SUSTAINABLE DEVELOPMENT OF EXPORT-ORIENTATED FARMED SEAFOOD IN MEKONG DELTA, VIETNAM

By

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DECLARATION

I do hereby declare that this thesis has been achieved by myself and is the result of my own investigations. The work presented in this thesis has not previously been submitted for any other degree or qualification.

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ABSTRACT

Aquaculture is playing an important role in the development of fisheries in Vietnam, a role which has accelerated since 2000. Sustainability in aquaculture is receiving increasing attention, and this issue is not only the concern of government, but also stakeholders participating in the value chain. Therefore, this study aims to identify sustainability issues of farmed seafood by assessing the main sustainability issues raising concern. The Global Value Chain framework described by Gereffi et al. (2005) is applied for this study to explore the business relationships in supply chain and the perceptions of sustainability concerned by the value chain actors. A combination of qualitative and quantitative methods was used to collect data. An assessment of four species cultured on the Mekong Delta, the countries farmed seafood 'hub', found a clear distinction between species cultured with a local domestic market orientation (Giant Freshwater Prawn *Macrobrachium rosenbergii*; and Tilapia *Oreochromis niloticus*) and the two key export commodities - Striped catfish (*Pangasianodon hypophthalmus*) and Penaeid shrimp *(Penaeus monodon & Litopenaeus vannamei*). These orientations were based on a range of factors including the development of effective seed supplies and the cultural value of marketing in the live format. This study, conducted in ten provinces in the Mekong Delta from 2009 to 2013 had a focus on understanding the export-orientated commodities, striped catfish and shrimp through collection of baseline information on the value chain of farmed seafood, focusing on the farming sector, the actors and institutions involved and beneficiaries. Sustainability issues and perceptions of experts (top-down) and primary stakeholders (bottom-up) opinions were assessed through participatory workshops.

Shrimp and striped catfish production are mainly farmed for export, with 83% and 95% of its production, respectively, leaving the country mainly after processing. Currently, mainly families operate small-/medium-scale farms; while large-farms are integrated within seafood processors. Production efficiency of large-farms tends to be better than small-/medium farms. Many striped catfish and shrimp farms are likely to reach several standard criteria such as economic feed conversion ratio (eFCR), stocking density, no banned chemical/drug and wild-seed use, and land property rights; however, there were still many standard criteria that existing farms could not meet such as effluent management, farm registration, fishmeal control, farm hygiene and record-keeping requirement. Hence, current farming practices, especially small-/medium farms have a long way to go to meet emergent international food standards. Recently, many small-/medium catfish farms faced problems with low fish prices, so they have had to cease catfish farming activities and temporarily stop farming; while some larger farms also had to temporarily stop farming. Therefore, fish price has tended to be a main driving force for catfish farm changes. In the shrimp industry, there were technical changes occurring in the high intensity level of shrimp farms (HiLI); whereas, the remaining shrimp farms had fewer changes in farm management. Most HiLI shrimp farms were affected by AHPNS disease, which was a main factor driving their farm changes.

Many perceptions of sustainability were identified by stakeholder groups, however seven sustainability issues had a high level of agreement among stakeholders including *input cost, capital & credit costs, unstable markets, government regulation & policy*, *disease, seed quality, water quality and water availability* factors. Hatcheries, farmers and manager groups were more concerned about environmental issues; while for the input suppliers and processors, economics was the main issue. Farmers and processors were two main actors that played an important role in the production process of the value chain. Small-/medium farms dominated the number of farms overall and still played an important role in primary production. However, small-scale farms were considered as more vulnerable actors in the value chain, and they faced more difficulties in meeting increasing requirements on food quality/safety. To maintain the position in the value chain, the solutions could be horizontal and vertical coordination. Thus policy makers will need to find ways to include them in the planning processes. To reach sustainability will require the efforts of direct stakeholders, the role of the state agencies is essential in negotiation and diplomacy to create partnerships with the seafood importing countries. However, efforts to develop sustainable production become impossible without participation from importers, retailers and consumers.

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ABBREVIATIONS

AHPNS	Acute Hepatopancreatic Necrosis Syndrome
AIS	Agricultural innovation system
ASC	Aquaculture Stewardship Council
BAP	Best aquaculture practices
BMP	Better management practices
BNP	Bacillary Necrosis of Pangasius
BOD	Biological Oxygen Demand
BTS	Black tiger shrimp
CoC	Code of conduct
COD	Chemical Oxygen Demand
CTU	Can Tho University
DO	Dissolved Oxygen
DoAH	Department of Animal Health
DOFI	Department of Fisheries
DPSIR	Driving force-pressure-state-impact-response
EF	Extended family
eFCR	Economic Feed Conversion Ratio
EMS	Early mortality syndrome
FAO	Food and Agriculture Organization
FM	Fish mortality
GAA	Global Aquaculture Alliance
GAP	Good aquaculture practice
GFP	Giant freshwater prawn
GSO	General Statictics Office
GSSI	Global Sustainable Seafood Initiative
GVC	Global value chain
HiLI	High level of investment
HOSO	Head-on Shell-on
IDS	In-depth survey
IFS	Integrated farm survey

LoLI	Low level of investment
MARD	Ministry of Agriculture & Rural Development
MAS	Motile Aeromonad Septicaemia
MKD	Mekong Delta
MOFI	Ministry of Fisheries
MT	Metric tonnes
NGO	Non Government Organization
PCR	Polymerase Chain Reaction
PL	Post larvae
RASFF	Rapid Alert System for Food and Feed
RIA	Research Institute for Aquaculture
SC	Standards categories
SD	Stocking density
ShAD	Shrimp aquaculture dialoges
SIn	Sustainability indicator
SIs	Sustainability issues
SoS	State of system
SPF	Specific pathogen free
SPSS	Statistical Package for the Social Sciences
SR	Survival rate
TLS	Telephone survey
TSS	Total suspended solids
US$	US Dollars
VASEP	Vietnamese Association of Seafood Exporters and Producers
VIFEP	Vietnamese Institute of Fisheries and Economic Planning
VINAFIS	Vietnamese Fisheries Society
VND	Vietnam Dong (Vietnam currency)
WLS	White-legged shrimp
WSSV	White Spot Syndrome Virus
YHV	Yellow Head Virus

CHAPTER 1

Introduction and Literature review

1.1. Rationale for conducting research

Vietnam is a major seafood exporter with products being sold to more than 163 countries (MARD 2009a; VASEP 2010). Aquaculture plays an important role in fisheries development, having grown rapidly since 2000 (MARD 2009b). Shrimp and striped catfish are considered as the main target species for farmed seafood exports in Vietnam up to 2020 (MARD 2009b; MARD 2009c; GOV 2013). In 2013, shrimp and striped catfish products accounted for 46% and 26% of seafood export value, respectively (Fisheries Directorate 2014). The Mekong Delta ($8^{0}33'$-$10^{0}55'N$, $104^{0}30'$-$106^{0}50'E$), the termination of the Lower Mekong Basin (Van Zalinge et al. 2004; Vu & Phan 2008), is popularly referred as the food basket of Vietnam (Phan et al. 2009; De Silva 2012). The aquaculture sector in the Mekong Delta (MKD) made up 76% of shrimp and all of the striped catfish exports in 2013 (Fisheries Directorate 2014). Striped catfish is produced intensively on a relatively small area (6,000ha) concentrated along main channels of the Mekong (*Tien*) and Bassac (*Hau*) rivers and primary canals; there are potentially large inland areas including 13,000ha available for further development, which 10,000ha of them planned for catfish farming in the master plan up to 2020 (MARD 2009; Nguyen et al. 2009; VIFEP 2009; GOV 2013). Shrimp is produced in a range of different systems located along a broad coastal belt stretching from Ca Mau province in the southwest tip to Long An province in the east (Nguyen et al. 2009; VIFEP 2009b). An analysis of the current status of farming practices shows that family-operated farms still dominate in terms of culture area and production (Phan et al. 2009; Tran et al. 2013). An assessment of current farming practices based on farm characteristics and allocation into different categories can help to show a clearly comprehensive view of the catfish and shrimp farming. Such an analysis can contribute to improved understanding useful for managers and policy makers, and lead to improved policies and management that are likely to differ by farm category.

Certifiers of aquaculture products increasingly require evidence of environmental protection and social responsibility that some types of farms may fulfill more easily than others. Technical barriers affecting long-term development of production are unlikely to be scale neutral; small-scale farms often particularly suffer from limited farm infrastructure and capital investment (Dey & Ahmed 2005; Siar & Sajise 2009; Umesh et al. 2009; Belton et al. 2011; Washington & Ababouch 2011). Market trends towards increased demand for certified products are likely to continue (Corsin et al. 2007; Reilly 2007; Yamprayoon & Sukhumparnich 2010). Increasingly consumers are interested in the process through which a product is produced, and consumers are increasingly concerned about the farming practices (Bush & Oosterveer 2007; Corsin et al. 2007; Reilly 2007; Brunori et al. 2011; Bush & Belton 2012; Han & Immink 2013). Therefore, an assessment of the gaps between the range of current farming practices and standard criteria required for certification are critical. Equally those responsible for certification that may disadvantage certain producers need to be aware of development trends and evolution within the sector as well as the potential impacts of these changes on the various actors involved. Understanding of changes on the farm over time and what needs to be improved to ensure sustainable development is necessary. Furthermore, sustainable development of a value chain will be affected by many actors, of which farmers are only one, so any changes at the farm level will also impact on the value chain (Khoi 2007; Vo et al. 2009a; Le 2011; Le et al. 2011; Khoi 2011).

Aquatic animal products play an important role in the world's food system, and the market for them is growing strongly (Busch & Bain 2004; Valdimarsson 2007; Subasinghe et al.

2009; Young et al. 2011; Belton & Bush 2014). To satisfy the high demand for seafood products, aquaculture has been undergoing diversification of farmed species and intensification of production systems (Lin & Yi 2003; Crab et al. 2007; Bosma & Verdegem 2011). Food is a major issue in the politics of sustainable consumption and production because of its impact on the environment, economy and social cohesion (Neiland et al. 2001; Crab et al. 2007; De Silva & Hasan 2007; Kluts et al. 2012; Reisch et al. 2013). In Vietnam, since 2000, limits for aquaculture development have been identified (Nguyen et al. 2009; Tuan et al. 2013) that acknowledge i) development of aqua-farming is unstable and has a high risk; ii) aquaculture has been a cause of environmental pollution of soil and water; iii) the operational linkages among stakeholders along the value chain of farmed species are limited; and iv) guaranteed food safety standards for farmed production are insufficient. As an outcome, sustainability issues have been made a higher priority in the master plan of the fisheries sector up to 2020 (Nguyen et al. 2009; MARD 2009b; GOV 2013). Although sustainable development has become a target for aquaculture planners (MARD 2009b; MARD 2009c); its value has been to direct strategies for future development in general. There has been a lack of specific analysis on factors that drive sustainability, such as the role of value chain actors and which factors influence their operations, etc. Value chains of aquatic production typically include many stakeholders, either as direct, indirect or supporting actors. To upgrade a value chain towards sustainable development, clarification on current practices and the role of stakeholders along the value chain are needed. Consideration of the gradually increasing interest in sustainable food consumption (Subasinghe et al. 2009; Bostock et al. 2010; Brunori et al. 2011; Reisch et al. 2013), an understanding of the perceptions of sustainability issues by different stakeholder groups along value chains and their corresponding measurement tools should be within the scope of the planning process. Thus, this study aims to identify the sustainability issues of striped catfish and shrimp industries by assessing what the main sustainability issues are raising concern. These are likely to encompass social, economic and environmental factors at a defined level in the system hierarchy in the context of this study. The further expectation of this study is to develop a framework for sustainability assessment of aquatic farmed products. This chapter begins with a literature review of sustainability issues and certification in the aquaculture sector. This is followed by an introduction to research, including research objectives, research scope and structure of the thesis.

