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Why are cluster farmers adopting more aquaculture technologies and practices? The role of trust and interaction within shrimp farmers' networks in the Mekong Delta, Vietnam

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ABSTRACT

A common avenue to enable adoption of technologies and practices by small-scale producers is by means of farmer clusters. These are achieved by building networks and partnerships between farmers and other actors within the supply chain. This paper examines the role that farmer clusters play in the adoption of practices and technologies by shrimp farmers in Vietnam. Understanding the decisions that lead to adoption is important because these have a key impact on sustainable land use in aquaculture. We report on two complementary studies that test the role of farmer clusters in accessing different sources of knowledge and the trust associated with each of the knowledge sources. First, a survey ($N = 193$) tested the relationship between cluster membership and adoption, and showed that shrimp farmers who are members of farmer clusters are more likely to adopt three types of pond management practices (i.e. water quality management, feed input, and disease control practices). Furthermore, frequency of interaction with, and trust related to, key stakeholder actors could partly explain this relationship. Second, focus group discussions further zoomed into the dynamics that underlie the adoption of technologies and practices by cluster farmers and non-cluster farmers, respectively. We found that input retailers, buyers and hatcheries were only valued for their input on specific products and issues, but not trusted, as the information always needed being verified through testing by, amongst others, neighbors. Consequently, trust relations with these actors can be described as strongly calculative. Farmer clusters increase trust and tighten relationships between members. As a result, members trust each other when verifying information or sharing knowledge acquired from less trusted sources. On the basis of these results, we argue that reliance on existing farmer networks (i.e. clusters) is a viable tool to improve adoption of sustainable technologies and achieve land use planning objectives. Further implications for research and policy are discussed.

1. Introduction

Aquaculture is projected to continue to grow by reaching a production of 187 million tons by 2030 (World Bank, 2013), and become the primary source of fish for human consumption. Recent research on the future of aquaculture development highlighted the diversity and magnitude of the risks faced by the sector and associated negative social and environmental outcomes generated by this rapid growth (FAIRR, 2019). The aquaculture sector is geographically centered in Asia where 90% of the global production happens (FAO, 2018) – dominated by emerging small and medium scale commercial enterprises that have gradually been intensifying their production since the late eighties (Belton et al., 2017).

With increasing risk for producers and mounting competition for natural resources, planning aquaculture development is a priority for main producing countries in order to sustain sector growth and sustainable land use. As such, the development of shrimp farming in coastal zones has become a key example of land use transformation and need for regulation (Bush et al., 2010; Le et al., 2018; Tran et al., 2018). Attempts to steer the aquaculture sector toward more sustainable practices, organized at the landscape level to mitigate negative impact and integrate producers within the landscape, has met with limited

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success (Ha et al., 2013; Bottema et al., 2018; Nguyen et al., 2019). However, in Asia, adoption of technologies, standards and practices by small and medium scale farmers often translate in bottlenecks for mitigating negative impacts and safeguarding landscape values (Blythe et al., 2017; Diedrich et al., 2019).

Technology and practice adoption research has recently become popular within the field of aquaculture studies that look at adoption of aquaculture technologies and practices from various angles. The most dominant strands of research explains adoption by analyzing farm characteristics (e.g., Diedrich et al., 2019; Engle et al., 2017; Ngoc et al., 2016), by integrating social dynamics (Blythe et al., 2017; Brugere et al., 2017) and risk perceptions (Lebel et al., 2016; Joffre et al., 2018). These approaches suggests that adoption of improved aquaculture technologies and practices requires an understanding of farmers' decision making, and should take into account the socio-economic context in which farmers operate and introduce innovations (Bush et al., 2013; Bottema et al., 2018). These strands of research also recognize that the process of adoption is not a discrete event only, but as a continuous process of adaptation and learning and highlights the potential of collective action, such as farmer clusters, for adoption and of technologies and practices (Joffre et al., 2019; Bottema, 2019).

This strand of research follows the approach promoted by governments and development agencies to enable adoption and adaptation of technologies and practices by small-scale producers through supporting the creation of agricultural clusters in which there is a strong emphasis on building networks and partnerships between farmers and other supply chain actors (Umesh et al., 2008; Ha et al., 2013; Ramirez et al., 2018; Van der Lee et al., 2018). Clusters can be defined as "…a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities…" (Porter, 2000, p. 16). This definition allows for a wide range of diversity in terms of structure and organization, and types of interaction between actors, which may also include geographical proximity and concentration. Clusters are diverse and their structure and composition affects the outcomes of the cluster (Matous, 2015). Examples of spontaneous and accretive organized clusters (Hu et al., 2019) or more formally organized organizations (Ha et al., 2013) exist in the aquaculture sector. Clusters diversify the type and range of relationships between producers and other actors within the value chain (Van der Lee et al., 2018; Hu et al., 2019) and optimize the flow of knowledge technology and support services in order to innovate (Chan et al., 2010). These clusters are different from knowledge networks as they can deliver not only technical upgrading, but also value chain and institutional upgrading with, for example, more sophisticated input and output service arrangements or facilitate the establishment of quality standards for products (Van der Lee et al., 2018).

Such clusters should enable *vertical* and *horizontal coordination* between actors of the value chain. Linkages with different segments and actors of the value chain are comprised under vertical coordination (Dirven, 2001; Molema et al., 2016; Kilelu et al., 2017a), in order, for instance, to provide inputs and services to farmers and to buy, trade and process products from farmers. Collective action between producers who aim to reduce costs is comprised under horizontal coordination (Mohan and De Silva, 2010; Kassam et al., 2011; Ha et al., 2013), such as by forming cooperatives or joint input purchases, or by organizing group-learning events around technical topics.

Hence, in this study we distinguish between farmers acting individually with other actors of the value chain and supporting actors, and farmers that are part of organized as a group to foster interactions with other value chain segments. We call the latter 'farmer cluster' (see also Fig. 1 below). It has been argued widely that farmer clusters have benefits for farmers as they enable collective action and joint learning and improve farmer's bargaining position and offer possibilities to lower costs based on scale (Brunori and Rossi, 2000; Devaux et al., 2009; Kilelu et al., 2017a: Zhong et al., 2018), but the degree of vertical integration, types of governance arrangements, and collective action in terms of inclusiveness and fostering trust between farmers) (Bijman and Wijers, 2019; Kilelu et al., 2017b) varies greatly.

In aquaculture, this diversity which influences the performance of the farmer clusters has been analyzed within the shrimp industry in Vietnam (Ha et al., 2013; Joffre et al., 2019). However, the underlying mechanisms that drive adoption of technologies by aquaculture farmer clusters are still not well understood. This is especially true with regards to the degree by which relevant actors interacting with farmer clusters influence adoption of technologies and practices. This is an important question, as it has been shown that farmers mobilize different sources of knowledge for specific adoption decisions (Aguilar-Gallegos et al., 2015; Cofré-Bravo et al., 2019; Kuehne et al., 2017; Lambrecht et al., 2014), in which the nature of the relationships primarily depends on the actors and the decisions they take. Some actors, such as fellow farmers, may hold close social proximity and high trust relationships, while other actors may hold more distant relationships and a lower degree of trust (Cofré-Bravo et al., 2019; Agyekumhene et al., 2018).

Therefore our research sets out to answer the question: In which ways do aquaculture farmer clusters facilitate access to, and foster trust in, specific sources of knowledge and ultimately enable adoption of technologies and practices? In order to answer this question we employ a mixed-methods approach and report on two complementary studies. The first is a survey to establish the relationship between clustering, quality and quantity of farmer interactions, and adoption of farming practices; the second consists of a focus group procedure to more fully understand how farmers maintain relations with, and to what degree their decision making is influenced by, relevant network partners.

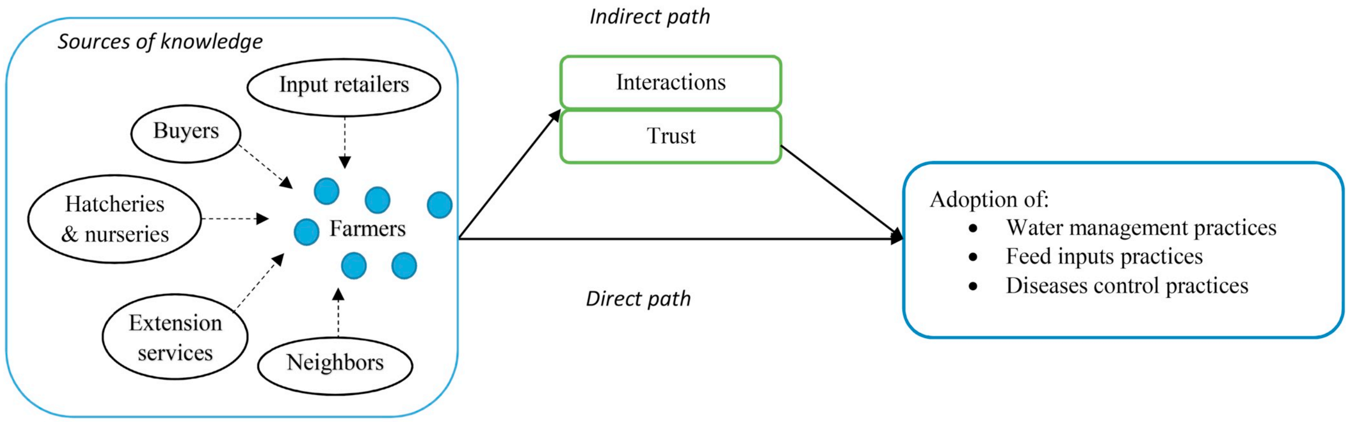
The current study considers the case of shrimp farming in the Mekong Delta to investigate the role of aquaculture farmer clusters in determining access to knowledge and influencing adoption of agricultural practices. In Section 2 of this paper, we present our analytical framework (Section 2.1), followed by the research context (Section 2.2). Sections 3 and 4 describe the method and results of the quantitative approach taken in Study 1, and the method and results of the qualitative approach of Study 2, respectively. Section 5 discusses the main findings of our mixed-methods approach, before offering a conclusion in Section 6.

