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Dependency on aquaculture in northern Vietnam

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Abstract Whilst a range of studies address the aquaculture livelihoods in southern Vietnam's Mekong Delta, the role of aquaculture in northern Vietnam remains less described. We, therefore, conducted interviews with 199 households in the two northern provinces Quang Ninh and Nghe An in 2014 to analyse the dependence on aquaculture in these two provinces and amongst farmers specializing in shrimp and freshwater fish production, respectively. Further, we tested the ability of different socio-economic variables to explain the observed reliance on aquaculture using an ANCOVA model. The study identifies a substantial reliance on aquaculture of farmers in the study area with at least half of their income generated by aquaculture. Our analyses highlight that the educational background of farmers explain their engagement in aquaculture better than how long they have worked as aquaculture farmers. Freshwater fish farmers were shown to rely less on aquaculture as it is only generating a supplementary income. In contrast, the shrimp farmers are not only those having the highest share of income from aquaculture but also earning their main living from aquaculture. The fact that both shrimp and fish farmers have diverse sources of income shows the unstable or risky nature of aquaculture livelihoods in the study area. Our findings suggest that policies promoting aquaculture should focus on training of farmers whilst acknowledging that a diverse income portfolio increases livelihood resilience to external shocks such as extreme weather events, diseases and fluctuating market prices.

Keywords Aquaculture · Freshwater fish farming · Livelihood · Shrimp farming · Vietnam

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Introduction

Vietnam has a high potential for aquaculture development, given its large coastal areas and abundance of ponds, rivers, lakes and estuaries (Phuong et al. 2006). Rapid growth in aquaculture has boosted the country's economy through exported products as well as improving farmers' livelihoods in rural areas (Duc 2009; Lan 2013; Lan 2009). However, the Integrated Agriculture-Aquaculture (IAA) system (Kluts et al. 2012; Phong et al. 2007) is a "climate-dependent" activity with high risk of failure from natural hazards (Adger 1999; Allison et al. 2009). This is highly typical for Vietnam, because evidence demonstrates that disasters like typhoons, floods and droughts have increased in frequency and intensity during the past 20 years (Adger 1999; Dasgupta et al. 2009; Schad et al. 2012).

Most of the existing literature on Vietnam's aquaculture livelihoods (Ha and van Dijk 2013; Joffre and Schmitt 2010; Loc et al. 2010), however, focuses on the Mekong Delta, southern Vietnam—the dominant and widespread aquaculture area of the country. Recently, the scope of aquaculture development in northern Vietnam and the Red River Delta has received attention.

In the Red River Delta, IAA is dominated by small-scale farming activity at household level. In this system, the grass carp, rohu, common carp, the *Nile tilapia*, the filter feeders silver carp and bighead carp are the main cultured species (Pucher et al. 2014; Pucher et al. 2013). Pucher et al. (2014) found that by using semi-intensive rather than traditional management in freshwater fish farming, the farmers could increase fish yields and income, but this change requires knowledge of investments, feed/fertilizer ingredients and feeding technique. In addition to traditional freshwater fish farming, shrimp farming is also an important aquaculture system in northern Vietnam. Whilst the freshwater fish farming is mainly for home consumption and for local market, shrimp farming is a market-oriented product and for regional and international market (Lan 2013). Black-tiger shrimp (*Penaeus monodon*) and white-legged shrimp (*Penaeus vannamei)* are the two brackish water shrimp species mainly raised in the area. Following the national trend, shrimp culture was booming in the early 2000s in northern coastal provinces with government policy incentives related to land use planning and infrastructure investment. Tran (2013) found the intensive shrimp culture in the region to be operated in small-size ponds but with high shrimp stocking densities, and the production depended on inputs of industrial feed and chemicals.

In general, it is widely acknowledged that shrimp farming provides wealth and job opportunities for communities in aquaculture areas despite its adverse environmental impacts (Lan 2009), whilst fish is cultured as a part of VAC system (Vietnamese Acronym for Garden, Pond, Livestock quarters) (Luu et al. 2002). In the VAC system, fish is cultured to utilize the livestock manures and fish farming is only a supplementary income or contribution to food supply of domestic markets (Nguyen et al. 2005). Whilst aquaculture in northern Vietnam recently has started to expand, studies which focus on the socio-economic profile in the area remain sparse. This paper, therefore, attempts to contribute to the knowledge base by investigating the role of aquaculture to farmers' livelihoods in northern Vietnam with emphasis on their level of dependence on aquaculture. The objectives of this study are the following:

1. To understand the role of aquaculture for household incomes and thus the household dependence on aquaculture in the study areas.
2. To identify the factors affecting households' income from aquaculture and discuss differences between two important aquaculture areas.