1.2. Sustainability issues in Aquaculture development

1.2.1. Sustainability development

a). Sustainable development concept

There are various definitions of terms used by different authors and organizations, that are synonyms for sustainable development such as, 'green chemistry', 'cleaner production' and 'pollution prevention', etc. (Glavič & Lukman 2007; Bell & Morse 2008). The general definition of sustainable development defined by the International Institute for Sustainable Development is: *"Sustainable development is not a 'fixed state of harmony'. Rather, it is an ongoing process of evolution in which people take actions leading to development that meets their current needs without compromising ability of future generations to meet their own needs"* (Hardi & Zdan 1997).

Sustainability in the context of sustainable development is characterized by its many dimensions (Sheriff 2004; Bell & Morse 2008). Sustainability can be defined by principles that have environmental and ecological, economic, and societal dimensions (Lehtonen 2004; Glavič & Lukman 2007; Simard et al. 2008; SustainAqua 2009). Disregard of any of these three dimensions of sustainable development cannot adequately address sustainability (Sheriff 2004; Setthasakko 2007). Three-dimensional principles can serve as a basis for building a more complex system (Glavič & Lukman 2007). The definition of the system in a sustainability context allows us to determine what it is we are trying to sustain (Sheriff 2004; Bell & Morse 2008). The system is a whole and has the potential to change itself; the system is involved with its own sustainability; it can change as its environment alters in order to be sustained (Bell & Morse 2008). Sustainable systems present the highest level of activities required to make progress towards sustainable development (Glavič & Lukman 2007). Sustainable development emphasizes the evolution of human society from a responsible economic point of view, in accordance with environmental and natural processes. Furthermore, in the sustainable development paradigm the limitations of economic, societal and environmental resources are considered in order to contribute to present and future generations' welfare and can be applied at local, regional, national and international levels (Glavič & Lukman 2007). However, sustainability is vaguely defined and it does not provide explicit directions as to what the values of sustainable development are and little guidance on how to set priorities (Olesen et al. 2010). In the literature, there is frequent reference to two types of sustainability depending upon the costs incurred in attaining them: *strong* and *weak sustainability*. Strong sustainability implies that the environment is critical for our, and our children's, survival, and that any damage will have negative repercussions. It equates to what some call ecological sustainability and the focus is primarily on the environment (Sheriff 2004; Bell & Morse 2008; Gandini et al. 2009; Ekins 2011). Weak sustainability equates to a sort of economic sustainability where the emphasis is upon allocation of resources and levels of consumption, and financial value is a key element of system quality. Of these two, weak sustainability currently dominates in the global economy (Sheriff 2004; Bell & Morse 2008).

b). Innovation and agriculture development

Development enables agriculture and people to adapt when challenges occur and to respond readily when opportunities arise; because agriculture's characteristics, including physical, social and economic environment, change continually (Juma 2011; World Bank 2012). The World Bank (2012) noted that agricultural development depends on innovation, and innovation is recognised as a major source of improved productivity, competitiveness, and economic growth throughout advanced and emerging economies (Sumberg 2005; World Bank 2006; Spielman et al. 2009; Juma 2011; World Bank 2012). However, innovation in addition to technology, also includes social and institutional change; and has a systemic and co-evolutionary nature (Biggs 1990; Kilelu et al. 2013). Innovation also plays an important role in creating jobs, generating income, alleviating poverty, and driving social development (Sumberg 2005; Juma 2011; World Bank 2012). In this regard to the context, markets, globalization and a changing environment not only influence patterns of consumption, competition and trade, but also drive agricultural development and innovation (World Bank 2012). Actors involved in the value chain and in providing knowledge providing interact in new ways to generate ideas or develop responses to changing agricultural conditions (World Bank 2006; World Bank 2012). If the actors (farmers, agribusinesses, and even nations) are to cope, compete and thrive in the midst of changes in agriculture, they must innovate continuously (Juma 2011; EU SCAR 2012; World Bank 2012). Therefore, the agriculture sector is required to continually innovate if it is to contribute to sustainable development. In this context, the agricultural innovation system (AIS) approach has advocated as a framework for understanding bottlenecks and identifying opportunities for enhancing the innovation capacity of agricultural systems (World Bank 2006; World Bank 2012; Kilelu et al. 2013).

The AIS framework has been increasingly applied to analyze technological, economical and institutional change in the agriculture sector (Hall et al. 2003; Temel et al. 2003; Sumberg 2005; World Bank 2006; Spielman et al. 2008; Spielman et al. 2009; Klerkx et al. 2010; Juma 2011; EU SCAR 2012; World Bank 2012; Kilelu et al. 2013). The AIS approach shows innovation is the process of networking and interactive learning among multiple actors, such as farmers, input industries, processors, traders, researchers, government officials, and civil society organizations (World Bank 2006; Klerkx et al. 2010; Juma 2011; EU SCAR 2012; World Bank 2012). An innovation system can be defined as a system of innovation that involves these multiple actors and their interactions that involved in the production, use of knowledge, and the institutional and policy context that shapes the processes of interacting, knowledge sharing and learning (Sumberg 2005; World Bank 2006; Spielman et al. 2009; Juma 2011; EU SCAR 2012; World Bank 2012; Hermans et al. 2013; Hall 2014). An orchestrated innovation system has three main phases of development (World Bank 2006; Juma 2011; EU SCAR 2012): i) *pre-planned phase,* in which no research or other policy intervention has been made, as new opportunities have not yet been identified; ii) *foundation phase,* priority sectors and commodities have been identified, and the government supports them through research and policy interventions; and iii) an *expansion phase*, the government intervenes with projects and special programmes to link actors in the innovation system. Agricultural innovation typically arises through dynamic interaction among the actors who involved in value chain (i.e. growing, processing, packaging, distributing, and consuming or otherwise using agricultural products), and thus interactions between these diverse actors need to be open and to draw upon the most appropriate available knowledge (Juma 2011; EU SCAR 2012; World Bank 2012).

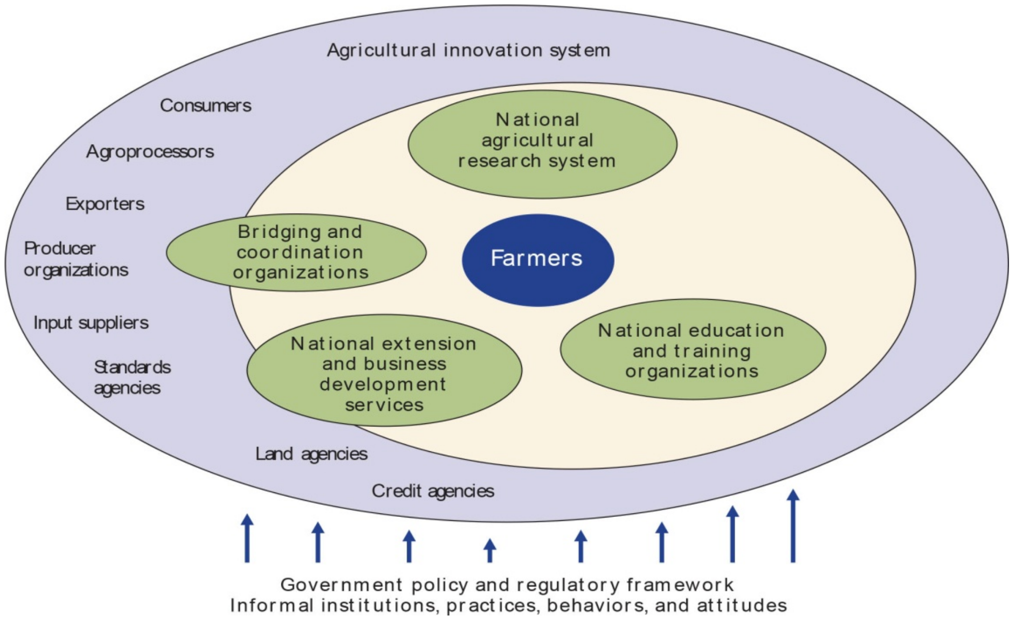

Figure 1.1. An Agriculture Innovation System: conceptual framework
Source: Rivera et al. (2006); World Bank (2012)

In general, AIS principles and action integrate the more traditional interventions with the other complementary interventions needed for innovation to take place. The interventions include providing the professional skills, incentives, and resources to develop partnerships and businesses; improving knowledge flows; and ensuring conditions that enable actors to innovate (World Bank 2012). Figure 1.1 shows the main actors including typical agricultural knowledge and technology providers and users, and the bridging or intermediary institutions that facilitate their interaction. The potential interactions between actors; and the agricultural policies and informal institutions, attitudes, and practices that either support or hinder the process of innovation also presents in this figure (World Bank 2006; World Bank 2012). AIS framework is a concept to describe a system of innovation, with emphasis on the organizations involved, the links and interactions between them. This figure also reflects that there are many more actors in the value chain that directly influence the decision making of farmers and their innovations (EU SCAR 2012).

In regards to the aquaculture sector, aquaculture is one of the fastest growing agro-food sectors globally, and this phenomenon is often referred to as the ‘blue revolution’ (Ponte et al. 2014). The ‘blue revolution’ in aquaculture sector rapidly increased productivity through technology-driven intensification of aquaculture production (Culver & Castle 2008; Ponte et al. 2014). Technology-driven intensification is an ordinary extension of past practices, and is still a better way to increase the aquaculture production in the future (Culver & Castle 2008). However, technology is just one among many other sources of innovation, and innovation is only one among many factors that influences sustainable livelihoods (Baur et al. 2003; Temel et al. 2003; Sumberg 2005; Spielman et al. 2008; Spielman et al. 2009; Klerkx et al. 2010; Kilelu et al. 2013). In this regard, ‘innovation’ of aquaculture may be associated with the introduction of new technology, significantly improved product (good or service) or process, and implementation of a new organizational method in business practices (World Bank 2006; Culver & Castle 2008). However, transformation of communities may not be positive if technological change challenges core community values to point that social cohesion is threatened. This reflects that the resistance to technological change can be strong when the potential beneficiaries of innovation have no pressing need for those benefits (Culver & Castle 2008).

c). Aquaculture and factors driving for sustainability

Aquaculture is producing an increasing proportion of fish to meet global demand for seafood as capture fisheries decline (Asche & Guttormsen 2009; Subasinghe et al. 2009; Smith et al. 2010; Bosma & Verdegem 2011; Huysveld et al. 2013). In value terms, fishery and aquaculture products are the most traded food in the world. In 2010 some 148.50 million MT accounting for 38% of total fisheries production was traded internationally (Young et al. 2011; FAO 2012). Developing countries accounted for over half the value of all seafood exports; of which 67% were directed to developed countries (FAO 2012), and the EU, Japan and the United States were the main importing markets (SEAT 2009; Smith et al. 2010; FAO 2012). Aquaculture can enhance both food security and employment in developing countries, and it is important for many economies in particular for developing nations (Browdy & Hargreaves 2008; Hishamunda et al. 2009; FAO 2012; Belton & Bush 2014). Aquaculture represents one strategy put forward by WCED (1987), and endorsed through Agenda 21 to tackle issues of food security, as it has the potential to make significant contributions to development by improving incomes, providing employment opportunities and increasing the returns on resource use (Nhuong et al. 2002; Sheriff 2004; Gandini et al. 2009; Le 2009; Subasinghe et al. 2009; Costa-Pierce et al. 2011; Belton 2013; Hishamunda et al. 2014). Increasing international trade in farmed seafood potentially affects large numbers of people, far removed from the sites of production, with wider implications for sustainability. In contrast, those promoting bio-economic interpretations of sustainable aquaculture use profitability based on sound environmental management as their key objective; in practice, tradeoffs are likely between environmental impacts and profitability. Trade-offs between policy and practice reflects weak and strong sustainability, and has become a constant tension (SEAT 2009) and the focus on sustainable production alone has shifted to incorporate to sustainable consumption (Brunori et al. 2011).