2. Methodology

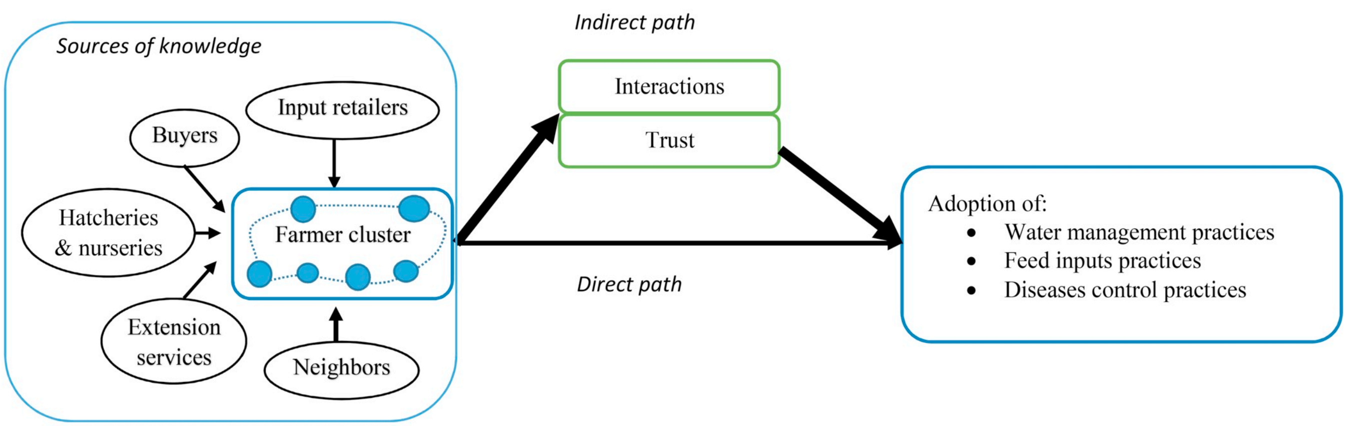
2.1. Analytical framework

Several dimensions and drivers influence adoption of aquaculture technology. Economic and social factors and technical characteristics of technologies influencing adoption are well studied (Blythe et al., 2017; Kumar et al., 2018; Diedrich et al., 2019). However, little is known, within the aquaculture sector, about access to knowledge and trust related to the knowledge source throughout the adoption process (Aguilar-Gallegos et al., 2015). Therefore, we focus our analysis on access to knowledge and the perceived quality of the knowledge acquired by farmers with a specific focus on the role played by trust, that we define as a positive expectation about the thoughts, behavior and decisions of others for oneself based on past experiences (Lewicki and Bunker, 1996). In addition, we look at the role farmer clusters might have in fostering relationships of knowledge exchange.

In agricultural research literature, frequency of relationships and trust associated with the knowledge source are analyzed as determinants of adoption of technologies and practices. Frequency of interaction with relevant network partners is one of the factors influencing adoption of technologies and practices. In addition to frequency, the quality or character of the relationship with these partners is often also considered important in the sharing of knowledge (Reed, 2008; De Vries et al., 2017). Various authors have argued that trust plays an essential role in these contexts. More specifically, knowledge-sharing and learning literature generally describes trust as a smoother of information-sharing and learning (Reed, 2008; Leeuwis, 2000), helpful in



a) *Non-cluster farmers model*, where interactions between the sources of knowledge and farmers are depicted by (-------►) and between individual farmers are infrequent and trust is relatively low which leads to limited adoption of technologies and practices. The indirect path to adoption is limited in magnitude (——►)



b) *Farmer cluster model* where interactions between the sources of knowledge and farmers (——►) and between farmers are relatively frequent and trust is relatively high, which leads to adoption of technologies and practices. The indirect path to adoption is relatively stronger in magnitude (➡)

Fig. 1. Conceptual model describing the adoption of aquaculture practices, distinguishing between a) non-cluster farmers and b) cluster farmers.

dealing with uncertainty and change that are inherently part of these processes (Pahl-Wostl, 2009), a key determinant for success (Berkes, 2009) or an objective in its own (Fazey et al., 2012).

We propose an analytical framework that explores the causal relationship between farmer clusters, how these affect the frequency of interaction with different sources of knowledge and the trust associated with each of these sources of knowledge to ultimately facilitate adoption of aquaculture technology and practices (Fig. 1). We expect that both types of relational features – the quantity (interaction frequency) and the quality (trust) – can act as informational resources: farmers are influenced by those they meet frequently and by those they trust. This can explain why cluster farmers adopt more farm management practices as a result of better-developed and more formalized networks (see Fig. 1).

Based on field observation and Joffre et al. (2019), we used 5 different type of sources of knowledge for shrimp farmers: i) extension services; ii) shrimp buyers; iii) hatcheries and nurseries; iv) input retailers and v) neighbors – other shrimp farmers and tested our model on three groups of aquaculture technologies and practices: i) water management; ii) feed inputs and iii) disease control.

2.2. Research context and research approach

The Mekong Delta is one of the planet's fastest-transforming agricultural landscapes of the last decades (Le et al., 2018). Beginning in the 1990s the landscape has undergone rice intensification, diversification of agriculture, and the boom of aquaculture – both in freshwater and coastal areas. Institutional and legal reforms, innovation in agriculture and aquaculture, and investments in infrastructure enabled the transformation (Drogoul et al., 2016). Previously the poorest in the Mekong Delta, the coastal area was converted into a shrimp aquaculture landscape in the 1990s at the expense of mangrove and rice fields. Since then the area devoted to shrimp aquaculture has remained stable, encompassing an area of 650,000 ha in 2016 (GSO, 2016). Compared to the shrimp industry in neighboring Thailand, which was heavily affected by disease outbreak leading to farm bankruptcy and abandoned ponds (FAO, 2019; Piamsomboon et al., 2015), Mekong Delta's shrimp producers managed to mitigate disease risk while intensifying their production system.

In sharp contrast to the Mekong Delta's pangasius sector, which gradually excluded smallholder producers (Bush and Belton, 2012), the shrimp sector is still dominated by smallholding farmers. Smallholders operate most of the shrimp cultivated area and contribute significantly to the volume of shrimp produced and exported (World Bank, 2014). Innovation and adoption of techniques by smallholders allowed a rapid increase in production, from about 70,000 tons in the 1990s to over 500,000 tons in 2016. Farmers have continuously been adopting new technologies and a wide range of systems aimed at intensifying production, which can be found throughout the coastal landscape (Boyd and Engle, 2017; Joffre and Bosma, 2009). Since 2012, the cultivation of both *Penaeus vannamei* and *P. monodon* has allowed producers to diversify their strategies.

Due to the multitude of smallholding farmers operating in the area, and the fact that they share a common resource (water), governmental and non-governmental parties alike promote adoption of technology through farmer clusters. The government and non-government organization developed farmer clusters as a strategy to upscale production to upscale production and to improve the quality and environmental performance of shrimp farms by using them as an entry point for extension services, NGOs and projects to transfer knowledge, upgrade production, access market (Ha et al., 2013), and enforce water management and disease prevention regulation (Dung et al., 2017).

In the Mekong Delta, farmer clusters are an organized group of producers. Farmer clusters aim at promoting exchanges and interactions between farmers and with private sector parties (e.g. feed companies or hatcheries). Compared to traditional “cooperatives”, farmer clusters have limited legal obligations and no collectivization of assets (Cooperative law 2003). As mentioned by Ha et al. (2013), a farmer cluster is a simplified form of a cooperative with no self-responsibility for financial obligations within the scope of charter or accumulated capital. Vietnamese shrimp farmer clusters are heterogeneous, diverse in their form, size and linkages with the private sector (Joffre et al., 2019), and combine different characteristics of agricultural clusters found in the literature, such as types of vertical and horizontal coordination.