3. To analyse the role of farm specialization (freshwater fish or brackish water shrimp production) in local livelihoods

Research methods

Study sites and data collection

The study areas, Quang Ninh and Nghe An (Fig. 1), are the two main aquaculture provinces in northern Vietnam which contain both freshwater and brackish water aquaculture. Quang Ninh is a mountainous and coastal province, widely known for its diversity and high aquaculture production. Nghe An is a large province in the north-central part of Vietnam, and freshwater aquaculture is more dominant in this province (ICA 2012).

The data for this study were obtained from two field surveys in 2014 in two provinces Quang Ninh and Nghe An, involving 199 aquaculture households. The criterion to select a district in each province is that it represents shrimp aquaculture in brackish water ponds or fish aquaculture in freshwater ponds in the province, and the selection was based on literature review (ICA 2012; Tai and Khoi 2005) and advice of the province's fishery official. The criterion to select a commune in each district is that it contains a substantial aquacultural area and represents either shrimp or/and freshwater fish production of the district. The communes in each district were purposely selected with advice of the district's fishery official. In Quang Ninh province, they are Dong Trieu, Quang Yen, Dam Ha and Mong Cai districts. In Nghe An province, they are Quynh Luu, Dien Chau, Nghi Loc, Nam Dan and Do Luong districts. The total number of freshwater fish and shrimp farms in each province was collected as equal as

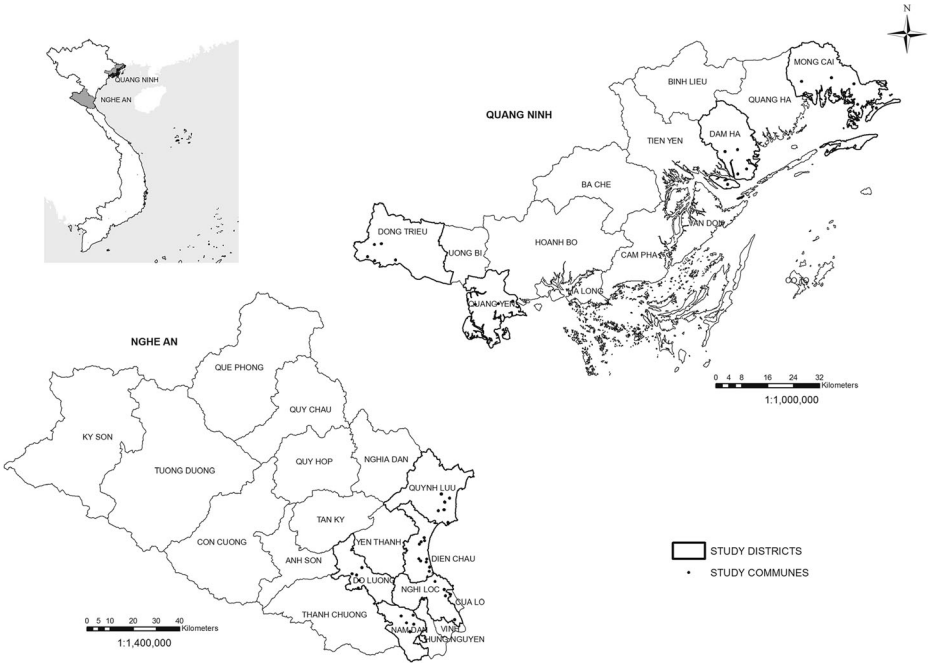

Fig. 1 Study area

possible. At least 20 farms in each district from different communes were randomly selected and yielded a total sample of 81 farms for Quang Ninh and 118 for Nghe An. This covered 105 shrimp farms (53 %) and 94 freshwater fish farms (47 %).

A semi-structured questionnaire was developed for personal interviews with farm owners. The variables in the questionnaire were prepared by the authors based on the research questions about the dependency on aquaculture of farmers' livelihoods. The questionnaire was tested and validated with aquaculture experts and the research team members. All questionnaires were completed by face-to-face interviews by the first author and researchers of the Research Institute of Aquaculture No. 1 (RIA1).