Some view the most sustainable way to increase aquaculture production is through intensification of existing systems (Lin & Yi 2003; Subasinghe et al. 2009; Costa-Pierce 2010; Bosma & Verdegem 2011). However, rapid growth of aquaculture could lead to a number of technical, environmental, economic and social problems (Neiland et al. 2001; Lin & Yi 2003; Crab et al. 2007; De Silva & Hasan 2007; Gandini et al. 2009; Kluts et al. 2012). The sector also faces resource allocation and technological challenges (De Silva & Hasan 2007). Consequently, the impacts of aquaculture on the environment and on society have been a major source of criticism, and caused reflection on the nature of sustainability within the aquaculture sector (Simard et al. 2008; Gandini et al. 2009; Valenti et al. 2011; EU 2013; USAID 2013). Further expansion of aquaculture is constrained by many factors, including lack of appropriate extension approaches and technological know-how, high prices of feed and other inputs, lack of quality seed, lack of suitable sites, water quality degradation and lack of investment capital (Costa-Pierce 2010; Murshed-E-Jahan & Pemsl 2011). A critical constraint in all livestock production is the challenge of maintaining health and welfare, particularly during intensification (Shang et al. 1998; Lebel et al. 2002; Rico et al. 2012). In addition, among the factors that might influence the sustainability and growth of seafood trade are the evolution of production and transportation costs, the products prices and alternative commodities (FAO 2012; Kelling 2012). Thus, if aquaculture is to continue its rapid expansion into the 21st century, a focus on sustainability and equity must go hand in hand with a focus on productivity (Dey & Ahmed 2005). Tacon et al. (2009) suggested that a strategy to ensure the contribution of aquaculture to sustainable development should be guide by three main principles: i) aquaculture should be developed in the context of ecosystem functions and services with no degradation of these beyond their resilience capacity; ii) aquaculture should improve human well-being and equity for stakeholders; and iii) aquaculture should be developed in the context of other relevant sectors. Aquaculture development needs be balanced among all four dimensions, namely food supply, food safety, environment and social/poverty concerns, which implies the nature of aquaculture development does pose trade-offs between social or economic benefits and environmental impacts (Steinfeld et al. 2006). Sustainability in aquaculture can therefore not only be weak sustainability (Bell & Morse 2008), but also environmental protection that is a form of strong sustainability as aquaculture development depends on a sound environment (Zhang 2014).

1.2.2. Sustainable aquaculture

The FAO definition of sustainable agricultural development is *"…such sustainable development in agriculture, forestry and fisheries sectors conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable"* (FAO 1995).

Sustainability of aquaculture has to be considered along with broader economic and environmental sustainability. It appears from examples in the region that aquaculture seriously damages the environment and can be economically unsustainable (Kutty 1995; Simard et al. 2008; Valenti et al. 2011). Sustainability of aquaculture not only requires that it has a neutral effect on the environment, but also that it be economically feasible, and take a more holistic approach to sustainability in which social issues receive progressively more attention (Sheriff 2004; Barrington et al. 2008). Sustainability in aquaculture is receiving increasing attention; emphasis is placed on policy development and the production of guidelines for sustainability. In a development context, the concept of sustainable aquaculture is often to be found associated with that of sustainable livelihoods, as development agencies and national governments seek to conserve natural resources whilst simultaneously improving the livelihoods of farmers (Sheriff 2004). It has been claimed that sustainable aquaculture occurs when it is capable of self-regeneration with fewer inputs from the outside, and with minimal negative environmental, social, and economic impacts (Jolly et al. 2009; Exequiel et al. 2009). Unfortunately, the imprecision of such definitions makes them difficult to use as 'self-generation' and 'fewer' inputs are subjective. At the farm level highly integrated systems described for China in the 1970s (Ruddle & Gongfu 1988; Little & Edwards 2003) were actually dependent of large volumes of outside nutrients from beyond the farm. For example, the EU strategy for sustainable development of the European aquaculture industry aims at creating long-term secure employment, assuring the availability to consumers of products that are healthy, safe and of good quality, as well as promoting animal welfare standards and ensuring an environmentally sound industry (Focardi et al. 2005; Brunori et al. 2011). Again this may be misleading in that Europe is, and is likely to remain, highly dependent on flows of nutrients from outside the region as imported feed ingredients, the production of such concentrated feeds has large global environmental impact (Mungkung et al. 2006; Bosma et al. 2011; Cao et al. 2011; Heijungs et al. 2012; Huysveld et al. 2013).

There have been several efforts to create a conceptual framework for understanding and defining sustainable aquaculture. The objectives of aquaculture development are aligned with the three national goals of economic development, social development and environmental sustainability (Simard et al. 2008; Bueno 2009; Paul & Vogl 2011). With scarce resources and a growing population, decision-makers face the challenge of developing a sustainable aquaculture industry in their planning decisions (Martinez-Cordero & Leung 2003). For aquaculture to survive and be sustainable it also has to compete with other systems to achieve its designated goal (Jolly et al. 2009). Thus, the necessity for inter-sectoral linkages to promote sustainable rural development; loss of access to the natural resource base may be due to unsustainable models of resource management and exclusion of use as a result of other competing uses such protected areas, tourism and large-scale agriculture development (Siar & Sajise 2009). Consequently, the absence of a system perspective on the development plan are the major barriers to the creation of corporate sustainability (Setthasakko 2007). Recently, a consensus or stakeholder view has approached sustainability of aquaculture from three perspectives that are presented in the following sections (Frankic & Hershner 2003; Sheriff 2004; Pullin et al. 2007; Simard et al. 2008; Ommani & Chizari 2010; Samuel-Fitwi et al. 2012).

a). Environmental sustainability

Aquaculture operations must be environmentally friendly over a long-time horizon to be sustainable. Sustainable development requires intergenerational equity, that is, the potential of future generations must be at least as high as the present (Hishamunda &Ridler 2008). Thus, it is logical to define environmental sustainability as the maintenance of important environmental functions, and hence the maintenance of the capacity of the capital stock to provide those functions (Ekins 2011). Environmentally sustainable aquaculture can be said to be concerned with the maintenance of environmental sink and source capacities, keeping waste emissions within the assimilative capacities of the environment without impairing it and maintaining the supply of required inputs for the future of the production system (Sheriff 2004). Environmental concerns have focused on the quantity of land, water and energy use; water quality and control of effluents. In creating a sustainable aquaculture, it is essential to strike a balance between the need for aquaculture development and the need for natural resource conservation (Kutty 1995; Frankic & Hershner 2003; Ommani & Chizari 2010). Hence, aquaculture needs an enabling policy environment to grow in a sustainable manner and to be integrated into the agro-ecosystems, while minimizing conflict occurrence (Lehtonen 2004; Subasinghe et al. 2009). Environmental policy should be considered not only in terms of environmental impacts but also the interactions between the environmental, social and economic dimensions of development (Lehtonen 2004). The main actors in aquaculture, including policy makers, the private sector, development donors, producers and consumers will have to strive more for its sustainability (Pullin et al. 2007).

Aquaculture has been vigorously developed in recent years (Muir 2005; Subasinghe et al. 2009; Bostock et al. 2010; FAO 2012; Belton & Bush 2014), and to satisfy these demands of aquatic animal products, aquaculture development requires a larger share of natural resources and has a greater environmental impact (Lin & Yi 2003; Subasinghe et al. 2009). Therefore, the challenge for sustainable aquaculture growth is to improve production performance while, at the same time, to minimize the environmental impacts (Frankic & Hershner 2003; Martinez-Cordero & Leung 2003). For example, the intensification and expansion of striped catfish production is a strategy to meet increasing export demands; however, this may lead to an increase in environmental impacts in both local impacts (i.e. pollution of surface water in the Mekong rivers) and global impacts (i.e. contributing to most impact categories on the eutrophication and freshwater aquatic ecotoxicity because of high feed production (ingredient production, transport and milling)), which is one of the main outcomes of the sector expanding (Bosma et al. 2009; Nguyen & Dang 2009; Phan et al. 2009; Anh et al. 2010b; Cao et al. 2010; Bosma et al. 2011; De Silva & Nguyen 2011; Le 2011; Kluts et al. 2012; Nguyen et al. 2013; Huysveld et al. 2013). The sustainability of striped catfish farming is well related to external water environment and effluent management. Striped catfish ponds are characterized by highly intensive, high flow-through systems that produce high volume dilute effluents. Such effluents are impractical to treat and have been considered as a source of pollutant causing degradation of water environment in the long-term (Bosma et al. 2009; Anh et al. 2010b; Cao et al. 2010; Truong et al. 2011; Kluts et al. 2012; Nguyen et al. 2013; Phan et al. 2013; Mungkung et al. 2006; Nguyen et al. 2014). Effluents only cause problems when discharged to surface waters, and this is always the case if they are not managed judiciously (Avnimelech 2003; Rahman & Yakupitiyage 2004; Anh et al. 2010b; Truong et al. 2011; Phan et al. 2013). Managing of effluent from striped catfish ponds so that environmental pollution can be minimized is crucial for more sustainable farming striped catfish culture in the MKD (Phuong et al. 2008; Cao et al. 2010; Truong et al. 2011; Phan et al. 2013). Management practices should be implemented to reduce the amount of suspended solids lost from farms in effluents and erosion, and to ensure that each individual farm operates in as environmentally responsible manner (Boyd et al. 2000). Environmental impacts can be reduced by using pond sludge in agriculture (Boyd & Michael 1996; Rahman & Yakupitiyage 2004; Cao et al. 2010; Truong et al. 2011; Phan et al. 2013; Haque et al. 2013) and by using feeds with a lower FCR (Boyd & Michael 1996; Bosma et al. 2009; Anh et al. 2010b; Bosma & Verdegem 2011). Compared to pangasius, a much greater range of intensity is obvious within the Vietnamese shrimp industry; extensive systems, that receive very few nutrients, may be nutrient sinks. Many diseases of importance to the aquaculture industry are linked to environmental deterioration and stress associated with farm intensification (Shang et al. 1998; Lebel et al. 2002; Rico et al. 2012). The shrimp industry has been overwhelmed by aquatic animal health problems (Kutty 1995; Rico et al. 2012), and shrimp diseases have emerged as a major constraint to sustainable growth of shrimp culture (Shang et al. 1998; Lebel et al. 2002; Rico et al. 2012). Shrimp disease problems provoke the largest losses in the sector with many countries having faced a significant reduction in production (Gräslund & Bengtsson 2001; FAO 2013a). To solve this problem, farmers have relied on a wide variety of synthetic and natural chemical and biological treatments to prevent and treat disease (Bush et al. 2010b; Rico et al. 2012), giving rise to concerns about impacts of such chemicals on surrounding ecosystems (Rico et al. 2012; Rico et al. 2013). Governments, shrimp farmers and the chemical industry all have the responsibility to promote and inaugurate restrictive and relevant use of chemicals in shrimp farming (Gräslund & Bengtsson 2001). Solutions to the problem must deal with site selection, design and sustainable farm management (Shang et al. 1998; Lebel et al. 2002; Rico et al. 2012).

b). Economic sustainability

Development of aquaculture typically seeks to serve major purposes: food security, income generation and employment (Lin & Yi 2003). To achieve sustainability policies should be considered that constrain day to day operations of the economy in ways that enhance the natural resource endowments of future generations, but with an eye towards the economic implications of specific steps to implement such a policy (Ekins 2011). In reality, a trade-off is likely to be sought by policy makers and governments who seek to find a balance between a strong and weak sustainability approach (Sheriff 2004). Economically sustainable aquaculture ensures an income sufficient over the long term to enable continued inputs, necessary developments, and profitability consistent with those of other long-term agriculture investments (Kutty 1995). Economic issues have revolved around profitability, market demand and production efficiency (Bueno 2009; Ommani & Chizari 2010). To be sustainable, aquaculture must offer the prospect of adequate returns; this means that not only should returns be positive, but also they should be comparable to those from similar activities (Khiem et al. 2010; Ommani & Chizari 2010; Ha et al. 2013). Although some research suggest that the level of returns must be stable, meaning mortality rates and prices of inputs and outputs should not be too volatile (Hishamunda & Ridler 2008), in practice the stability of returns may be more important, especially for smallholders with limited assets to support perturbations in such input and market prices.