This study is comprised of two consecutive phases for which an explanatory sequential mixed-method design was used (Creswell, 2014). Such a design was chosen to test the role of farmer clusters in accessing different knowledge sources and the trust associated with each of the sources. The first study consisted of a survey design, aimed at understanding the influence of farmer clusters on the frequency of interaction with, and trust related to, different sources of knowledge and the extent to which these variables influenced adoption of aquaculture technologies The second study was carried out to further explore the underlying links between farmer clusters and adoption of technology and was comprised of focus group discussions (FGDs). The focus of the FDGs was based on the results of Study 1, and the FGDs discussed knowledge exchange in relation to the key-stakeholders (buyers, retailers, extension service, hatcheries, neighbors).

3. Study 1

3.1. Method

3.1.1. Sample and procedure

The survey was conducted in January 2019 in 5 districts of Soc Trang and Bac Lieu provinces in the Mekong Delta (Fig. 2). In total, 193 shrimp farmers were interviewed, 104 of whom belonged to a farmer cluster. In total 14 farmer clusters were included in the sample. Survey sites were selected in collaboration with the provincial Department of Agriculture and Rural Development in order to cover a wide range of farming intensity from extensive to intensive shrimp farming. Survey sites corresponded to a Commune and included both members and non-member of a farmer cluster. Within each area, surveyed hamlets were selected based on accessibility while farms were selected randomly.

Farmer clusters varied in size (5 to 39 members). All clusters surveyed were more than 7 years old, with one formed in 1994 (25 years of existence). The majority of the clusters (63%) had specific arrangements with feed companies (or their feed distributors) for bulk purchase (with specific discount prices and technical support from company technicians), but less then (37%) were contracted by processing companies to secure market prices.

The survey was composed of several sets of questions, including farm characteristics (farmed area, number of ponds, stocking density of the two shrimp species), membership in a farm cluster, the frequency of interaction with different sources of knowledge within the farmer's network, the perceived trust in those information sources, and the adoption of 17 aquaculture practices (the full list of survey items is provided in the supplementary materials). Trust in information sources was measured with six items per network partner (Schoorman et al., 2007). Aquaculture practices included water quality management practices, feed inputs-related practices, and disease control practices. Selection of the 17 aquaculture practices was based on a consultation with local experts and previous field research (Joffre et al., 2019). The experts were asked to identify the most important practices used in shrimp farming in the Mekong Delta. The sources of knowledge explored were related to public sector actors that included extension services, input retailers, hatchery and nursery managers, shrimp buyers, and neighbors. Questions related to adoption, frequency of interaction with knowledge sources, and perceptions of trust were framed according to Likert-type scales (e.g. to assess level of trust, 1 = disagree strongly; 5 = strongly agree).

3.1.2. Analysis

For the analysis, we used farm characteristics as control variables. We assessed frequency of interaction with five different sources of knowledge within the farmer's network, and the perceived trust in those five information sources (each trust score was a composite score of the six underlying items). Aquaculture practices were grouped into 3 categories related to i) water quality management (6 items: use of probiotics to improve water quality; use of carbohydrates; water treatment pond; stocking of tilapia in treatment pond; use of quality test kit; use of minerals), ii) feed input (4 items: use of probiotics to improve digestion and shrimp gut health; high quality feed; use of vitamins and minerals; use of feed additives); and iii) disease control practices (7 items: use of pathogen-free PLs; high quality post larvae; deployment of biosecurity measure to prevent access of pathogens; use of antibiotics, line pond bottom, monitor vibrio concentration during the culture period; independent pathogen tests on purchased PLs). The level of adoption of the new variables was computed by averaging the adoption level of the different practices making up this new variable.

In order to test our research model (Fig. 1), we first performed a series of hierarchical regression analyses, after which we performed a formal test of mediation to see whether the interaction frequency and perceived trust (middle blocks in Fig. 1) could explain the association between farm clustering and the adoption of farming practices. The model aims at exploring what drives the adoption of three types of aquaculture practices: (1) water quality management, (2) feed inputs, and (3) disease control. To analyze these adoption processes, a series of three separate hierarchical regression analyses were performed, each focusing on one of the dependent variables. Each hierarchical regression analysis included four steps. In Step 1 control variables were entered: size of the farm in hectares, number of ponds, and densities of the two shrimp species; in step 2 our main independent variable – clustering – was included; by performing this step we wanted to establish whether clustering could predict the dependent variables beyond the farm characteristics (i.e. the control variables). Finally, in Step 3 frequency of interaction and levels of trust were added. These steps were aimed at establishing whether the association between clustering and farming practices would statistically decrease (i.e. their regression weights becoming smaller or insignificant) upon entering the hypothesized mediators: frequency of interaction and perceptions of trust.

Finally, to formally test for mediation, a series of bootstrap analyses (Preacher and Hayes, 2004) was employed to test the reduction in the direct effect between clustering and the three different types of farming practices of interest. This approach involves computing 95% confidence intervals (CIs; 5000 bootstrap resamples) around indirect effects; mediation is indicated by CIs that do not contain zero.

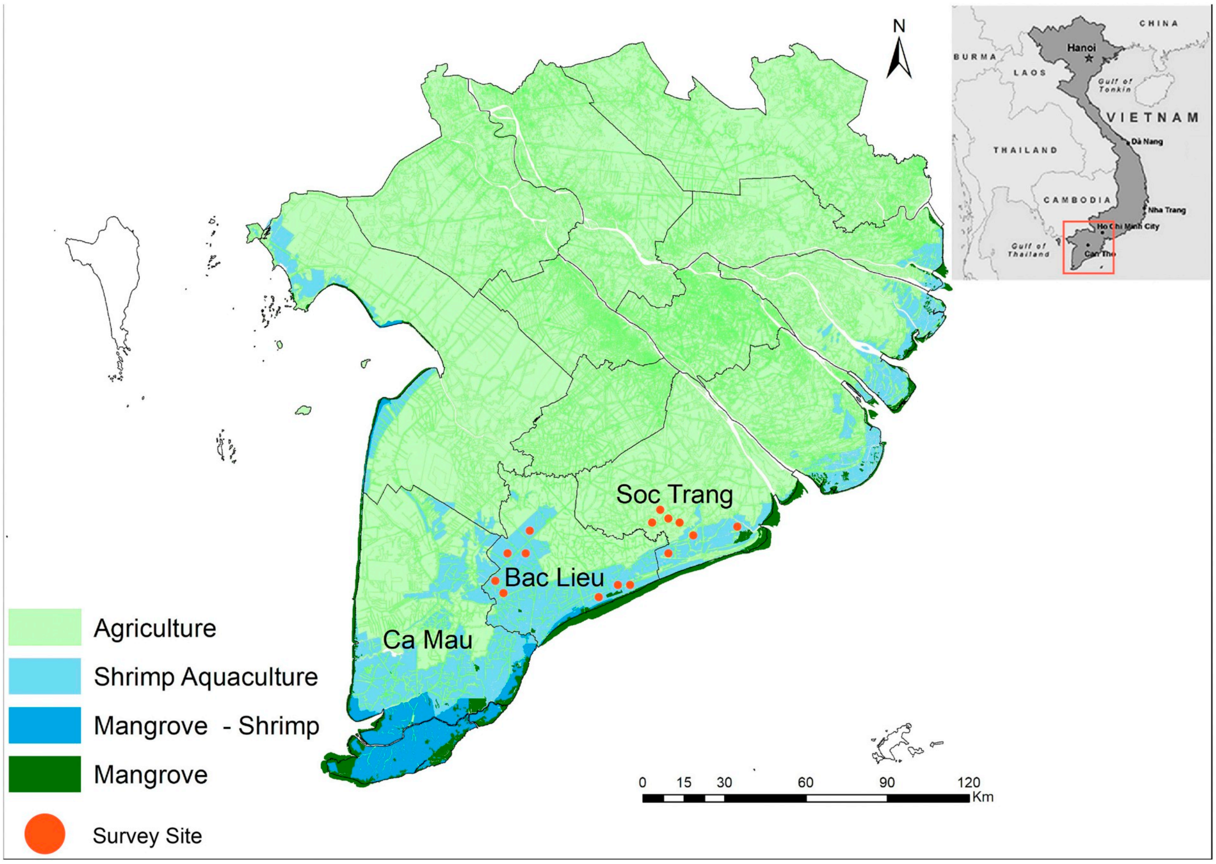


Fig. 2. Study area and survey sites (indicated by red dots) in Bac Lieu and Soc Trang provinces in the Mekong Delta. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

3.2. Results

3.2.1. Descriptive statistics

Means and standard deviations of the study variables are reported in Table 1. Participants reported having frequent interactions with neighbors, and less frequent interaction with buyers. Perceived trust was highest for extension services and neighbors, and lowest for buyers. Average scores for current adoption of water quality management and input feed inputs were slightly above the scale midpoint, while the average score for disease control practices was a bit below the measurement scale's midpoint, with plausible variations in the responses. This indicates that our sample represents an adequate range of adoption. We also explored differences between farmers who are part of a cluster, and non-cluster farmers. Relative to non-cluster farmers, cluster farmers tend to have a higher number of ponds, a higher stocking density of *vannamei* shrimp, and more frequent interactions with

Table 1
Means and standard deviations of the study variables for the whole sample, for both non-cluster and cluster farmers.

