*, which had a value of -0.498. This means that if the other variables did not change, with every unit of increase in the level of training for aquaculture households carried out by fishery extensions (including extension programmes designed for facilitating improved productivity, disease prevention, pond treatment and rehabilitation, extension of irrigation works, seed selection, the protection of land and water resources and disaster prevention), the use of chemicals will decrease by 0.498 units. With the regression results, we can see that the amount of inorganic chemical use in aquaculture in the South Central provinces depends mainly on the guidance provided by local training courses (offered by the businesses and chemical companies that trade and sell chemicals as well as extension centres in the local area) and on the communication taking place among neighbouring aquaculture households participating in cooperative groups. The trend in using inorganic chemicals in aquaculture results from a herd mentality, shared mainly among farmers following the guidance of those who sell chemicals on the free market. This dependence can be both beneficial and harmful to the goal of transitioning towards green aquaculture processes. One disadvantage of this state of affairs is that the use of inorganic chemicals in aquaculture currently depends highly on the chemical companies, the training programmes that educate farmers on the use of chemicals and the businesses that cooperate with local organisations. While the goal of these agencies and enterprises is to sell as many chemicals (including antibiotics, vitamins and probiotics) as possible, if the local extension centres cannot control and manage these training programmes, aquaculture households may not receive correct information about the harmful effects and allowed doses of the inorganic chemicals they use. This can, in turn, lead to large-

17

scale pollution of land and water resources, outcomes that lie in opposition to the objectives of green agriculture development. The local extension centres must have the coordination mechanisms necessary to manage the operation of these chemical companies sold on the free market in order to strengthen the implementation of training programmes to educate farmers about inorganic chemicals. This will lead to the general improvement of land and water resources, and the use of inorganic substances in aquaculture will be likely to decrease further.

The regression results also show that the farmers' level of education and awareness about the harmful effects of inorganic chemicals had only a small effect on the decision to use chemicals in their ponds. The price of inorganic chemicals is not a large factor in deciding a household's use of chemicals (-0.271). Although the price of chemicals in some of the investigated areas is considered to be very high compared to other expenses, when a farm's prawn ponds become diseased, the household still purchases and uses antibiotics, as they are guided to do in training courses held by chemical companies two to three times per year.

5. Policy recommendations

Based on the results of this study, the authors propose a number of policy recommendations in order to influence the factors affecting the use of inorganic chemicals in aquaculture in a way that limits their use in accordance with the objectives of green agriculture development in the SCR.

5.1 Recommendations for the government

The government should increase its investment in programmes that support and encourage the establishment of ecological aquaculture models, aquaculture models that are in line with the Vietnamese Good Agriculture Practices (VietGAP)[4] and Biofloc[5] technology. These are eco-friendly aquaculture models that require limited use of antibiotics and other toxic inorganic chemicals, thereby resulting in clean and safe products for users. In addition, the government needs to increase budget allocations towards the areas that have the greatest potential for large-scale aquaculture development.

18

This would lead to the development of specialised agricultural areas with high-tech applications.

The government should also issue sanctions and penalties for households, aquaculture businesses and producers that use antibiotics and inorganic chemicals included in Agency Ministry of Agriculture and Rural Development's (2014) Official List of Banned and Restricted Drugs, Chemicals and Antibiotics. At the same time, there should be regulations on the functions and specific tasks of organisations in charge of the inspection, control and sanctioning of businesses that are in violation of permitted antibiotic and chemical use. These organisations should be associated from government ministries to local departments and subordinate units in each province. The responsibility for inspection, control and sanctioning should only be assigned to one specific unit that has the authority to act against violations (e.g., in the prohibited trade and use of chemicals and other agricultural materials). This centralisation of authority will prevent the shirking of duties that often takes place when management responsibilities are assigned to multiple organisations at the same time.

The government should also extend the unsecured credit programme for aquaculture farmers so that they may obtain funding for investments in aquaculture development, equipment upgrades and the application of innovative and advanced aquaculture procedures that adhere to eco-friendly agricultural standards. In addition, Prime Minister (2010) issued regulations such as the Credit Policies for Agricultural and Rural Development should be revised to loosen the rules on loan conditions so that households are able to implement environmentally friendly models while maintaining effective business practices with reduced losses over the long term.

5.2 Recommendations for local authorities and extension centres

In order to cope with limited budget resources in aquaculture development at the provincial and municipal levels, extension centres should increase support to farms to help provide financing, materials, seeds and expert advice, instead of wasting the budget through activities that advocate the use of inorganic chemicals in aquaculture. Local

19

authorities should facilitate cooperation between enterprises and aquaculture farmers and encourage these enterprises to invest in farms in order to help develop farming models in accordance with the standards of clean and high production yields. Under such a programme, farmers would affirm their intent to use the seeds and clean farming processes provided to them by the enterprises and promise to sell the harvested products to the investing enterprises in accordance with their contractual agreement. This will enhance the value chain from production to product supply in way that is sustainable, environmentally safe and beneficial for all parties.