Aquaculture is essentially an economic activity, carried out in order to generate a financial benefit for operators; thus, economic sustainability is also a goal for most farm operations. The relationship between good farm management to reduce negative impacts on the environment, and the subsequent economic benefits which can result, is therefore a key topic in sustainable aquaculture (Sheriff 2004). For example, the striped catfish industry generates income for producers, processors, exporters; and creates employment (Nguyen &

Dang 2009; VIFEP 2009a; Nguyen et al. 2009; Le 2011; De Silva & Nguyen 2011). The financial sustainability of fish farming depends mainly on the market prices of products and inputs, and on the production efficiency. Concern about the variability of price reflects the fact that catfish farmers are producing their product without any guarantee of a sales price as a result of weak operational linkages between farmers and processors (Bremer et al. 2013). Le & Cheong (2010) also pointed out that striped catfish price variability and unstable input costs were perceived generally as the most significant risk of this industry. Both of these factors can be potentially detrimental and risk threatening the sustainability of this sector. To ensure the economic viability of the catfish farming sector, more realistic price structures need to be established (De Silva & Nguyen 2011), along with long-term relationships between farmers and processors. In addition, improvement in farm management and technical measures were perceived to be a more effective way to price risk reduction (Le & Cheong 2010).

c). Social sustainability

Sustainable aquaculture must not only maximize benefits, but also minimize accumulation of detriments, as well as other types of negative impacts on the natural and social environment (Frankic & Hershner 2003). Social objectives are of equal importance to economic and environmental concerns, in terms of well-being and equity for present and future generations (Sheriff 2004; Glavič & Lukman 2007). The aim is to ensure that the basic needs of the entire global community are met, excess consumption of materials and energy is reduced and environmental damage is avoided (Glavič & Lukman 2007). Sustainable production and consumption are about finding workable solution to social and environmental imbalances through more responsible behavior by stakeholders. Sociological interests have centered on employment, local concerns such as ownership, regional sources of inputs and labour (Ommani & Chizari 2010); and thus social sustainability depends on household capabilities, entitlements to resources, and on market chain organization (Bosma & Verdegem 2011). To be sustainable, aquaculture must have appropriate sites and systems acceptable to the local communities (Kutty 1995). Setthasakko (2007) indicated that building a good relationship with local communities is important for doing business in the long-run. In order to integrate sustainability, development and management of aquaculture, it is essential that the conflicts between the use of resources and their users should be well managed (Kutty 1995; Gandini et al. 2009). For instance, considering the growing population pressure and competitive uses of land in areas suitable for aquaculture, the potential to increase aquaculture production by expanding the farmed area is limited. Intensification of existing systems may be the most sustainable way to increase aquaculture and avoiding social conflicts (Bosma & Verdegem 2011).

"Sustainable consumption" has emerged as being a key component of ethically responsible food systems. This concept encompasses multiple aspects, ranging from food and water security to fair trading conditions, to species-appropriate livestock breeding (Reisch et al. 2013). Thus, aquaculture should promote both food security and safety as key components of human well-being as well as ensuring high welfare outcomes for both the fish and those vulnerable actors in associated value chains. Planning for sustainable seafood supplies for society must involve the close interaction of both aquaculture and fisheries planners (Costa-Pierce 2010). The growth of aquaculture has been coincidental with increased social awareness of the environmental consequences of development (Sheriff 2004) and social responsibility (De Silva & Nguyen 2011; Khoi et al. 2011). For example, the rapid growth of the striped catfish industry has led to a series of concerns over environmental and social sustainability (Anh et al. 2010b; Pham et al. 2011; Le 2011; De Silva & Nguyen

2011). Little et al. (2012) noted the negative coverage of the striped catfish and its trade with the EU by organizations such as the WWF and members of the European Parliament in terms of environmental, social and safety attributes. However, the same authors recommend that all risk analyses should be science based. Moreover, safety and quality control systems need to be based on risk assessment, and any actions taken should be communicated to all interested parties in a manner that is unambiguous, transparent and accessible (Ababouch 2007). The sustainability of aquaculture requires the development of new national policies and regulations (De Silva & Nguyen 2011; Rico et al. 2012; Rico et al. 2013). Based on the recognized human health hazards of consuming antibiotic residues, the government has supported the establishment of several food safety controls at the National level as well as in the private sector (Rico et al. 2012). It reflects that Vietnam has strived to comply with the requirements set by the international markets in order to retain access to them. Strengthened food safety control systems have resulted in a decline in Rapid Alert System for Food and Feed (RASFF) notifications and the number of rejections at EU borders in recent years, for instance, there was a significant number of rejections at EU border of pangasius fillets consignments in 2009, but by 2012 the total number of border rejections was relatively low (Palin et al. 2013). This gives more assurance that the products being exported from Vietnam do not pose a significant danger to EU consumers (Little et al. 2012; Palin et al. 2013).

1.2.3. Aquaculture certification

a). Major certification standards for aquaculture farming

Seafood markets have become increasingly stringent towards food quality and safety in recent years, and then these issues increasingly began to include criteria related to environmental and socioeconomic sustainability (Corsin et al. 2007; Bush 2008; Bush

2009; Brunori et al. 2011; CBI 2012). These criteria are generally expressed as standards, however standards can be either mandatory or voluntary (Corsin et al. 2007; De Silva & Nguyen 2011; Mohan 2013). Mohan (2013) interpreted the drivers for food standards development as i) society looking for sustainable consumption, food safety, quality and equity products; and ii) markets looking for an endorsement declaring compliance or conformity to standards. Thus, certification schemes specific to aquaculture have developed and emerged over the last decade (Bostock et al. 2010; Belton 2010; Washington & Ababouch 2011; Belton et al. 2011). Certification standards are mostly a set of criteria developed by private organisations and NGOs (Belton et al. 2011; De Silva & Nguyen 2011). Certification is a market driven tool that provides guarantees related to quality, safety, environmental impacts, social responsibility, traceability and transparency of production processes (Washington & Ababouch 2011; Mohan 2013).

The popular aquaculture certification standards promoted by NGOs and industrial organisations such as ASC, GlobalGAP and GAA-BAP are designed to improve social and environmental performance of global aquaculture production (Tran et al. 2013; Mohan 2013). A brief summary of information on three popular certification schemes promoted in the aquaculture sector, and the degree emphasis placed by each of the three schemes in a number of important categories and selected criteria is presented in Table 1.1 (Corsin et al. 2007; Bush et al. 2009; GAA 2009; GAA 2010; ASC 2010; GlobalGAP 2011; Ponte et al. 2011; Belton et al. 2011; Nguyen 2012; Haugen et al. 2013). The level of emphasis of each category and criteria describe the level of legal compliance of the standard requirements, and it depends on the goal and type of standards such as GlobalGAP mainly relating to food safety and quality while GAA-BAP and ASC mostly focusing on broader sustainability attributes and environmental protection (GAA 2009; GAA 2010; ASC 2010; GlobalGAP 2011).

Table 1.1. Emphasis placed on key issues by three major certification schemes

Item	Category and selected criteria[a]	Schemes[b]
Type:	B2B related to food safety and quality	GlobalGAP
	B2C related to sustainability or environmental protection	GAA-BAP; ASC
Goal:	- Minimize negative environmental impacts, reducing chemical use, ensuring responsible approach to labour safety and animal welfare.	GlobalGAP
	- Promotion of environmentally and socially responsible aquaculture	GAA-BAP
	- Minimize environmental/social impacts associated with aquaculture	ASC
Aspects:		
Environment issues	*Effluent management; Storage and disposal of supplies; Soil and water management; Ecosystem protection; Microbial sanitation; Energy efficiency; Predator control*	*GlobalGAP[1]; GAA-BAP[2]; ASC[2]*
Social and legal issues	*Property rights and Regulatory compliance; Community relations; Health and safety; Forced Labour; Employment conditions*	*GlobalGAP[2]; GAA-BAP[1]; ASC[2]*
Food safety	*Food safety assurance; Food quality assurance; Drug and chemical management*	*GlobalGAP[2]; GAA-BAP[1]; ASC[1]*
Chain-related issues	*Post larvae sources; Traceability; Harvest and transport; Sale of merchandise; Transport, Slaughtering and processing*	*GlobalGAP[2]; BAP[2]; ASC[1]*
Aquaculture production	*Pest management; Feeding (practices and storage); Stocking density; Health and hygiene; Biodiversity impact assessment; Sourcing, identification and Traceability; Fish health and welfare*	*GlobalGAP[2]; GAA-BAP[1]; ASC[1]*
Costs:	Certification fees US$3,000-7,000; Annual fees: US$1,000-1,300	GlobalGAP
	Certification fees US$650-5,000; Annual fees: US$1,850-3,000	GAA-BAP
	Certification fees US$4,500-6,000; Annual fees: US$1,000-2,000	ASC

[a]presents selected major criteria; [b]leye of emphasis: [1]some emphasis, [2]heavy emphasis.

Private standards and related certification schemes are becoming significant features of international seafood trade and marketing (Bostock et al. 2010; Washington & Ababouch 2011; Belton et al. 2011). Their use is also becoming more common in efforts to ensure food safety, quality and environmental sustainability in the growing aquaculture industry (Corsin et al. 2007; Washington & Ababouch 2011). Little et al. (2012) argued that the safety and sustainability of aquaculture must be understood in the context of the wider political economy of increasingly broad networks of actors involved in risk definition. Specifically, the standard development process is considered to be democratic, inclusive and science-based, while audits and certification are understood as objective and transparent (Konefal & Hatanaka 2011). Although certification makes a contribution, it also has significant limits; and thus certification is only one of several tools that could move the industry towards more sustainable production and indeed a 'sustainability thinking process', but not a solution to all problems (Allsopp et al. 2008; Bush et al. 2013; Mohan 2013; Han & Immink 2013). Recently, certification moved from control of the finished product at the processing plants to control on the overall process (Corsin et al. 2007; Reilly 2007; Yamprayoon & Sukhumparnich 2010; Nguyen 2012). Certification might require the introduction of new management systems; however, seafood producers in developing countries already struggle to meet mandatory requirements (Washington & Ababouch 2011). For instance, the Vietnamese striped catfish industry has garnered increasing international interest and scrutiny recently due to its rapid ascendance to global prominence (Bush et al. 2009; Belton et al. 2011), as a result it has become the potential subject of certification standards. Although food safety is probably the most significant issue there is evidence of increasing awareness of the environmental and social issues related to striped catfish industry (Bush et al. 2009; Anh 2010). To meet the growing sustainability expectations of these export markets, Vietnam has made a number of steps towards certification; the VietGAP standards were developed, promoted and considered a stepping stone towards compliance to internationally recognized standards such as the ASC, GlobalGAP and BAP (Nguyen et al. 2009; Ponte et al. 2011; GOV 2013).

b). Role of food standards in sustainable aquaculture

Certification is to increase consumer trust, provide legitimacy to producers and reduce liability by ensuring compliance with food safety and quality standards (Bush et al. 2013). Trifkovic (2013) indicated that food quality and safety standards have gained an important position in world markets recently. However, until recently there was only a small proportion of world aquaculture production certified (4.6%), and an estimate of additional demand was low (7.9%) (Bush et al. 2013). The greatest demand for certified aquaculture products comes from North America and Europe (Bush et al. 2013). Constraints to further growth are the higher market prices for certified products; the price of striped catfish products certified by ASC was 10-25% higher than uncertified products in the Netherlands market (Beukers et al. 2012). Overall, the impact of private standards on the trade and marketing of seafood is likely to increase as supermarket chains consolidate their role as the primary distributors, and as their procurement policies move away from open markets towards contractual supply relationships (Washington & Ababouch 2011). Standards are becoming increasingly important for developing country farms and firms because they determine the mechanisms of participation in specific global value chains and shape market access to specific countries (SEAT 2009). Standards have been characterised as a tool of communication between the primary producers and the end consumers, enabling primary producer economic freedom with social responsibility (De Silva & Nguyen 2011). Moreover, standards set entry barriers to new participants in a value chain and raise new challenges to existing developing country suppliers (SEAT 2009).