	Total sample		Non-cluster farmers		Cluster farmers	
	M	*SD*	*M*	*SD*	*M*	*SD*
Farm size	1.77	2.69	1.78	3.72	1.77	1.28
Number of ponds	3.72	2.68	**3.09**	2.77	**4.26**	2.49
Stocking density *P. vannamei*	30.81	28.08	**23.71**	23.94	**36.88**	29.99
Stocking density *P. monodon*	8.08	9.29	7.82	10.76	8.31	7.86
Extension service interactions	3.60	1.09	**3.30**	1.03	**3.85**	1.09
Input retailers interactions	2.98	1.31	2.92	1.12	3.04	1.45
Hatchery and nursery interactions	2.74	1.22	**2.38**	1.06	**3.04**	1.28
Buyers interactions	2.15	1.16	2.08	0.96	2.20	1.30
Neighbors interactions	4.02	0.095	3.92	0.79	4.10	1.07
Extension service trust	4.07	0.55	**3.92**	0.51	**4.21**	0.55
Input retailers trust	3.33	1.11	3.37	0.82	3.29	1.31
Hatchery and nursery trust	3.48	0.88	**3.31**	0.76	**3.62**	0.96
Buyers trust	2.80	0.94	2.78	0.73	2.81	1.10
Neighbors trust	4.27	0.59	**4.13**	0.45	**4.38**	0.67
Water quality management practices	3.54	0.96	**3.22**	1.00	**3.82**	0.82
Feed input practices	3.61	1.25	**3.21**	1.38	**3.96**	1.02
Disease control input practices	2.40	0.54	**2.29**	0.56	**2.49**	0.51

Note. M = mean. SD = standard deviation. Significant different means between cluster and non-cluster farmers are indicated by bold typeface (all *Fs* > 5.74, all *ps* < .05).

Table 2
Results of hierarchical regression analyses on water quality management practices.

Step and variables	1	2	3
1. Farm size	−0.11	−0.09	−0.05
Number of ponds	0.43***	0.38***	0.32***
Stocking density *P. vannamei*	0.23**	0.20***	0.16*
Stocking density *P. monodon*	0.04	0.05	0.04
2. Cluster		0.18**	0.08
3. Extension service interactions			0.15*
Input retailers interactions			0.19*
Hatchery and nursery interactions			0.03
Buyers interactions			−0.14*
Neighbor interactions			0.02
Extension service trust			0.01
Input retailers trust			−0.06
Hatchery and nursery trust			0.09
Buyer trust			0.05
Neighbor trust			0.25***
ΔR^2	0.29***	0.03**	0.15***
Corrected R^2	0.28***	0.30***	0.43***

Note. Standardized regression coefficients are being reported.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

extension services, hatcheries and nurseries Furthermore, they also reported higher levels of trust in extension services, hatchery, and neighbors. Finally, cluster farmers adopt more practices related to water quality management, feed input, and disease control. In all, we observed considerable differences between both types of farmers related to their structural, perceptual, and behavioral characteristics.

3.2.2. Regression results

This study set out to investigate what drives three types of aquaculture practices, (1) water quality management, (2) feed inputs, and (3) disease control. Hence, a series of three separate hierarchical regression analyses were performed, each focusing on one of the dependent variables. As discussed, in Step 1 we entered farm characteristics as control variables: size of the farm in hectares, number of ponds, and densities of the two shrimp species; in step 2 the independent variable of clustering was included; in Step 3, frequency of interaction with different sources of knowledge within the farmer's network and the perceived trust in those information actors were entered. The first analysis regressed water quality management practices on the predictor variables as described above (see Table 2). Step 1 controlled for farm characteristics; it showed that adoption of water quality management practices is significantly related to increased farming intensity of *P. vannamei* and the number of ponds in the farm. Step 2 showed that clustering positively predicted water quality practices. Upon entering frequency of interaction and levels of trust, clustering was no longer significant, suggesting that the frequency of interaction and levels of trust could explain the association. Specifically, interactions with extension services and input retailers positively predicted adoption of water quality practices, while those with buyers had a negative relationship. Also, trust in neighbors was positively associated with water quality-related farmers' practices.

The second analysis regressed feed input practices on the predictor variables (see Table 3). As in the first regression analysis, we controlled for farm characteristics in Step 1 and this indicated that stocking density of *P. vannamei* and *P. monodon* predicted adoption of feed input practices, as well as the number of ponds. Then, Step 2 showed that clustering positively predicted feed input practices. Upon entering frequency of interaction and levels of trust, clustering was no longer significant, suggesting that frequency of interaction and levels of trust could explain the association. Specifically, frequency of interaction with input retailers positively predicted feed input practices, as well as trust in hatchery while neighbors positively predicted feed input practices.

Table 3
Results of hierarchical regression analyses on feed input practices.

Step and variables	1	2	3
1. Farm size	−0.13†	−0.10	−0.11
Number of ponds	0.32***	0.28**	0.23**
Stocking density *P. vannamei*	0.37***	0.35***	0.32***
Stocking density *P. monodon*	0.17**	0.18**	0.18**
2. Cluster		0.15*	0.07
3. Extension service interactions			0.08
Input retailers interactions			0.28***
Hatchery and nursery interactions			0.05
Buyers interactions			−0.02
Neighbor interactions			−0.03
Extension service trust			−0.05
Input retailers trust			−0.14
Hatchery and nursery trust			0.14*
Buyers trust			0.00
Neighbor trust			0.15*
ΔR^2	0.40***	0.02*	0.11***
Corrected R^2	0.38***	0.40***	0.49***

Note. Standardized regression coefficients are being reported.
† $p < .10$.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

Table 4
Results of hierarchical regression analyses on disease control practices.

Step and variables	1	2	3
1. Farm size	−0.13†	−0.12†	−0.13†
Number of ponds	0.23**	0.22**	0.16†
Stocking density *P. vannamei*	0.47***	0.47***	0.46***
Stocking density *P. monodon*	0.09	0.09	0.07
2. Cluster		0.02	−0.02
3. Extension service interactions			0.21**
Input retailers interactions			0.15†
Hatchery and nursery interactions			−0.05
Buyers interactions			0.07
Neighbor interactions			0.07
Extension service trust			−0.07
Input retailers trust			−0.04
Hatchery and nursery trust			0.09
Buyers trust			−0.02
Neighbor trust			0.02
ΔR^2	0.37***	0.00	0.09**
Corrected R^2	0.36***	0.36***	0.41***

Note. Standardized regression coefficients are being reported.
† $p < .10$.
** $p < .01$.
*** $p < .001$.

The final regression analysis regressed disease control practices on the predictor variables (see Table 4). Step 1 controlled for farm characteristics and showed that adoption of disease control practices is significantly related to increased farming intensity of *P. vannamei* and the number of ponds in the farm. Step 2 did not show a relationship between clustering and predicted disease control practices. Upon entering frequency of interaction and levels of trust in Step 3, results showed that interactions with extension services were positively related to disease control practices.

3.2.3. Mediation analyses

Mediation is indicated when the relationship between an independent variable and a dependent one runs via a mediating variable – see Fig. 1 for the research model that describes how clustering leads to the three types of farming practices via frequency of interaction and levels of trust. Hence, mediation means that the independent variable

Table 5
Bootstrap analyses of indirect relationships.

Mediator	Water quality practices				Feed input practices				Disease control input practices			
	Indirect effect	SE	95% CI for indirect effect		Indirect effect	SE	95% CI for indirect effect		Indirect effect	SE	95% CI for indirect effect	
			Lower	Upper			Lower	Upper			Lower	Upper
Ext. service interactions	.06	.04	**.00**	**.16**	.04	.04	-.02	.15	.05	.02	**.01**	**.11**
Input retailers interactions	.00	.03	-.05	.08	.01	.05	-.09	.12	.00	.01	-.02	.03
Hatchery interactions	.01	.03	-.05	.08	.03	.04	-.04	.13	-.01	.02	-.08	.02
Buyers interactions	-.01	.02	-.08	.02	.00	.01	-.05	.01	.00	.01	-.01	.04
Neighbors interactions	.00	.01	-.01	.04	.00	.01	-.04	.01	.00	.01	-.01	.03
Extension service trust	.00	.03	-.06	.07	-.02	.04	-.13	.04	-.02	.02	-.06	.01
Input retailers trust	.01	.02	-.01	.08	.03	.03	-.01	.14	.00	.01	-.01	.04
Hatchery trust	.03	.02	-.00	.10	.05	.04	-.01	.15	.01	.02	-.01	.05
Buyers trust	.00	.01	-.03	.03	.00	.01	-.03	.03	.00	.01	-.01	.01
Neighbors trust	.09	.04	**.01**	**.19**	.07	.04	**.01**	**.18**	.00	.01	-.02	.04

Note. SE = standard error; CI = confidence interval. Significant indirect effects ($p < .05$) are displayed in bold.

influences one or more mediating variables (the mediators), which in turn influence the dependent variable (Baron and Kenny, 1986). Therefore, the mediator provides insight into the underlying process of the relation between the independent and the dependent variables.