Local authorities should also specify units responsible for inspecting and managing the trade in agricultural materials and households' chemical use. These units should be in charge of strictly managing the trading of harmful chemicals, antibiotics and other agricultural materials. The units should require that these parties sell toxic inorganic chemicals or antibiotics only to those buyers who have valid prescriptions with names and doses prescribed by the local veterinary department. They should also ensure that chemicals are not sold in higher quantities than that which is allowed for a given farm. Currently, there is a complex and unregulated web of enterprises and chemical companies engaging in the trade of agricultural materials, inorganic chemicals and antibiotics. These entities organise several classes every year for farmers, with the aim of advertising to these farmers in order to sell their agricultural supplies. Meanwhile, according to the survey results, the levels of education and awareness of aquaculture processes among farmers were quite low, and this greatly affects the amount of inorganic chemicals used. The farmers tend merely to follow the advice of their acquaintances in the cooperative group or to use the amount that enterprises have recommended in their promotional classes. This has created apertures in the trading activities, sales and use of harmful chemicals and antibiotics in the aquaculture sector.

The roles and responsibilities of local extension centres should be strengthened. Extension centre staff need to more clearly define their roles and responsibilities and carry out regular field surveys at prawn farming areas in the province to understand the situation and interact with farmers. During the distribution of surveys in several

20

provinces, including Ninh Thuan, and the in-depth interviews with prawn farmers in Ninh Phuoc district and Thuan Nam district, some farmers reported that even though they are situated in areas planned for aquaculture development, no visits had been made by the local extension workers to guide the households in applying farming models. Meanwhile, the businesses that sell feed and chemicals organise classes for farmers in order to sell their products. According to the recommendations of the majority of farmers, the work of the local extension centres needs to be improved in practical terms, through strengthening training for farmers, helping farmers gain access to new technologies and, most critically, enforcing regulations on the use of antibiotics and other inorganic chemicals.

5.3 For aquaculture farmers

Aquaculture farmers who want to maintain benefits in the long term need to voluntarily raise their own awareness about the environmental protection of water and land resources and about aquaculture models that promote biological and ecological diversity. Pollution is the main cause of ecological damage and is a major risk factor of the traditional intensive farming model. The damage and diseases brought about by environmental pollution stem primarily from improper and unscientific cultivation methods and the abuse of inorganic chemicals. Therefore, aquaculture farmers need to raise their awareness of proper practices and learn to correct unscientific farming habits if they wish to derive the maximum benefit from their farms over the long term. Moreover, the use of inorganic chemicals and antibiotics should be influenced not only by tradition but also by the advice of veterinary department and local extension workers.

As they gain in awareness of environmentally friendly farming practices, farmers need to organise the collection of waste products such as antibiotic bottles and in hollow concrete cylinders in front of the gates of farming ponds and collect garbage on a routine basis. In this way, they can help facilitate proper waste collection. At the same time, farmers and cooperative group members in the region need to be encouraged to come together to organise events to clean canals and aquaculture water resources, promote general hygiene and help spread positive actions throughout the aquaculture community.

Without the necessary funds and conditions to invest in the VietGAP aquaculture model, if farmers want to take into account their own long-term benefits, they need to reduce the stocking densities of the traditional intensive farming model or switch to an ecological farming model that combines fish and prawns. If farmers seek to obtain immediate results, the productivity of high-density intensive prawn farming appears to be a better option, but in the long term, faced with increasing environmental pollution and unpredictable epidemics, these farmers are placing themselves at high risk. Therefore, the transition to an ecological farming model that combines, for example, prawns with rabbit fish, mullet, milkfish and grouper, can help to create long-term stability, lowered risk and reduced pressure on the environment. This will help decrease the occurrence of disease, resulting in a greatly reduced need for antibiotics and other inorganic chemicals in aquaculture practices.

Notes

[1] The South Central region focused upon in this study includes the provinces of Da Nang, Quang Nam, Quang Ngai, Binh Dinh, Phu Yen, Khanh Hoa, Ninh Thuan and Binh Thuan.

[2] These results are compiled from data from the General Statistics Office of Vietnam.

[3] Rod unit in Viet Nam = 500 m^2

[4] Biofloc technology is an aquaculture technology based on Biofloc particles. This technology can be used as feed for prawn and fish.

[5] The Vietnamese Good Agricultural Practices (VietGAP) refer to a set of best practices for agricultural production in Vietnam.

22

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23

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24

Public interest statement

Vietnam has enormous potential for aquaculture and aquaculture has currently strongly developed. However, the outcomes of this development are water and soil pollution, low value agricultural products due to abuse of inorganic chemicals and antibiotics. This research investigates the current situation of using inorganic chemicals and antibiotics in aquaculture in Southern Central Region in Viet Nam. Based on the result, we recommend some solutions in order to reduce the amount of inorganic chemicals and antibiotics used in aquaculture. The identified factors include extension services, supporting policies and participation level in "cooperative groups" in aquaculture. Therefore, the Vietnamese government should focus on improve extension services and propaganda in aquaculture so as to reach the aim of green growth and sustainable development.

About the author

My name is Bui Duc Hung, a Ph.D in economics, and currently I am working as the director of Social Sciences Institution for The Central Region in Viet Nam. I specialize in growth model in economics, restructuring the economy, regional economic development, regional links, green growth and sustainable development.

This article is based on the research "Green agriculture development in Southern Central Provinces". I have carried out since 2015. My reseach was a project of VietNam goverment which funded by National Foundation for Science and Technology Development. This research has both theoretical and practice meanings because it mentions the contents of the green growth theories and green growth in agriculture in a relatively systematic way and contributing to implement Vietnam's national strategy for green growth, especially green growth in agriculture in the South Central provinces.

26