Certification in aquaculture can have positive effects by spurring new competitive advantages and investments, but it can also disguise underlying intentions to protect domestic industries and restrict market access (Subasinghe et al. 2009). Even though the producers bear high costs of investment in standards, previous studies have found that the return from standards can be positive compared to uncertified cases (Trifković 2013). Application of ASC standards to striped catfish farms increased productivity by 15% (Corsin 2013) and shrimp farms certified by GAA-BAP achieved better production efficiency (Lam & Truong 2010). In Thailand, Code of Conduct (CoC) shrimp farms obtained a higher net profit of US$0.48/kg (Pongthanapanich & Eva 2006). In addition, the large impacts of certifying programmes can be partly explained with reference to the higher prices from production with standards (Trifković 2013), such as the ASC certified catfish farms can receive 5% premium price (Corsin 2013); shrimp farms can get 6% premium price when their farm are certified by Naturland (Ha et al. 2012; Omoto 2012; Vu et al. 2013); shrimp farms certified by GAA-BAP received an 11% premium price (Lam & Truong 2010); and CoC shrimp farms in Thailand achieved a price premium of US$0.63/kg over conventional shrimp (Pongthanapanich & Eva 2006). The higher than standard price is most likely a consequence of better quality, which is achieved through application of standards (Trifković 2013; Corsin 2013). One should expect farms that apply standards to be better off than comparable farms with traditional production (Pham & Truong 2011; Tuan 2013; Trifković 2013). For farmers and processors alike, the adoption of standards is motivated by a desire to improve market access by ensuring quality supply (Bush et al. 2010; Trifković 2013). Belton et al. (2011) also indicated that certification is an increasingly pervasive form of market governance through which retailers and NGOs are able to exert control over producers of primary products in order to secure their interests. Although certification is an important contributor to sustainable production and consumption, the long-term impact of certification should also be considered, such as i) only commodities exported to developed markets are covered, while dominant species like carps are not seriously considered; and ii) only better performing segment of the sector are considered (Mohan 2013).

c). Producer compliance constraints and the way forward

The complexities of food safety and public health regarding the origins of products, production process and potential dangers to importing countries can dramatically affect access to markets by producers in developing countries (Dey & Ahmed 2005; SEAT 2009; Kelling et al. 2010). A lack of proper knowledge and awareness, poor access to information on requirements, lack of expertise and trained people to examine compliance requirements, lack of technological capacity and weak implementation and monitoring capacity, have all been cited as major constraints for developing countries (Kelling et al. 2010; Mohan 2013; Ponte et al. 2014; Jespersen et al. 2014). As certification programmes proliferate, questions will be raised about which certification programmes best serve consumer protection, the environment, the public and the producers (Subasinghe et al. 2009). Compliance with some certification requirements could be difficult for producers, especially small-farmers, who own or lease their farms and operate them individually (Corsin et al. 2007; Nguyen et al. 2009; Subasinghe et al. 2009; Umesh et al. 2009; Bostock et al. 2010; Bush et al. 2010b; Khiem et al. 2010; Belton et al. 2011; Belton & Little 2011; Pham et al. 2011; Washington & Ababouch 2011; De Silva & Nguyen 2011; Ha et al. 2013; Haugen et al. 2013; Mohan 2013; Bush et al. 2013). For instance, certification is not widespread at the striped catfish farm level, a higher prevalence of certification is found among the vertically integrated farms owned by pangasius processors (Belton et al. 2011; Bush & Belton 2012; Trifković 2013). The larger catfish farms are most likely to achieve certification, since they tend to possess organizational structures and characteristics amenable to the adaptation which will be needed to meet standard requirements, and the requisite capitals required to facilitate proactive engagement with certifiers (Bush et al. 2010; Belton et al. 2011; Bush & Belton 2012; Jespersen et al. 2014). There appears to be a general belief that for the long-term sustainability and economic survival of this sector it will have to make a shift towards large-scale farming practices (Phan et al. 2009; De Silva & Nguyen 2011; Bosma & Verdegem 2011; Bush & Belton 2012; Trifković 2013; Jespersen et al. 2014; Ponte et al. 2014). The application of private standards at the farm level is inhibited by financial constraints, as the costs of farm upgrading and certification are high and tend to exclude the small-producers from the export supply chain (Dey & Ahmed 2005; Oosterveer 2006; Subasinghe et al. 2009; Belton

2010; Khiem et al. 2010; Belton et al. 2011; Pham et al. 2011; Haugen et al. 2013). In addition, at the producer level, the main concern is that standards may marginalize the small farmers who are unable to meet the strict requirements due to a lack of technical skills as well as a lack of ability to meet complex documentation requirements (Umesh et al. 2009; Khiem et al. 2010; Belton & Little 2011; Pham et al. 2011; Trifković 2013; Haugen et al. 2013). However, not all food certifications will exclude the small-scale farmers in the supply chain but in order to maintain their position in the markets the small-scale farms need to form cooperatives, and they can certify their products through contract production for export companies using a group certification scheme. For example, Fair trade for organic coffee production in Nicaragua (Bacon 2005; Utting 2008; Valkila 2009; Bacon 2010), in Mexico (Gómez Tovar et al. 2005; González & Nigh 2005) and in Peru (Ruben et al. 2009; Ruben & Fort 2012); Fair trade is a form of alternative trade that seeks to improve the position of disempowered producers by ensuring that they are paid fair prices for their goods and that financial benefits are used to promote sustainable development in their communities (Lyon 2006; Valkila & Nygren 2009; Bacon 2010; Ruben & Fort 2012). Fair Trade certification is only available to cooperatives of small-scale farmers, therefore, for a small-scale farmer to be Fair trade and organically certified, a cooperative membership is mandatory (Gómez Tovar et al. 2005; Cruz 2006; Valkila & Nygren 2009; Valkila 2009; Bacon 2010).

Small-scale farmers make up the majority of Asian aquaculture and are mainly operated by families and individuals (Subasinghe et al. 2009; De Silva & Davy 2009b; Tacon et al. 2009; Lazard et al. 2010; De Silva & Nguyen 2011) and capacity for collective action necessary for such forms of certification limited. Small-scale aquaculture has been characterized variously as family owned and operated, with a large percentage of the labour usually provided by household members, utilizing small areas of land and/or water, and limited investment in assets and operational costs (Siar & Sajise 2009; Bueno 2009; Belton 2010; Belton & Little 2011; Belton 2013). Small-scale fish farmers, especially of pangasius, are not necessarily 'poor', their systems are intensive and require significant capital (Belton 2010; Belton & Little 2011; Belton 2013); for instance, the difference between small-scale rice farmers and pangasius farmers shows that the 'Vietnamese pangasius farmers cannot be considered as poor smallholders' due to the high levels of investment required to partake in the activity and the returns which can be achieved (Mantingh & Dung 2008; Belton et al. 2011). In contrast a typical small-scale rice farmer is likely to be poor, practicing low-input farming on a limited land holding (1.2ha) and earning just US$470 per annum (Belton 2010; Belton 2013). Because the small-scale farmers operate independently and individually, the certification for individual farmers is not only prohibitively expensive but also impractical (De Silva & Nguyen 2011). However, participation in certification programmes will be essential for better market access in the future. If the small-farmers are to benefit from this potentially profitable trade, policy-makers will need to find ways to include them in these processes (Dey & Ahmed 2005; De Silva & Nguyen 2011). Group certification of small-farmers could be a solution to retain them in the participation of certification programmes (Umesh et al. 2009; Nguyen et al. 2010; Le 2011; Pham et al. 2011; Mohan 2013; Trifković 2013). The grouping of small-farmers that share common natural resources becomes imperative to extend coverage to all small-scale farmers in a cost-effective manner (Srinath et al. 2000; Umesh et al. 2009; De Silva & Nguyen 2011). There is growing evidence that a farmer group based approach can save on certification costs, as well as enable improved internal monitoring systems, upgrading of communal infrastructure, improved economies of scale in production (Umesh 2007; Umesh et al. 2009; Nguyen et al. 2010; Tran et al. 2013). Thus, the group certification approach can be one way forward; it can help to achieve economy of scale, reduce costs and efforts of certification, and enable small-scale farmers to participate. Fair trade certification for organic coffee production in Central and South America as an example for the group certification of the small-scale producers, to apply Fair trade certification the small-scale farmers must be organized into independent and democratic associations (Gómez Tovar et al. 2005; Lyon 2006; Utting 2008; Ruben et al. 2009; Valkila & Nygren 2009; Valkila 2009; Bacon 2010; Ruben & Fort 2012). For many small-farmers organizing into group certification, they are able to produce sufficient quantities to interest international buyers and may be one way for reducing these high costs in cases of coffee production (Rice 2001; Gómez Tovar et al. 2005; Valkila 2009; Markelova & Mwangi 2010), organic fruit production in Uganda (Preißel & Reckling 2010), dragon fruit in Vietnam (Thao et al. 2006), and the group forest certification for smallholders (Nussbaum 2002; Auer 2012). However, Ha et al. (2013) noted that producer farmer groups are not a panacea for solving the challenges faced by small-holder farmers alone; and if farmers are not able to improve market access or an increased price for their product, they are unlikely to continue on a certification path (Ha & Bush 2010), and such groups are prone to breakup if they cannot get positive economic benefits from their collective action (Khiem et al. 2010). Hence, the government must play a more direct role in facilitating farmer cooperatives by providing infrastructure and creating a legal framework for agreement between farmers and the private sector (Nguyen et al. 2010; Le 2011; De Silva & Nguyen 2011; Ha et al. 2012; Tran et al. 2013). Besides, vertical coordination is suitable for improving the socioeconomic performance of small-scale farmers, thus reducing the gaps in the supply chain performance (Grunert et al. 2005; Khoi 2011). For instance, to meet increasing requirements for quality assurance, the striped catfish industry should set up models of vertical integration in which seafood processors play key roles based on well-known quality standards (Nguyen 2008; Nguyen 2009; Nguyen 2010). Thus, a substantial investment and policy support for the small-scale sector will be required (Nguyen et al. 2010; Le 2011; De Silva & Nguyen 2011; Pham et al. 2011; Tran et al. 2013; Mohan 2013). One of the prerequisites enabling aquaculture to make a contribution to sustainable development lies with a government's commitment to providing appropriate support to the sector (Dey & Ahmed 2005; Subasinghe et al. 2009; Nguyen 2010; Bush & Oosterveer 2012a; Ha et al. 2013). Moreover, the value chain actors in the seafood producing countries have invested considerably in upgrading to meet basic food quality and safety requirements, with the aim to access high-end European retail chains. Upgrading also enabled them to access less demanding end-markets and market segments (Ponte et al. 2014). Many seafood suppliers are increasingly able to meet stringent demands (i.e. logistics, quality, food safety, sustainability, etc.) placed by European value chain drivers (Jespersen et al. 2014).