The purpose of the interviews was to collect information of the socio-economic status of the farm, including age of the respondent, education, years of experience in aquaculture, number of family members working in aquaculture, sources of income, main income source and income share from aquaculture. Information related to aquaculture farming was also recorded (species cultured, types of cultivation, infrastructure and water management, role of aquaculture as a food supply, aquaculture training courses). After being completed, the questionnaires were checked and edited by the first author and team researchers to ensure accuracy. Then, all answers were entered and coded in MS Excel™.

Data analysis

To understand which socio-economic factors could explain household dependence on aquaculture, some variables from the questionnaires were selected for statistical analysis. The variables were identified through literature review and practical experience. A one-way ANCOVA was used to study the influence of both continuous and categorical independent variables on the continuous dependent variable, which is the income share from aquaculture as percentage of total income of each farm. The independent variables were (a) province (Nghe An and Quang Ninh), (b) farm type (freshwater fish and brackish water shrimp), (c) type of aquaculture cultivation (intensive and improved extensive), (d) education of the head of the household (normal education and higher education), (e) years of experience in aquaculture (years), (f) family labour working in aquaculture (number) and (g) sources of income (number).

We tested the hypothesis that the educational level of the household decision-maker, years of experience with aquaculture, the number of family members worked per farm, type of cultivation and the number of different income sources in households would influence the reliance on aquaculture. We also tested if reliance on aquaculture differed between the two provinces and between farm types.

"Education" was a binary variable in which normal education meant the head of the household held a high school degree or lower. Higher education meant he or she got extra education after high school such as vocational school or college/university. The education of the household decision maker could influence investment strategies related to the kind of aquaculture chosen because aquaculture farming requires both technique and knowledge.

"Years of experience with aquaculture" were speculated to be positively correlated to the reliance on aquaculture as a source of income. We assumed that the households with more experience would invest more in aquaculture and at the same time obtain a higher income share from aquaculture.

"The number of family labour working in aquaculture field" was an important variable displaying the involvement of the household in aquaculture, and the households with more

labour was expected to get higher income. We selected family labour rather than hired labour because in the study areas, most farms were small scale and family based.

"Type of aquaculture cultivation" was a binary variable of intensive and improved extensive farming. The threshold to define the two types of aquaculture cultivations is based on the feeding technique, investment and labour of the farm. Intensive farming relies on the fertilizer, commercial feeds, high stocking density, more invested in infrastructure and labour than improved extensive one. Improved extensive relies on natural feeds, little or no fertilizer, low stocking density, less invested in infrastructure and labour than intensive farming.

"The total number of income sources" reflected the diversification of a household's income.

In the statistical analysis, independent variables were considered significant at p values ≤ 0.05. Before running the final ANCOVA model, the dependent variable (income share from aquaculture as percentage of total income of each farm) is arcsine transformed to normalize in order to improve the model validity. To validate the model, we used the normal quartile and residual method (Ekstrøm 2014). All statistical analyses were conducted in R version 3.1.0.

Results

Reliance on aquaculture

Aquaculture plays an important role in the selected communes (or districts) of the study areas with most of interviewed households (67 %), having an income share from aquaculture of more than 50 % (Table 1). However, this number varies between farm types, with more shrimp farmers (n = 83) having at least half of their incomes from aquaculture. Regarding the main income source of the interviewed households, 56 % of farmers rank aquaculture as their main income. Amongst these farmers, shrimp farmers account for 69 %, whilst fish farmers only account for 31 %.

Sources of incomes for households in the study area are on-farm activities including aquaculture, livestock, rice or/and fruit cultivation and off-farm ones including service and salary. Amongst these, cultivation, livestock and aquaculture, which are the main components of the IAA system, are three popular income sources. Most households have three sources of income with the median for "the total number of income sources" variable that is 3 (Table 1). Only 6 % households rely on aquaculture as the only income source, all of them being shrimp farms. Whilst only 25 % shrimp farms have at least three sources of income, this number for fish farms is 45 %. A negative relation between number of income sources and reliance on income from aquaculture was found (Fig. 2). The trend is more clear for shrimp farming with income from aquaculture decreasing from nearly 90 to 70 and 30 % as the number of sources increases. On the other hand, freshwater fish farming accounts for around 50 % of the household income, irrespective of the number of income-generating activities.