The results from the bootstrap analyses for indirect effects are presented in Table 5. The mediation analysis shows the two mediators that can be identified and that can explain the relation between clustering and adoption of water quality management practices – as the value 0 was not included in the respective 95% confidence intervals: interaction frequency with extension service, and trust in neighbors. The other mediators tested were not found to explain the relationship between clustering and adoption of water management practices.

The second bootstrap analysis tested possible indirect pathways between clustering and feed input practices. One mediator indicated that trust in neighbors explains the relation between clustering and feed input practices. However, the other mediators were not found to explain this relationship.

Finally, the third and last bootstrap analysis tested possible indirect pathways between clustering and disease control practices. The results indicated that interactions with extension services formed an indirect pathway between clustering and disease control practices; the other mediators were not found to be significant.

4. Study 2

The results of Study 1 demonstrate that membership in a farmer cluster influences adoption of aquaculture practices by increasing the number of interactions with extension services and input retailers. Farmer cluster membership does not affect trust in external knowledge sources, but mediation analyses show that adoption of feed and water quality technologies is influenced by experienced trust in neighbors. The results show that cluster membership is essential for being exposed to new technologies and knowledge and for establishing trust with peers. However, our understanding of the quality of the relationship with external knowledge sources and with other members of the cluster is limited at best. For example, it is challenging to explain why increased interactions are not automatically linked to increased trust, or why increased trust between peers leads to adoption of aquaculture technology. In order to get more in-depth understanding of the complexity of relationships within and outside farmer clusters, we designed and conducted a second study with a qualitative methodology.

4.1. Method

From March 20th to March 23rd 2019, the research team facilitated 15 focus group discussions (FGDs), including 8 with farmer cluster members and 7 with shrimp farmers not belonging to any farmer cluster. The survey sites were selected randomly within the survey site of Study 1. Focus group discussions were organized with 5 to 8 farmer cluster's representatives and members selected by the provincial Department of Agriculture and Rural Development. A similar selection process was followed for FGDs with non-cluster farmers. FDGs were conducted in Vietnamese, and covered themes regarding interactions with different sources of knowledge, adoption of technology and factors influencing adoption behaviors. The discussion also covered themes related to trust and the type of trust associated with different sources of knowledge and adoption of technology.

Notes were taken throughout the 15 FGDs, and for every FDG a summarizing report was written. Data from the FGDs was analyzed using AtlasTI 8.4. Listed coding (or topic coding) was used to analyze the different sources of information (stakeholders), how they were viewed in terms of trust, value of information provided and general relationship with the source of information. Following study 1, the codes used were: buyer, retailer, neighbor, extension services, hatcheries, trust and institutional trust. Quotes for these codes were classified in two groups: non-cluster farmers, and farmers who were members of a cluster. Based on this first round of coding, two codes were added: media and learning, as these were both regularly referred to as keepers and diffusers of information. Coded data was analyzed per group.

4.2. Results

The different focus group discussions across the Mekong Delta indicated that relations with the different sources of knowledge vary in intensity of interaction and vary in character influencing trust relations and the uptake of practices and technologies. Following our FGDs we can broadly identify three groups: (1) retailers, hatcheries & buyers; (2) extension services; (3) neighbors.

4.2.1. Retailers, hatcheries & buyers

The first group of sources of knowledge was made up of buyers, hatcheries and retailers. For all shrimp farmers, these stakeholders are important sources of specific sets of knowledge. The buyers are seen as an important source of knowledge regarding market prices, the hatcheries about when to start the crop and the retailers for feed and aquaculture techniques. However, for other issues, information or insights, these stakeholders are labeled as “not knowing”, “*they know nothing about [shrimp] cultures*”, and not cooperative “*from the buyers we do not get any recommendations*.” as farmers stated when referring to buyers. Moreover, the information received is met with reluctance and participants indicate that information needs to be verified. As one farmer illustrated: “*We all follow the recommendation from [...] at the hatcheries but the results depend on luck!*” and: “*Our trust is based on experience with the retailers, on listening, testing and evaluating the results. If these are good,* *we trust him; if not, we do not*". Other shrimp farmers are in charge of testing and evaluating. This shows that the interaction with these sources of knowledge is characterized by product information, and that trust in these sources is strongly calculative based upon evaluating new techniques, products and practices with peers.

The participants rated the frequency of interaction with this first group as not very high. However, here we see a difference between farmer cluster members and non-cluster farmers. Farmer cluster members tend to have less frequent contacts with these stakeholders, while non- cluster farmers have more frequent contacts and more long-standing relations. As one of them explained: *"With the retailers the relationship is long, more than 20 years*". This difference is explained by the finding that non-cluster farmers have ample contact with extension services. As such, they rely more heavily on other sources of knowledge, such as, in this this case, mostly the retailers.

4.2.2. Extension services

The second group centered on the interactions between shrimp farmers and extension services. The different members of farmer cluster interviewed valued extension services highly "*We believe the extension service and aquaculture department are scientists, we trust their knowledge*", although they were also critical of the information provided and stated that new methods still needed to be tested to verify whether they would work in local context "*The extension service provides information about general situation, not contextualized. So we need to select the technology that fits our context and situation. We make the selection by ourselves and some people adapt the technology to their investment capacity*". According to our participants, the stronger relation can be explained by three main aspects: 1) by the high level of interaction, varying from several times a year to 2 times per month (depending on the group) in which there is a lot of room for questions and discussion; 2) because of the type of knowledge shared whereby buyers only provide information about markets, retailers about products or of a more technical nature, and finally extension services about broader topics such as climate, disease prevention and development etc.; 3) different groups also expressed trusting the extension services because the representatives are school-educated "*Extension people [...] we believe them because they have a deep knowledge of shrimp farming that they learned in school*". This does not apply to farmers that are not part of a farmer cluster, as extension services mainly focus on farmer clusters. Information from extension services in fact does reach non-cluster farmers mainly through word-of-mouth or when non-cluster farmers discretely visit information sessions. As a result, members of farmer clusters receive knowledge earlier and through more structured interactions than non-cluster farmers. Despite the general trust in knowledge provided by extension services, this creates a delay in the uptake of new techniques and practices amongst non-cluster farmers.

4.2.3. Neighbors

The third group consisted of interactions between shrimp farmers and their neighbors. According to the participants, both members and non-member of a farmer cluster, this third group is very important and had frequent interactions: "*we have been learning from our own experience for the last 20 years. We have been meeting every month to share knowledge in the community house."* Within a farmer cluster, members are each other's key-informant concerning techniques, information and practices. Farmers not belonging to a cluster, on the other hand, rely on their neighbors. The interactions consist of discussing new techniques or products suggested by retailers, buyers or extension services. In addition, interactions also consist of discussing the results of testing new techniques and practices. As a result, the farmer cluster, or neighboring farmers in the case of non-cluster farmer, form communities of practice through which they share and learn. Farmers indicated that these communities allow for room to fail when trying out new practices, which benefit all farmers. In addition, the interactions are characterized by strong collective identity and mutual trust, or as one of the farmers said "*we are farmers, we trust each other*". This characteristic of the interactions positively influences the uptake of techniques and practices, which can be viewed as a two-stage process. First, farmers receive knowledge from buyers, extension services, retailers and hatcheries critically. Second, they discuss and test it at the farm level in farmer communities.

5. Discussion

5.1. Overview of findings

This study explored the processes whereby aquaculture farmer clusters facilitate access to, and foster, trust in specific sources of knowledge, which ultimately enable adoption of technology and practices. We show that shrimp farmers who are members of farmer clusters, relative to those who are not, are more likely to adopt three types of pond management practices (i.e. water quality management, feed input, and disease control practices). The results furthermore show that frequency of interaction with, and trust in, network partners underlie the relationship between clustering and adoption practices; more specifically, interactions with extension services, and trust in neighbors were important in explaining this relationship. Other mediators were not found to be significant, which can be explained by the nature of the interactions and the lack of trust identified during FDGs. More specifically, input retailers, buyers and hatcheries were only valued for their input on specific products and issues, but not trusted as this information always needed being verified through testing (by, amongst others, the neighbors). Consequently, the trust relation with these actors can be described as strongly calculative.

An important observation was that trust in neighbors and extension services was significantly higher for cluster farmers than for non-cluster farmers (Study 1) and the same observation was made during FGDs (Study 2). The FGDs revealed that higher trust in extension services might be explained by the observation that extension services specifically prioritize farmers who are part of clusters over non-cluster farmers. Furthermore, the FGDs also revealed that interactions with neighbors within clusters were more structured, leading to higher reliability and thus trust. The uptake of pond management practices is indeed slower for farmers who do not belong to a cluster because they are more dependent on knowledge sources as a replacement for resources that could have been offered by extension services.