There are over 75 global certification programmes with different sustainability promises. However, in some circumstances, there is poor transparency of performance of existing certification programmes, higher costs because of duplication and confusion among producers, buyers and consumers. Thus, global benchmarking tools are being developed for seafood certification and labeling programmes to ensure confidence in the supply and promotion of sustainable seafood to consumers, as well as to promote improvement in the certification programmes (Prein 2013). Benchmarking certification is a tool to help solving the compliance constraints for application and expanding of certification programmes. Weymann (2013) reported that the GlobalGAP, ASC and GAA-BAP organizations had a first meeting on 24th April 2013 to discuss benchmarking certification and also defined the first areas on which they will work together, which are i) reducing duplication of effort for farms that undertake certification against more than one standard; ii) exploring common approaches to the management of certificate information potentially through shared IT platforms; iii) developing common approaches to auditor training; and iv) developing shared approaches to chain of custody certification. Moreover, the Global Sustainable Seafood Initiative (GSSI) project is ongoing. The GSSI milestones are the development of benchmarked tools in 2013 and capacity-building of producers/suppliers in 2015 (Prein 2013).

1.3. Introduction to research

1.3.1. Research objectives

General objectives: the objectives of this study was to identify the main sustainability issues of striped catfish and shrimp industries in the Mekong Delta, Vietnam: establishing the main sustainability issues raising concern and assessing how stakeholders are dealing with the challenges of sustainability issues for future development.

The specific objectives of the study were:

- To provide an assessment of the development trends of major farmed seafood species in the MKD that are exported or have potential for export, and also identify the major factors that explain variation between them.
- To analyse the major factors affecting farming practices among farm categories; and the distance between current farming practices and the standard criteria (i.e. ASC/GAA-BAP/Global GAP).
- To assess the main changes of catfish and shrimp farming practices over time; the major factors driving any changes; and the factors related to sustainability issues.
- To identify perceptions of sustainability held by different stakeholder groups along the value chain; and their corresponding measurement tools and mitigation actions.

1.3.2. Focus of the research

The Sustaining Ethical Aquaculture Trade (SEAT), a large collaborative EU research project (EU/FP7 funded project no. 222889), aimed to enhance the sustainability of four major aquatic food commodities farmed (Striped catfish, *Pangasianodon hypophthalmus*; Giant freshwater prawn, *Macrobrachium rosenbergii*; Shrimp, *Penaeus monodon/Litopenaeus vannamei*; Tilapia, *Oreochromis niloticus*) in four Asian countries (Bangladesh, China, Thailand and Vietnam) and exported to Europe (SEAT 2009). The project concept was to develop an improved framework for sustainability assessment of the trade in farmed aquatic products between Asia and Europe. This study was under taken as a part of the SEAT project, and the primary fieldwork focusing on the shrimp and striped catfish industries was carried-out in the MKD, Vietnam between 2009 and 2013. Both of these species are fast growing, and are systemically important in terms of seafood export. However, the rate of growth and levels of intensification of their systems in geographically restricted areas is unprecedented, leading to serious sustainability concerns. Therefore, this study focuses on identifying sustainability issues of shrimp and striped catfish industry development in the MKD to gain an in-depth understanding of selected food chains from a holistic systems perspective.

1.3.3. Structure of the thesis

The thesis is divided into four parts with seven chapters (Figure 1.2). Chapter 1 presents a literature review and introduction to research. Chapter 2 explains the conceptual framework of this study and research methodology. Chapter 3 provides an overview of the development trend of seafood farmed species, which includes four main farmed species (i.e. striped catfish; giant freshwater prawn; brackish-water shrimp; tilapia). The following chapters focus on the striped catfish and brackish-water shrimp, which are major seafood farmed species being traded for export. Chapter 4 examines different farming practices among catfish/shrimp farm categories, and assesses the ability of current farming practices to meet standard criteria. Chapter 5 explores the main reasons for the transitions in catfish and shrimp farming. Chapter 6 analyzes role of stakeholders along shrimp and catfish value chains, and identifies perceptions of sustainability issues by different stakeholders. Finally, chapter 7 presents an overall discussion and conclusions of research findings.

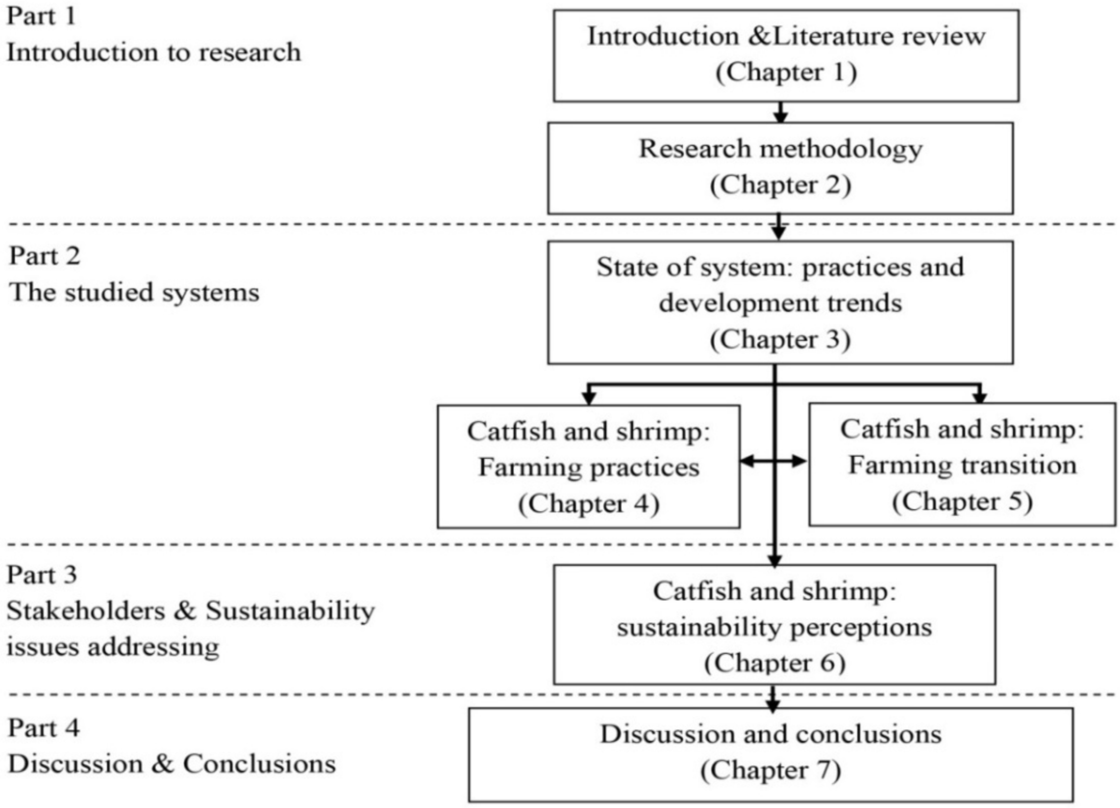

Figure 1.2. Schematic diagram of thesis

CHAPTER 2

Research methodology

2.1. Introduction

This chapter presents a conceptual framework for the study, research design, and steps of data collection, data management and analysis. Firstly, the Global Value Chain framework described by Gereffi et al. (2005) is applied for this study to explore the business relationships in the supply chain and the perceptions of sustainability by different value chain actors. Secondly, the research design presents the research phases used to collect data. Data management and analysis are presented in the final section of this chapter.

2.2. Global value chains: conceptual framework for the research

The main objective of this study is to identify perceptions of sustainability held by different stakeholder groups along the value chain and their corresponding measurement tools. In order to answer the research questions, the global value chain (GVC) framework was applied to examine governance issues that structure relationships between farmers, traders, processors, exporters in the MKD, and buyers in importing countries. Inquiry into the organisation of global production systems has been transformed by the development of the global value chain framework (Trifković 2013). This approach reveals the structure of business relations, including transactions and human behavior, related to information, product, and financial flows through the chains. Therefore, the GVC approach offers an opportunity to capture the synergy of intra- and intercompany integration and management (Porter 1985; Lambert & Cooper 2000; Luning et al. 2006; Khoi 2011). Additionally, the main concept of a value chain is taken to mean how private actors are organised in a set of exchanges from production to consumption. Further to this vertical dimension of the chain, horizontal dimensions are referred to; incorporating the organisation and relationship between producers, and to a lesser degree the interventions made by actors outside the value chain – most notably the government. The thesis lends itself to these concepts and in fact it is this value chain that better defines the 'system' under study.

The GVC analysis (GVCA) is an analytical tool that has been widely used to explain the dynamics of economic globalization and international trade, and is particularly pertinent to farmed seafood (Ponte et al. 2014; Jespersen et al. 2014). The study on governance in global value chains has covered a wide range of commodities such as textiles and apparel (Gereffi & Korzeniewicz 1994; Frederick & Gereffi 2011), automobiles (Sturgeon et al. 2009), electronics (Sturgeon 2002), services and technologies (Dillemuth et al. 2011), and agri-food sectors (Ponte 2002; Taylor 2005; Neilson 2008) and horticulture products (Dolan & Humphrey 2000; Busch & Bain 2004; Challies & Murray 2011). GVCA is based on examining discrete value chains that are explicitly governed to different degrees by one or more groups of lead firms (Ponte et al. 2014; Jespersen et al. 2014). Value chains represent the full range of value-adding activities that firms, farmers and workers carry out to bring a product from its conception to its end use and beyond. Ponte et al. (2014) indicated that GVCA has been employed to understand the wide variation of benefits accruing from participation in different value chains and end markets in development studies. GVCA focuses also on the vertical relationships between buyers and suppliers and the movement of a product from producer to consumer (Ponte & Gibbon 2006; Khoi 2011). Moreover, GVCA allows examination of relationships between different value chain actors engaged in production and trade of specific products, and the factors crucial for understanding specific governance outcomes (Trifković 2013).

Gereffi et al. (2005) have formulated an analytical framework that yields governance classifications that go beyond the original distinction between buyer-driven and producer-driven chains (Bolwig et al. 2010). Gereffi et al. (2005) developed a matrix of three independent variables that can each take two values (high and low): i) the complexity of the information and knowledge transfer required to sustain a particular transaction; ii) the ability to codify and transmit efficiently this information between the parties to the transaction; and iii) the capabilities of actual and potential suppliers in relation to the requirements of the transaction. These independent variables that determine the shape of the GVC governance structure are related to technology, information (complexity, codification) and the ability of suppliers to learn (capabilities). On the basis of these three variables, the researchers distinguish five different chain governance types: Market, Modular, Relational, Captive, and Hierarchy (Table 2.1).