The impact of socio-economic factors on aquaculture income share

Table 2 shows the estimated result for the final model which analyses the impact of socio-economic factors on income share and the interaction between province and farm types.

As expected, from Table 2, it can be seen that household head's education has a positive effect on income share from aquaculture. The income from aquaculture for higher education farmers is 8.7 % higher (95 % confidence interval (CI) from 0.7 to 17 %) than that of farmers

Table 1 Descriptive characteristics of the investigated farms by province, medians ± SD or *N* (%)

Characteristic	Unit	Quang Ninh	Nghe An	Total
Number of interviewed farm	Farm number (*N*)	81	118	199
Shrimp farm	*N* (%)	49 (60 %)	56 (47 %)	105 (53 %)
Fish farm	*N* (%)	32 (40 %)	62 (53 %)	94 (47 %)
Income from aquaculture <50 %	*N* (%)	25 (31 %)	41 (35 %)	66 (33 %)
Income from aquaculture ≥50 %	*N* (%)	56 (69 %)	77 (65 %)	133 (67 %)
Shrimp farm	*N*			83
Fish farm	*N*			50
Main income source from aquaculture	*N*	52	59	111 (56 %)
Shrimp farm	*N* (%)			77 (69 %)
Fish farm	*N* (%)			34 (31 %)
Main income source from other sources	*N*	29	59	88 (44 %)
Number of income sources	Median	3 ± 1.1	3 ± 0.8	
Shrimp farm				
One income source	*N* (%)			12 (6 %)
Two income sources	*N* (%)			42 (21 %)
Three income sources or more	*N* (%)			51 (25 %)
Fish farm				
One income source	*N* (%)			0 (0 %)
Two income sources	*N* (%)			5 (3 %)
Three income sources or more	*N* (%)			89 (45 %)
Number of family labour (number)	Median	2 ± 0.7	2 ± 1.3	
Aquaculture experience of the farm (year)	Median	10 ± 5.3	11 ± 7.2	
Education status of the decision maker				
Normal education	*N* (%)	67 (83 %)	106 (90 %)	173 (87 %)
Higher education	*N* (%)	14 (17 %)	12 (10 %)	26 (13 %)

with lower education. Regarding the impact of experience, the aquaculture income only increases 0.6 % with each additional year of experience. The confidence interval reveals the difference ranges from 0.2 to 1 %.

Families with more income sources are associated with lower income share from aquaculture, as expected. Income will decrease, on average, by 10 % for each additional income source. The difference could be as much as 13 % or as little as 7 % based on the 95 % confidence interval. The assumption that the number of family members engaged in the households' aquaculture production is positively related to the share from aquaculture is confirmed in this model. The income increases 2.5 % for each increase of family person working in aquaculture. The difference is as little as 0.04 % or as much as 5 %. It is not surprising that the income share will decrease 10.5 % in improved extensive farming household if compared to intensive one and ranging from 16 to 5 %.

Especially, there is a highly significant interaction between province and farm type. In Quang Ninh province, the model estimates 92 % income share from aquaculture in shrimp farms and 66 % in fish farms. In Nghe An province, the model estimates 77 % income share from aquaculture in shrimp farms and 74 % in fish farms.