5.2. Theoretical and practical implications

5.2.1. On the importance of trust during the adoption process

Adoption of aquaculture technology and practices is facilitated by effective knowledge transfer from the source of the technology to the users (Brown and Ratna, 2013). Like several other cases (Thompson et al., 2006; Wandji et al., 2012; Dey et al., 2005), we found that extension services are central in conveying knowledge to farmers. However, we show that looking only at interactions with different sources of knowledge is not enough to understand the adoption process, as both the quality and nature of interactions and type of knowledge in relation to the actors are also important determinants. As such we found that trust related to the source of knowledge and type of knowledge plays a key role in the adoption of technology and practice.

Looking at the literature on the adoption of new technologies and practices, it is clear that the role of trust is frequently highlighted (Carolan, 2006). Our two studies underline these findings and show the importance of the role of trust, as both results show the dynamics for adoption both when trust is absent and when it is present. More specifically, our study indicates that both calculative and relational trust play a role (Lewicki et al., 2006). It shows that trust plays a role based on calculative arguments and behavior with actors more at a distance and in relation to specific product information, while trust based on shared identity and relatedness plays a role with actors who are closer and provide a wider variety of information to the shrimp farmers who have more frequent and organized interactions with the knowledge source. In relation to adaptation of practices, our study underlines the need to be more specific when discussing trust, as it is especially relational trust between actors that fosters the adaptation of new agricultural practices, while calculative trust plays a key role in evaluating specific product information.

5.2.2. Implications for better value chain coordination

Within farmer clusters, ties and connections between farmers and with other sector actors seem to be more effective than for non-cluster farmers. Both type of interactions play a significant role in the adoption process. Hence, farmer clusters facilitate both vertical and horizontal coordination to enable innovation (Kilelu et al., 2017a, 2017b). Our findings are in line with previous studies (Omta, 2002; Pittaway et al., 2004; Aguilar-Gallegos et al., 2015), showing that diverse sources of knowledge and higher frequency of interaction increase adoption of new technology. The importance of peers within these networks for adoption is often highlighted (Gielen et al., 2003; Oreszczyn et al., 2010; Cofré-Bravo et al., 2019). In our case, the farmer cluster plays the role of a “closed network” (Cofré-Bravo et al., 2019) for mutual learning and confirming/infirming information received from external (and less trusted) sources. This type of network is characterized by strong ties and trust, as opposed to the “open network”, which is external to the farmer cluster and made of diverse types of stakeholders but with limited trust. As such, our study provides additional insight into the adoption process within farmer clusters by showing not only the importance of diversity of sources of knowledge (Aguilar-Gallegos et al., 2015; Ramirez et al., 2018), but linking this with the trust associated with the knowledge source and the role played by clusters in building trusted relationships.

However, our study provides limited information regarding vertical coordination efficiency, as described in Ha et al. (2013) in the Mekong Delta. Additionally, although we found a clear farmer effect on horizontal coordination, we did not explore the farmer cluster effect on collective action to mitigate disease risk (Bottema, 2019). Moreover, farmer cluster organization and diversity was not explored in detail in this study. That is, the role of relationships, complexity of intra-cluster relationships, and diversity of farmer clusters in their management and collective action was not investigated. The analysis does not allow for identifying the diversity in cluster collective management and their associated outcomes, nor the role of specific individual in the performance of farmer clusters as mentioned by Ha et al., 2013.

The analytical framework use to investigate the research questions has some limitations. First, we limited the number of sources of knowledge, not including media such as TV or radio unless it was brought up by focus group participants in study 2. Second, we did not include other drivers of innovation or influencing the update of innovation, such as regulatory framework and policies. Finally, the analysis does not allow intra-cluster analysis, as well as to take into account the organization and regulation the different clusters and their diversity.

5.2.3. Implications for planners and policy makers

For planners and local authorities, using existing farmer networks to facilitate adoption could be another tool to improve adoption of sustainable technologies and achieve land use planning objectives. A similar approach found in the area-based management of aquaculture supports adoption of quality standards and manages production and financial risks (Bottema et al., 2018; Bottema, 2019). While this research focused on risk management, our findings aligned with their implications to design approaches to convey knowledge and information to farmers in order to further sustainable development of the aquaculture sector in the Mekong Delta's coastal zone. To support adoption of sustainable practices and steer the sector toward sustainable intensification, the private and public sectors should intervene within existing networks of farmers, as a first entry point.

In addition, within the Vietnamese context, farmer clusters can be used as an entry point to a more participatory approach to extension. Literature about aquaculture technologies and practices adoption shows that participatory approaches are more successful than traditional top-down Transfer of Technology approaches (Murshed-E-Jahan et al., 2008; Thompson et al., 2006; Nandeesha et al., 2012). Based on our results we argue that – within the context of Vietnam, where the top-down extension service is still the dominant model (Minh et al., 2010) – using a farmer cluster to create group-based learning can be not only an effective method, but also culturally appropriate within a top-down managing tradition (Schad et al., 2011). State traditions (in this case top-down implementation) are often difficult to change, therefore localized approaches are important, (Friederichsen et al., 2013). Minh et al. (2014) showed that extension workers roles in Vietnam could be fine-tuned to respond to the needs of farmers and facilitate innovation of sustainable practices within groups of farmers.

Although grouping farmers in clusters is a priority of the Vietnamese government, only a limited number of farmers are part of a cluster, leaving the majority of farmers outside the cluster structure and thus less influenced by extension service and other knowledge sources. Therefore, in order to reach more farmers the existing clusters could be used to i) directly integrate outside farmers and/or ii) used as a platform for extension services and access to other source of knowledge. Both options will require new policies and support to either i) support the growth of the existing clusters or ii) diversify the role and function of the cluster as more accessible “platforms” for exchange and knowledge.

Finally, we found that perception of information quality is related to the trust associated with the source of information. Hence, enabling adoption of new technology and practices requires also improved trust between private sector and farmers. From a policy recommendation perspective, updating the regulatory framework (and its enforcement) to improve quality of inputs (post larvae, feed) and their certification mechanisms to fit the farmers' requirements could help to (re)build trust between parties and facilitate adoption.

6. Conclusion

Through this study, we were able to establish that membership in farmer clusters increases interactions with different sources of knowledge, and influences trust in specific sources of knowledge, ultimately increasing the adoption rate of both technology and aquaculture practices. We found that knowledge from private sector partners often needs being verified and that farmer clusters play a key role in such “peer-led validation or verification”. Farmer clusters supported trusting extension services and the knowledge they provide. Furthermore, by helping to structure relationships they also facilitated the development of trust in, and knowledge-sharing between, fellow members. Those findings led to three main policy recommendations:

- Enabling the adoption of sustainable practices will require creating trust in inputs quality. Building trust in input quality will require a reform of the regulatory framework and its enforcement.
- Farmer clusters are key organizational platforms to adoption and dissemination of sustainable aquaculture practices, both for private and public extension services;
- Group learning within farmer clusters is culturally appropriate in the Vietnamese context;

Although farmer clusters were at the center of the study, the organizational governance and underlying mechanisms that facilitate vertical coordination between farmer networks and the broader value chain were not explored in detail. For example, Ha et al. (2013) highlighted the social and political status of farmer cluster's leaders in the performance of the cluster and its capacity to effectively organize with actors of the value chain. Organization, size of the cluster and its dynamics might also play a role in the type and quality of interactions both within the cluster and with actors external to the cluster and partially explain the adoption process. Nonetheless this study demonstrates that farmer clusters can be instrumental in steering smallholding farmers toward sustainable practices by tightening relationships within the farmer cluster and outside of the sector and (re)building trust. Ultimately, these geographical units could be further analyzed to assess their potential for an enhanced horizontal coordination to better mitigate disease risk, one of the major constraints in the aquaculture sector.

Declaration of Competing Interest

The authors declare that they have no conflict of interest.

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Appendix A. Supplementary data

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References

Aguilar-Gallegos, N., Muñoz-Rodríguez, M., Santoyo-Cortés, H., Aguilar-Ávila, J., Klerkx, L., 2015. Information networks that generate economic value: a study on clusters of adopters of new or improved technologies and practices among oil palm growers in Mexico. Agr.Syst. 135, 122–132.

Agyekumhene, C., de Vries, J., van Paassen, A., Macnaghten, P., Schut, M., Bregt, A., 2018. Digital platforms for smallholder credit access: The mediation of trust for cooperation in maize value chain financing. NJAS: Wageningen J. Life Sci. https://doi.org/10.1016/j.njas.2018.06.001.

Baron, R.M., Kenny, D.A., 1986. The moderator–mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. J. Pers. Soc. Psychol. 51, 1173–1182.