Table 2.1. Key determinants of global value chain governance[1]

Governance type	Complexity of transactions	Ability to codify transactions	Capabilities in the supply-base	Degree of explicit coordination and power asymmetry
Market	Low	High	High	Low
Modular	High	High	High	↑
Relational	High	Low	High	│
Captive	High	High	Low	↓
Hierarchy	High	Low	Low	High

Source: Gereffi et al. (2005)

The matrix yields five possible categories of coordination (Gereffi et al. 2005; Bolwig et al. 2010; Ponte et al. 2014): 1) *Market* governance is characterised by spot or repeated market-type inter-firm exchanges, and is dominant when transactions are easily codified and typified by low informational complexity and high supplier capabilities; with low costs of switching to new partners for both parties of the exchange; 2) *Modular* governance shows inter-firm relations involving more specialised suppliers who finance part of production on the part of the customer but whose technology is sufficiently generic to

[1] Gereffi et al. (2005) exclude three combinations. The two combinations of low complexity of transactions and low ability to codify are unlikely to occur. The combination of low complexity of transactions, high ability to codify and low supplier capability leads to exclusion and is not considered as a governance type.

allow its use by a broad customer base, this type of governance is characterised by high informational complexity, ease of codification and high supplier capabilities; 3) *Relational* governance characterised by inter-firm relations involving multiple inter-dependencies, often underwritten by close social ties, and this governance form occurs when product specifications cannot be easily codified while informational complexity and high supplier capabilities are both high; 4) *Captive* governance arises when the ability to codify and the informational complexity of product specifications are both high but supplier capabilities are low, this governance type is characterised by inter-firm relations involving one-way dependency of suppliers, high levels of supplier monitoring and high costs of switching for suppliers; and 5) *Hierarchy* governance is characterised by vertical integration, and occurs when product specification cannot be codified and characterised by high informational complexity and low capabilities amongst independent suppliers.

The five GVC types are presented in Figure 2.1 (Gereffi et al. 2005), the small arrows represent exchange based on price while the larger block arrows represent thicker flows of information and control, regulated through explicit coordination. This includes instructions coming from a more powerful buyer to a less powerful supplier. The degree of explicit coordination and degree of power asymmetry are increasing from left to right (i.e. movement from market to hierarchy governances) in the Figure 2.1. According to Kelling (2012), the GVC coordination mechanisms help to identify specific governance type that may emerge at individual nodes and contributes to an overall view of governance when the variety of the governance forms at different nodes is taken into account.

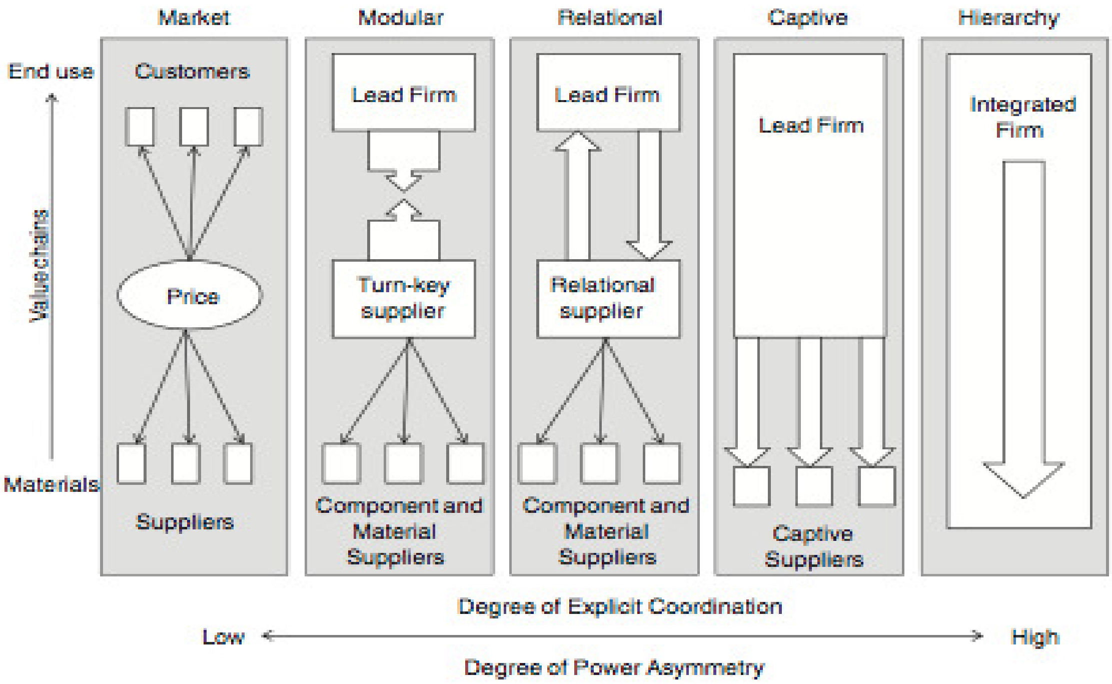

Figure 2.1. Five global value chain governance types
Source: Gereffi et al. (2005)

2.3. Research design

The research was designed as four phases (Figure 2.2), and in each phase the general sample-frame, study instruments (i.e. semi-structured/structured questionnaires, topic checklists, GPS recorder, etc.) and data collection were presented in the following sections.

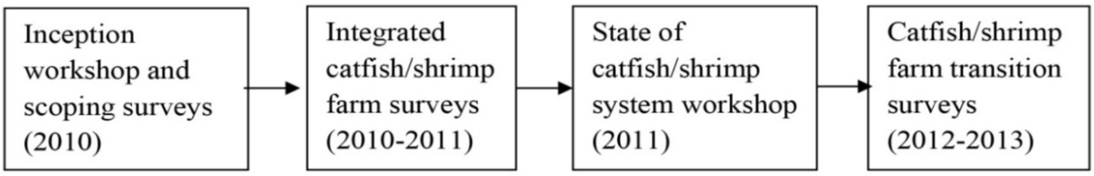

Figure 2.2. The four phases of research design

2.3.1. Phase One: Scoping survey

The first phase contributed to develop the strategies and research design, and planning process of research project to reach the goals.

a). Inception workshop

Workshop preparations were begun two months before the date set for the inception workshop allowing time for secondary data collection, a brief report and presentation on the planning process. Secondary data about the development trends of farmed species production were collected from the Fisheries Directorate, Department of Aquaculture, VASEP, and provincial Department of Fisheries. In addition, secondary data on aquaculture development were also obtained through visits to local government institutions. Secondary data/information was revised and synthesized to prepare a report on the overview of the farmed species development in the MKD and a planning process (i.e. research objectives, contents of future research activities and schedule) of the research project that was presented in the workshop. The inception workshop was aimed to provide an assessment and overview of the major farmed species' development and to identify system boundaries and stakeholders. An initial typology of sustainability issues was developed to triangulate with the 30 participants drawn from different stakeholder groups along the value chain of farmed species. The workshop was held in Can Tho University in January 2010 and a participatory approach was used to foster interaction with the stakeholders, stimulate broader support and involvement and encourage ownership of the research project (Reed et al. 2006).

b). Scoping survey

The scoping survey was aimed to get an overview of the state of the system of relevant stakeholders along the value chain of farmed species that focused on four main species (striped catfish, brackish-water shrimp, giant freshwater prawn, and tilapia), and it also evaluated the current challenges and constraints for future development. Based on the secondary data and results of the inception workshop, the emerging understanding of the development of the major farmed species in the MKD was revised and synthesized, informing the choice of criteria for site selection, type of key informant interviews and sample size for primary data collection. In each province, survey sites and stakeholders were purposively selected for field visits using a sample-frame developed from secondary data of the respective Provincial Department of Fisheries. The main criteria for site selection were 1) contribution to the total aquaculture area and production; 2) seed supply sources and availability; 3) concentration of culture systems; 4) geographical conditions (i.e. distance to mainstream rivers); and 5) concentration of seafood processors.

Table 2.2. Summary of surveyed samples in the scoping survey

Stakeholder groups	**Sample size**				**Stakeholder's visits**
	Catfish[a]	**Prawn**[b]	**Shrimp**[c]	**Tilapia**[d]	
Grow-out producers	55	26	80	27	Grow-out farmers
Seed producers	58	8	15	7	Hatcheries and nurseries
Input suppliers	14	6	7	7	Traders and companies
Processors	8				Seafood processors
Post-harvest operators	1	4	10	3	Fish/shrimp traders
Services providers	16				Waged labour groups
Government Institutions	13	4	7	4	DoF officers, NAFIQUAD branch 5 & 6

(a) Surveys were carried-out in Can Tho, An Giang, Dong Thap, Vinh Long, Ben Tre, Soc Trang; (b) Surveys were carried-out in An Giang, Dong Thap, Ben Tre; (c) Surveys were carried-out in Ca Mau, Soc Trang, Ben Tre; (d) Surveys were carried-out in Dong Thap, Vinh Long, Tien Giang; (DoF) Department of Fisheries; (NAFIQUAD) National Agro-forestry-fisheries Quality Assurance Department.

The scoping survey was conducted to get data from a number of key informants who were direct or indirect stakeholders along the value chain of the four main farmed species, ranging from input suppliers, farmers and employees in seafood processing companies, government officials and service providers. This survey also provided information and data for value chain organization analysis. Primary data were collected through topic checklists that contained both structured and the open questions related to value chain actor's operation, and allows respondents to participate in the discussion during the survey

(Appendix 1). The primary data were collected from stakeholder's visits, and key informant interviews between April and June 2010. Both qualitative and quantitative approaches were applied in this survey. The details of the survey sites covered are presented in Figure 2.3; and Table 2.2 presents a summary of the numbers of stakeholders interviewed.

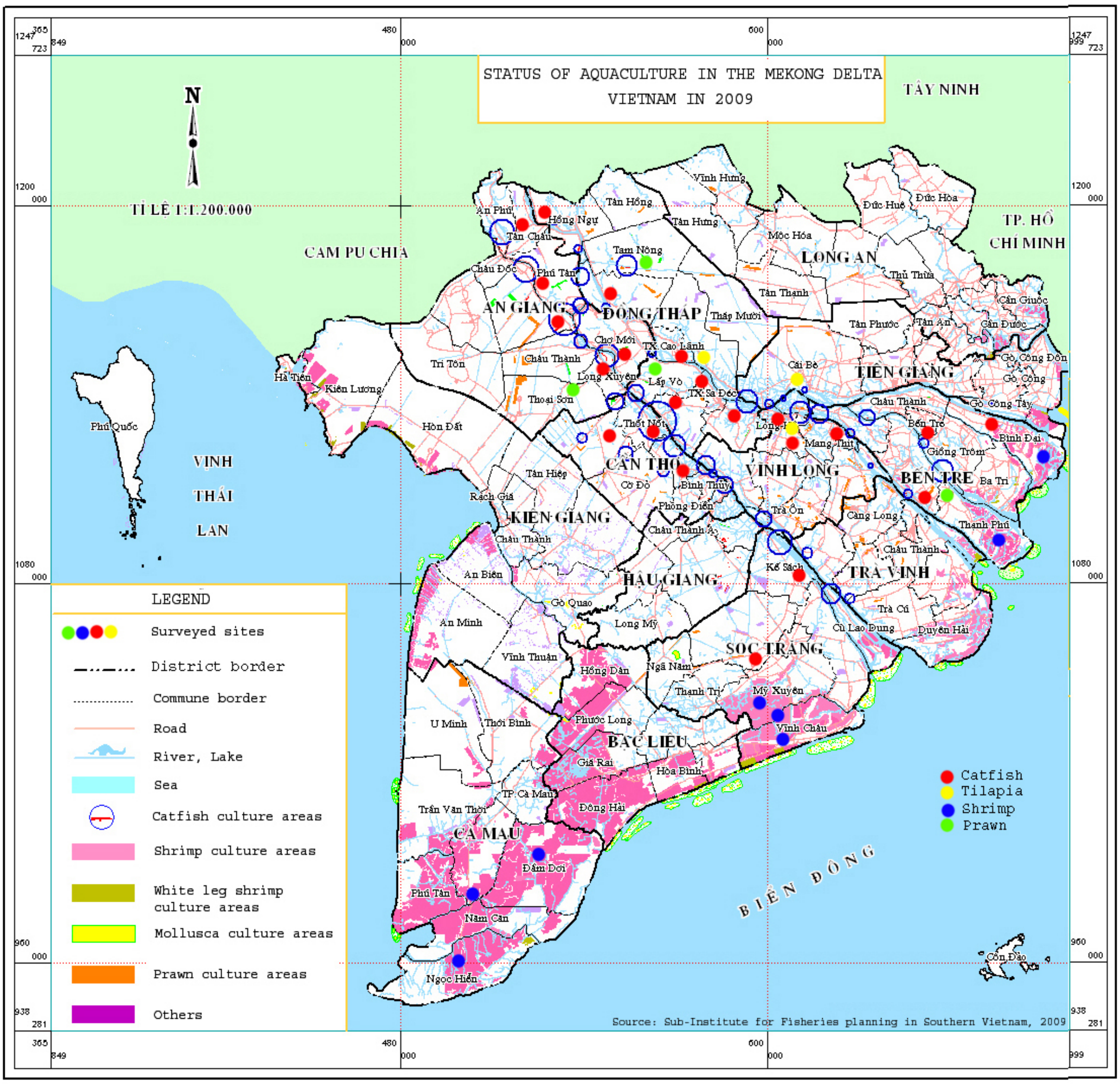

Figure 2.3. Location of scoping survey of four farmed species in the MKD
Source: reproduced from Nguyen et al. (2009)