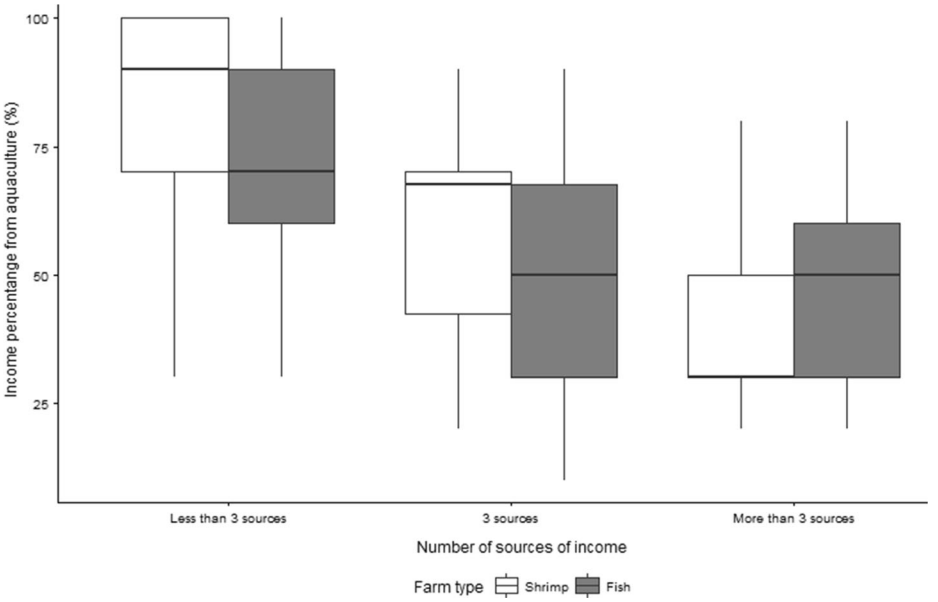

Fig. 2 Relationship between income diversity and farm type

Discussion

This is the first in-depth study comparing brackish water shrimp and freshwater fish farming as well as the role of aquaculture to farmers' livelihood in Quang Ninh and Nghe An, two important aquaculture areas in northern Vietnam.

Table 2 The impact of socio-economic factors on aquaculture income share

	Estimate	Standard error	*t* value	*p* value
Higher education	8.7	4.0	2.2	0.03*
Experience years	0.6	0.2	2.9	0.00**
Number of total income sources	−10.3	1.6	−6.3	0.00***
Number of family labour	2.5	1.2	2.0	0.05*
Type of cultivation, improved extensive	−10.5	2.9	−3.6	0.00***
Quang Ninh, shrimp	91.9	5.8	15.8	<2e − 16***
Quang Ninh, fish	65.8	8.0	8.3	0.00***
Nghe An, shrimp	77.1	6.4	12.0	<2e − 16***
Nghe An, fish	73.6	7.3	10.1	<2e − 16***

Multiple R^2 0.9134, adjusted R^2 0.9093, F statistic 222.8 on 9 and 190 df, p value <2.2e − 16

*$p < 0.05$

**$p < 0.01$

***$p < 0.001$

Education impact on aquaculture activity

The result emphasizes the importance of education and technology to aquaculture. Whilst experience also contributes to the income share with 0.6 % income increase, the impact of education is more impressive with 8.7 % points. People with higher education can accommodate new techniques with greater ease, be more informed about new best practises and they also considered more trusted worthy in gathering the capital to invest in their aquaculture activities. Even though most of households in the study area have at least 10 years of experience, educational background of the household's decision makers explains their engagement in aquaculture better than how long they have worked as aquaculture farmers. Another explanation for the role of experience is that one side accumulation of experience probably is not linear with time. Thus, the increase of experience from year 1 to year 2 probably is lower than the increase from year 8 to year 9. The result supports the findings of Bui et al. (2014) and Phung Duc and Waibel (2009) that the education of household heads have significant effects on the households' income. A possible explanation is that higher educated farmers are better adopting new cultivars, methods and techniques to get higher income share from aquaculture. Similarly, Pucher et al. (2014) mentioned skill and knowledge as requirements for farmers to apply intensive aquaculture, which increases their income. Joffre and Schmitt (2010) also found that shrimp households and private shrimp companies who could afford to invest in knowledge and techniques earn higher profits and reduce risks of harvest lost by reducing the occurrence of virus outbreaks.

The role of fish and shrimp aquaculture in the study areas

The study highlights the important role of aquaculture in the study area where most of the interviewed households have income shares from aquaculture of more than 50 % of their total income. However, amongst 199 farmers, only half of them consider aquaculture as their main income. Aquaculture is one amongst many income-generating activities in the study areas, not the primary livelihood and farmers have to depend on many other sources to survive. According to Adger (1999), at the household level, "the diversity of income sources could be used as an indicator of vulnerability, and it is assumed that the greater the diversity of income the greater resilience of livelihood to disruption of particular sources". Similarly, Allison and Ellis (2001) found that fish farmers in low-income countries pursued diversified livelihood strategies because diversification reduced the risk of livelihood failure by spreading it across more than one income source and diversity is an important attribute of rural livelihoods in developing countries.