Belton, B., Bush, S.R., Little, D.C., 2017. Not just for the wealthy: rethinking farmed fish consumption in the global south. Glob. Food. Secur 1–8. (march) available at. https://doi.org/10.1016/j.gfs.2017.10.005.

Berkes, F., 2009. Evolution of co-management: role of knowledge generation, bridging organizations and social learning. J. Environ. Manag. 90, 1692–1702.

Bijman, J., Wijers, G., 2019. Exploring the inclusiveness of producer cooperatives. Curr. Opin. Environ. Sustain. 41, 74–79.

Blythe, J., Sulu, R., Harohau, D., Weeks, R., Schwarz, A.M., Mills, D., Phillips, M., 2017. Social dynamics shaping the diffusion of sustainable aquaculture innovations in the Solomon Islands. Sustain 9. https://doi.org/10.3390/su9010126.

Bottema, M.J.M., 2019. Institutionalizing area-level risk management : limitations faced by the private sector in aquaculture improvement projects. Aquaculture 512 (July), 734310. Available at. https://doi.org/10.1016/j.aquaculture.2019.734310.

Bottema, M.J.M., Bush, S.R., Oosterveer, P., 2018. Moving beyond the shrimp farm: spaces of shared environmental risk? Geogr. J. https://doi.org/10.1111/geoj.12280.

Boyd, C.E., Engle, C., 2017. Resource use assessment of shrimp, Litopenaeus vannamei and Penaeus monodon, production in Thailand and Vietnam. J. World Aquacult. Soc. 48 (2), 201–226.

Brown, B., Ratna, F., 2013. Fish farmer field school: towards healthier milkfish/shrimp polyculture and fish farmer empowerment in South Sulawesi. Aquacu. Asia 18 (2), 12–19.

Brugere, C., Mark, D., Ll, K., 2017. People matter in animal disease surveillance : challenges and opportunities for the aquaculture sector. Aquaculture 467, 158–169. Available at. https://doi.org/10.1016/j.aquaculture.2016.04.012.

Brunori, G., Rossi, A., 2000. Synergy and coherence through collective action: some insights from wine routes in Tuscany. Sociol. Rural. 40, 409–423.

Bush, S.R., Belton, B., 2012. Out of the factory and into the fish pond can certification transform Vietnamese Pangasius? Food practices in transition: changing food consumption, retail and production in the age of reflexive modernity. In: Spaargaren, G. (Ed.), Food in a Sustainable World: Transitions in the Consumption, Retail And Production of Food. Anne Loeber and Peter Oosterveer, Routledge, London, pp. 257–290.

Bush, S.R., Van Zwieten, P.A.M., Visser, L., Van Dijk, H., Bosma, R., 2010. Scenarios for resilient shrimp aquaculture in tropical coastal areas. Ecol. Soc. 15 (2).

Bush, S.R., Belton, B., Hall, D., Vandergeest, P., Murray, F.J., Ponte, S., Oosterveer, P.J.M., Islam, M.S., Mol, A.P.J., Hatanaka, M., Kruijssen, F., Ha, T.T.T., Little, D.C., Kusumawati, R., 2013. Certify sustainable aquaculture? Science (80-.) 341, 1067–1068. https://doi.org/10.1126/science.1237314.

Carolan, M., 2006. Social change and the adoption and adaptation of knowledge claims: whose truth do you trust in regard to sustainable agriculture? Agric. Hum. Values 23, 325–339.

Chan, K.-Y.A., Oerlemans, L.A.G., Pretorius, M.W., 2010. Knowledge exchange behaviours of science park firms: the innovation hub case. Tech. Anal. Strat. Manag. 22 (2), 207–228.

Cofré-Bravo, G., Klerkx, L., Engler, A., 2019. Combinations of bonding, bridging, and linking social capital for farm innovation: how farmers configure different support networks. J. Rural. Stud. 69, 53–64.

Creswell, J.W., 2014. Research Design: Qualitative, Quantitative and Mixed Methods Approaches, 4th ed. Sage, Thousand Oaks, CA.

De Vries, J.R., Van Bommel, S., Peters, K., 2017. Where there is no history: how to create trust and connection in learning for transformation in water governance. Water 9 (2), 130–145.

Devaux, A., Horton, D., Velasco, C., Thiele, G., Lopez, G., Bernet, T., Reinoso, I., Ordinola, M., 2009. Collective action for market chain innovation in the Andes. Food Policy 34, 31–38.

Dey, M.M., Paraguas, F.J., Srichantuk, N., Xinhua, Y., Bhatta, R., Dung, L., 2005. Technical efficiency of freshwater pond polyculture production in selected Asian countries. Aquac. Econ. Manag. 9 (1–2), 39–63.

Diedrich, A., Blythe, J., Petersen, E., Euriga, E., Fatchiya, A., Shimada, T., Jones, C., 2019. Socio-economic drivers of adoption of small-scale aquaculture in Indonesia. Sustainability 1–15. https://doi.org/10.3390/su11061543.

Dirven, M., 2001. Dairy clusters in Latin America in the context of globalization Int. Food Agribus. Man. 2 (3/4), 301–313.

Drogoul, A., Huynh, N.Q., Truong, Q.C., 2016. Coupling environmental, social and economic models to understand land-use change dynamics in the Mekong delta. Front. Environ. Sci. 4, 19. https://doi.org/10.3389/fenvs.2016.00019.

Dung, L.C., Tuan, V.V., Tuan, L.A., Huan, T.T.N., Long, P.K., 2017. Participatory water management for reducing risk of shrimp diseases in coastal areas of the Vietnamese Mekong Delta. In: Lower Mekong Public Policy Initiative. Policy Brief. 7.

Engle, C.R., Mcnevin, A., Racine, P., Boyd, C.E., Paungkaew, D., Viriyatum, R., Tinh, H.Q., Minh, H.N., 2017. Economics of sustainable intensification of aquaculture: evidence from shrimp farms in Vietnam and Thailand. J. World Aquacult. Soc. 48 (2), 227–239.

FAIRR, 2019. Shallow returns? ESG risk and opportunities in aquaculture. In: FAIRRinitiatives, pp. 15.

FAO, 2018. The State of World Fisheries and Aquaculture 2018. Rome, FAO.

FAO, 2019. http://www.fao.org/fishery/sofia/en Accessed June 2019.

Fazey, I., Evely, A., Reed, M., Stringer, L., Kruijssen, J., White, P., Newsham, A., Jin, L., Cortazzi, M., Phillipson, J., 2012. Knowledge exchange: a review and research agenda for environmental management. Environ. Conserv. 40, 19–36.

Friederichsen, R., Minh, T.T., Neef, A., Hoffmann, V., 2013. Adapting the innovation systems approach to agricultural development in Vietnam: challenges to the public extension service. Agric. Hum. Values 30 (4), 555–568. Available at: https://doi.org/10.1007/s10460-013-9433-y.

Gielen, P.M., Hoeve, A., Nieuwenhuis, L.F.M., 2003. Learning entrepreneurs: learning and innovation in small companies. Eur. Educ. Res. J. 2, 90. https://doi.org/10.2304/eerj.2003.2.1.13.

GSO, 2016. General Statistics Office of Vietnam. https://www.gso.gov.vn/default_en aspx?tabid=778, Accessed date: May 2019.

Ha, T.T.T., Bush, S.R., van Dijk, H., 2013. The cluster panacea? Questioning the role of cooperative shrimp aquaculture in Vietnam. Aquaculture 388–391 (1), 89–98.

Hu, C., Zhang, X., Reardon, T., Hernandez, R., 2019. Value-chain clusters and aquaculture innovation in Bangladesh. Food Policy. https://doi.org/10.1016/j.foodpol.2017.07.009. 0–1.

Joffre, O.M., Bosma, R.H., 2009. Typology of shrimp farming in Bac Lieu Province, Mekong Delta, using multivariate statistics. Agric. Ecosyst. Environ. 132 (1–2), 153–159.

Joffre, O.M., Poortvliet, P.M., Klerkx, L., 2018. Are shrimp farmers actual gamblers? An analysis of risk perception and risk management behaviors among shrimp farmers in the Mekong Delta. Aquaculture 495 (April), 528–537.

Joffre, O.M., Poortvliet, P.M., Klerkx, L., 2019. To cluster or not to cluster farmers? In fl uences on network interactions, risk perceptions, and adoption of aquaculture practices. Agric. Syst. 173, 151–160.

Kassam, L., Subasinghe, R., Phillips, M., 2011. Aquaculture farmer organizations and cluster management. Concept and experiences. In: FAO Fisheries and Aquaculture Technical Paper 563. FAO, Rome.

Kilelu, C., Klerkx, L., Leeuwis, C., 2017a. Supporting smallholder commercialization by enhancing integrated coordination in agrifood value chains: experiences with dairy hubs in Kenya. Exp. Agric. 53 (2), 269–287.