There is a fact that freshwater fish farmers with lower share of income from aquaculture tend to have more sources of income than shrimp farmers and freshwater fish aquaculture always supplies around 50 % of income even though the number of income sources increase. This means that freshwater aquaculture can be run as side activity with a substantial contribution to household income. Especially in some communes near the coast in the study area, local people prefer eating sea fish rather than freshwater fish and fish is cultured as a part of VAC system (Luu et al. 2002). Therefore, fish farmers do not have motivation to invest in ponds (Ruben 2007) or feeding techniques (Pucher et al. 2014). This finding follows previous studies that all fishing famers had additional livelihood occupations (Martin et al. 2013) and the role of fish as a source of protein for local consumption (Hishamunda et al. 2009).

Freshwater fish farmers generally consider themselves rice farmers who do aquaculture as a supplementary income rather than aquaculture farmers. In contrast, the shrimp farmers are not only those having the highest share of total income from aquaculture or earning their main living from aquaculture but also those who consider themselves aquaculture farmers. It is not surprising that in the investigated households, the ones with 100 % household income from aquaculture are shrimp farmers. Shrimp farmers can be considered high at risk and at the same time highly dependent on aquaculture. A loss of shrimp harvest will immediately result in loss of income, whilst the high return from shrimp farming could enable the shrimp farmers to reinvest in infrastructure and techniques to improve yields. In the same line, Brennan et al. (2000) found that shrimp was the most important source of income in shrimp-based farms and other sources of income helped to assure the household of a basic income. This is in agreement with Ha et al. (2013) finding that successful shrimp farmers tended to diversify their livelihood less, although livelihood diversification reduced risks and improved incomes.

The fact that both shrimp and fish farmers have diverse sources of income shows the unstable or risky nature of aquaculture livelihood. The reason is that in coastal communities, all sources of income are considered "climate dependent" (Adger 1999), and in case the main income from aquaculture is lost, other income-generating activities help farmers to survive. Similarly, Handisyde et al. (2006) found that farmers were sensitive to climate change if aquaculture was their main income source. The extreme events would immediately affect farmers' income, and they did not have other financial sources to repair the situation.

Livelihood differences between Quang Ninh and Nghe an

Geographically, the difference in income share from aquaculture between the two study areas was also recorded. In Nghe An, there is not much difference of income share from aquaculture between shrimp and freshwater fish farms. In Quang Ninh, the income share for shrimp farms is much higher than fish farms. This difference can be explained by the fact that market accessibility is better in Quang Ninh than Nghe An. Quang Ninh with its ideal location near the big cities Ha Noi and Hai Phong and bordering China makes it easier for traders to transport aquaculture products.

Although education and experience were found to have impact on income share from aquaculture in the investigated households, we could not find any variable related to education or experience to explain the less reliance on aquaculture of investigated farmers in Nghe An. This can be only explained by the traditional farming techniques of freshwater aquaculture that farmers in this area follow. They follow the traditional VAC system with cheap input, not much investment and not much profit. According to El-Sayed (2006), in this system, the farmers use very few inputs with poor management, and consequently, the yield is generally low. Similarly, Nguyen Van and Tran Huu (2012) and Tai and Khoi (2005) found that in this system, farmers used organic manure from livestock and green manure from cassava and banana leafs rather than commercial food. Fish could be harvested all year around with not so high and undefined productivity. This kind of farming with short production cycles requires little capital investment and is appropriate for most farmers in Nghe An, and freshwater fish farming plays a role as an additional food supply for households.

Conclusion

This study contributes to the knowledge base of aquaculture development in the less investigated aquaculture area of northern Vietnam and identifies the emergence of aquaculture as an important livelihood component in the study area.

Our study demonstrates that aquaculture encompasses different cultivation intensities, different specializations and different risk exposures. These differences are not only recorded between two farm types but also geographically in two study areas. Whilst demonstrating the important role of aquaculture in the study area, this study also indicates the instability or vulnerability of aquaculture livelihoods. This finding is important because Vietnam is experiencing increased exposure to climate change with potential impacts on aquaculture. For small-holder aquaculture farmers with few possibilities of capital investments in their farms, income diversification could thus be a viable and smart alternative to reduce livelihood vulnerability.

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Author contributions All authors planned and designed the study, Le Minh Hanh conducted the field work, Le Minh Hanh and Martin Rudbeck Jepsen analysed the data and all authors prepared the manuscript.

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