Kilelu, C., Klerkx, L., Omore, A., Baltenweck, I., Leeuwis, C., Githinji, J., 2017b. Value chain upgrading and the inclusion of smallholders in markets: reflections on contributions of multi-stakeholder processes in dairy development in Tanzania. Eur. J. Dev. Res. 29, 1102–1121.

Kuehne, G., Llewellyn, R., Pannell, D.J., Wilkinson, R., Dolling, P., Ouzman, J., Ewing, M., 2017. Predicting farmer uptake of new agricultural practices: a tool for research, extension and policy. Agric. Syst. 156, 115–125.

Kumar, G., Engle, C., Tucker, C., 2018. Factors driving aquaculture technology and practice. J. World Aquacult. Soc. 49 (3), 447–476.

Lambrecht, E., Kühne, B., Gellynck, X., 2014. How do innovation partners differ with

respect to innovation type and stage in the innovation journey of farmers? Int. J. Entrep. Innov. 15, 191–203.
Le, T.N., Bregt, A.K., van Halsema, G.E., Hellegers, P.J.G.J., Nguyen, L.D., 2018. Interplay between land-use dynamics and changes in hydrological regime in the Vietnamese Mekong Delta. Land Use Policy 73, 269–280.
Lebel, P., Sriyasak, P., Kallayanamitra, C., Duangsuwan, C., Lebel, L., 2016. Learning about climate-related risks: decisions of northern Thailand fish farmers in a role-playing simulation game. Reg. Environ. Chang. 16, 1481–1494. https://doi.org/10.1007/s10113-015-0880-4.
Leeuwis, C., 2000. Reconceptualizing participation for sustainable rural development: towards a negotiation approach. Dev. Chang. 31, 931–959.
Lewicki, R., Bunker, B., 1996. Developing and maintaining trust in work relationships. In: Kramer, R.M., Tyler, T.R. (Eds.), Trust in Organizations. Sage, Thousand Oaks, CA, USA, pp. 114–139.
Lewicki, R., Tomlinson, E.C., Gillespie, N., 2006. Models of interpersonal trust development: theoretical approaches, empirical evidence, and future directions. J. Manag. 32 (6), 991–1022.
Matous, P., 2015. Social networks and environmental management at multiple levels: soil conservation in Sumatra. Ecol. Soc. 20, 37.
Minh, T.T., Larsen, C.E.S., Neef, A., 2010. Challenges to institutionalizing participatory extension: the case of farmer livestock schools in. J. Agric. Educ. Ext. 16, 179–194. https://doi.org/10.1080/13892241003651449.
Minh, T.T., Friederichsen, R., Neef, A., Hoffmann, V., 2014. Niche action and system harmonization for institutional change: prospects for demand-driven agricultural extension in Vietnam. J. Rural. Stud. 36, 273–284. https://doi.org/10.1016/j.jrurstud.2014.09.008.
Mohan, C.V., De Silva, S.S., 2010. Better management practices (BMPs) — gate way to ensuring sustainability of small scale aquaculture and meeting modern day market challenges and opportunities. Aquacul. Asia Mag. 15 (1), 9–14.
Molema, M., Segers, Y., Karel, E., 2016. Introduction: agribusiness clusters in Europe, 19th and 20th centuries. Tijdschrift voor Sociale en Economische Geschiedenis 13 (4), 1–16.
Murshed-E-Jahan, K., Beveridge, M.C.M., Brooks, A.C., 2008. Impact of long-term training and exten- Sion support on small-scale carp polyculture farms of Bangladesh. J. World Aquacult. Soc. 39, 441–453.
Nandeesha, M.C., Halwart, M., García Gómez, R., Alvarez, C.A., Atanda, T., Bhujel, R., Bosma, R., Giri, N.A., Hahn, C.M., Little, D., Luna, P., Marquez, G., Ramakrishna, R., Reantaso, M., Umesh, N.R., Villareal, H., Wilson, M., Yuan, D., 2012. Supporting farmer innovations, recognizing indigenous knowledge and disseminating success stories. In: Subasinghe, R.P., Arthur, J.R., Bartley, D.M., De Silva, S.S., Halwart, M., Hishamunda, N., Mohan, C.V., Sorgeloos, P. (Eds.), Farming the waters for people and food. Proceedings of the Global Conference on Aqua- culture 2010. 2010. FAO and NACA, Rome, Italy; Bangkok, Thailand, pp. 823–875 Phuket, Thailand, September 22–25.
Ngoc, P.T.A., Meuwissen, M.P.M., Le, T.C., Bosma, R.H., Verreth, J., Lansink, A.O., 2016. Adoption of recirculating aquaculture systems in large pangasius farms: a choice experiment. Aquaculture 460, 90–97. https://doi.org/10.1016/j.aquaculture.2016.03.055.
Nguyen, T.T.N., Tran, H.C., Ho, T.M.H., Burny, P., Lebailly, P., 2019. Dynamics of farming systems under the context of coastal zone development : the case of Xuan Thuy. Agriculture 9, 138. https://doi.org/10.3390/agriculture9070138.
Omta, O., 2002. Innovation in chains and networks. J. Chain Net. Sci. 2 (2), 73–80.
Oreszczyn, S., Lane, A., Carr, S., 2010. The role of networks of practice and webs of influencers on farmers' engagement with and learning about agricultural innovations. J. Rural. Stud. 26, 404–417. https://doi.org/10.1016/j.jrurstud.2010.03.003.
Pahl-Wostl, C., 2009. A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. Glob. Environ. Chang. 19, 354–365.
Piamsomboon, P., Inchaisri, C., Wongtavatchai, J., 2015. White spot disease risk factors associated with shrimp farming practices and geographical location in Chanthaburi province, Thailand. Dis. Aquat. Org. 117 (2), 145–153.
Pittaway, L., Robertson, M., Munir, K., Denyer, D., Neely, A., 2004. Networking and innovation: a systematic review of the evidence. Int. J. Manag. Rev. 5–6 (3–4), 137–168.
Porter, M.E., 2000. Location, competition, and economic development: local clusters in a global economy. Econ. Dev. Q. 14 (1), 15–34.
Preacher, K.J., Hayes, A.F., 2004. SPSS and SAS procedures for estimating indirect effects in simple mediation models. Behav. Res. Methods 36, 717–731.
Ramirez, M., Clarke, I., Klerkx, L., 2018. Analysing intermediary organisations and their influence on upgrading in emerging agricultural clusters. Environ. Plan. A: Econ. Space 50, 1314–1335.
Reed, M., 2008. Stakeholder participation for environmental management: a literature review. Biol. Conserv. 141, 2417–2431.
Schad, I., Roessler, R., Neef, A., Valle Zárate, A., Hoffmann, V., 2011. Group-based learning in an authoritarian setting? Novel extension approaches in Vietnam's northern uplands. J. Agric. Educ. Ext. 17, 85–98. https://doi.org/10.1080/1389224X.2011.536359.
Schoorman, F.D., Mayer, R.C., Davis, J.H., 2007. An integrative model of organizational trust: past, present, and future. Acad. Manag. Rev. 32, 344–354.
Thompson, P.M., Firoz Khan, A.K.M., Sultana, P., 2006. Comparison of aquaculture extension impacts in Bangladesh. Aquac. Econ. Manag. 10, 15–31.
Tran, H., Nguyen, Q., Kervyn, M., 2018. Land Use Policy Factors Influencing people ' s knowledge, Attitude, and Practice in Land Use Dynamics: A Case Study in Ca Mau province in the Mekong delta, Vietnam. Land Use Policy. 72. pp. 227–238. December 2017. Available at. https://doi.org/10.1016/j.landusepol.2017.12.009.
Umesh, N.R., Mohan, C.V., Phillips, M.J., Bhat, B.V., Ravi Babu, G., Chandra Mohan, A.B., Padiyar, P.A., 2008. Risk analysis in aquaculture – Experiences from small-scale shrimp farmers of India. In: Bondad-Reantaso, M.G., Arthur, J.R., Subasinghe, R.P. (Eds.), Understanding and Applying Risk Analysis in Aquaculture. FAO Fisheries and Aquaculture Technical Paper. No. 519. FAO, Rome, pp. 247–264.
Van der Lee, J., Klerkx, L., Bebe, B.O., Mengistu, A., Oosting, S., 2018. Intensification and upgrading dynamics in emerging dairy clusters in the east African highlands. Sustainability 10, 4324.
Wandji, D.N., Pouomogne, V., Binam, J.N., Nouaga, R.Y., 2012. Farmer ' s perception and adoption of new aquaculture Technologies in the Western Highlands of Cameroon. Tropicultura 30 (3), 180–184.
World Bank, 2013. FISH to 2030-Prospects for Fisheries and Aquaculture. Washington DC, USA.
World Bank, 2014. Reducing disease risk in aquaculture. In: Agricultural and Environmental Services Discussion Paper 09. Washington.
Zhong, Z., Zhang, C., Jia, F., Bijman, J., 2018. Vertical coordination and cooperative member benefits: case studies of four dairy farmers' cooperatives in China. J. Clean. Prod. 172, 2266–2277.