2.3.2. Phase Two: Integrated farm survey

The second phase was to assess current farming practices of striped catfish and shrimp farming; it also provided a comparison of the current practices linked to the criteria of selected major farmed seafood standards.

a). Sample-frame for striped catfish farm survey

✧ ***Survey site selection:*** a list of striped catfish farms in ten MKD provinces was created and analyzed. Based on these data lists, the distribution of fish farms by culture area and numbers of ponds was analyzed and the survey sites (i.e. District) were selected by the purposive sampling method. The criteria for site selection were: 1) position within the watershed i.e. An Giang and Dong Thap provinces were representative of upstream areas, Vinh Long and Can Tho provinces of inland and middle areas, and Tra Vinh, Soc Trang and Ben Tre provinces of downstream areas (Figure 2.4); 2) physical proximity to main channel of the major river system; and 3) areas with a high concentration of small and medium-scale farms (<1 ha of water area).

✧ ***Catfish farm selection:*** the striped catfish farms were selected by farm scale as classified by Murray et al. (2011). The authors pointed out that five alternative indicators, including 1) business ownership; 2) type of management; 3) full-time waged labour; 4) registered trading name; and 5) vertical integration were developed to classify farmers into small, medium or large categories. Business rather than land ownership was specified, as the security of land access arrangements varies widely according to political and cultural context. Waged labour and management requirements were indicative of wider input levels, and they reflected the levels of business scale. Indicators 4' and 5' described the farm value-chain configuration; larger farms being more likely to be registered entities, and vertically integrated. At each selected site (i.e. District), we collaborated with local officers to check catfish data-list and made the farm classification as described by Murray et al. (2011). Then randomized stratified sampling was used to select a sub-set of farms in each district. The catfish data-list developed showed that 84% of farms were small/medium scale, accounting for 42% of the total catfish farming area; therefore sample size of farm scale is not equal. The sample size ranged from 5-30 farms per each district, of which samples of small-farms ranged from 5-20 and medium-farm selection were 1-10. Larger farms were not concentrated in specific areas or province, 1-9 large-farms were selected per location in several provinces. The total number of catfish farms selected was 212 of which 110, 64 and 38 farms were small, medium and large scale, respectively.

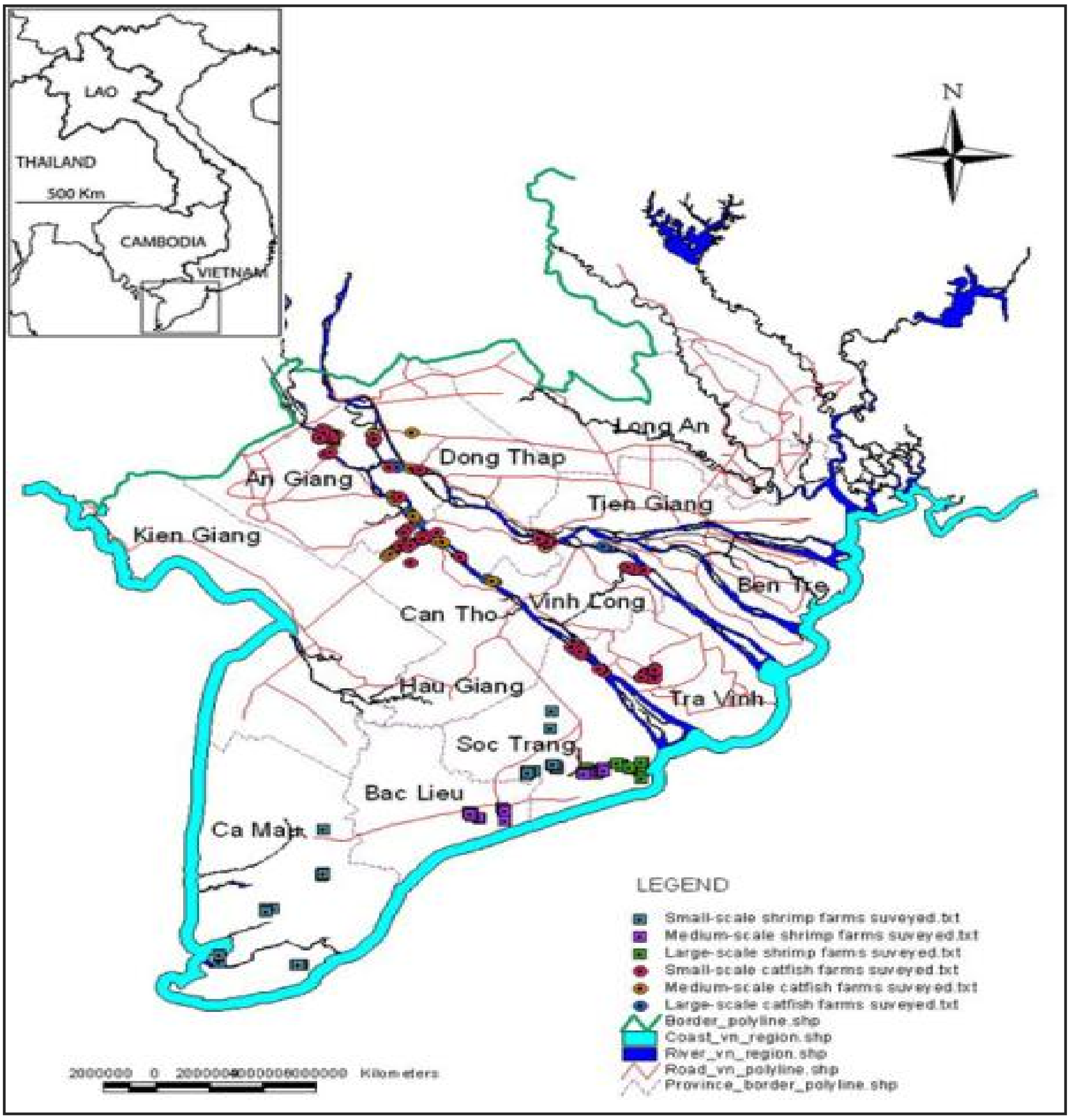

Figure 2.4. Integrated survey sites in the MKD

b). Sample-frame for shrimp farm survey

✧ ***Survey site selection:*** data on shrimp culture of the farm system in eight the MKD provinces was collected and analyzed. The distribution of shrimp farms by culture area and production was analyzed and the survey sites (i.e. District) were selected by the purposive sampling method. The criteria for site selection were 1) concentration of shrimp systems (i.e. type of shrimp system per district) such as mixed mangrove-shrimp and improved-extensive systems in Ca Mau province, semi-intensive/intensive and rice-shrimp rotation system in Soc Trang province, and semi-intensive system in Bac Lieu and Ben Tre provinces (Figure 2.4); 2) concentration of culture area (i.e. shrimp pond (ha) per disitrict); and 3) historical development of shrimp farming systems.

✧ ***Shrimp farms selection:*** the current shrimp farm systems in the MKD are quite diverse and there is a big difference in terms of technical and economic aspects among shrimp systems presented in Table 3.2 (Nguyen et al. 2009; VIFEP 2009). It is difficult to classify shrimp farms by farm scale as in the catfish farming sector; thus the shrimp farms were selected by farming systems as described by VIFEP (2009b) and Nguyen et al. (2009). Six indicators, including 1) seed source; 2) stocking density; 3) water exchange; 4) yield; 5) feed type; and 6) eFCR were used to classify farms into five categories (mixed mangrove-shrimp, improved extensive, rice-shrimp, semi-intensive and intensive shrimp system). The first four indicators were technical characteristics, and the remaining indicators represented economic differences. At each selected site, we collaborated with local officers to check shrimp data-lists and classify farms. After that, randomized stratified sampling was used to select a sub-set of farms in each district for interview. The improved-extensive and rice-shrimp rotation systems are the main systems in terms of culture area and production. Thus, the sample size was not equal among shrimp systems, and in each district selected the sample size ranged 5-30 farms. The total sample size was 230, of which 20 farms were intensive systems, 60 semi-intensive systems, 60 improved-extensive systems, 30 rice-shrimp systems and 30 mixed mangrove-shrimp. Additionally, 30 white-legged shrimp farms in the semi-intensive system were interviewed in Ben Tre province where white-legged shrimp culture was introduced firstly in the MKD.

c). IFS data collection

Structured-questionnaires were developed through contributions from the SEAT project partners, different sustainability perspectives were ensured through participation by different disciplines provided by different SEAT project partners, responsible for individual work packages on the project. The questionnaire was standardized by piloted interviews and the standardized questionnaire was used for the integrated farm survey to collect data (Murray et al. 2011)/(*see questionaires at www.seatglobal.eu*). Eight enumerators were trained in interviewing skills, data recording and method of minimizing errors in the investigation process. Interviewees selected were owners, managers or technicians who participated in and managed farm operations; and sometimes interviewees are a group of people who work in the same large-scale farms. The interviewees had to have reasonably good knowledge about the operation of their farm. The information was recorded and checked on the same interview day and the information gaps were supplemented by telephone. Farms selected in a district were all interviewed by eight enumerators before moving to the next district. The integrated farm survey (IFS) was carried-out between October 2010 and February 2011 to interview 212 striped catfish and 200 black tiger shrimp farmers, and 30 white-legged shrimp farmers in the period November and December 2011 to assess the status of these species in the MKD. The information collected in the study provided data from the last production cycle. In addition, the secondary data on the status of farming and relevant documents were also collected at the local fisheries office in the survey site.

2.3.3. Phase Three: State of system workshop

The third phase was to review and summarize significant outcomes of systems analysis conducted and sustainability issues identified during the earlier phases of the research project. The State of system workshop (SoS) mainly provided an analysis of sustainability perceptions concerned by different stakeholder groups. With participants coming from the different stakeholder group along value chains (Table 2.3), the SoS contributed to the formulation of sustainability perceptions based on expert (top-down) and primary stakeholder (bottom-up) opinion. According to Reed et al. (2006), although there are clear benefits to both bottom–up and top–down approaches to sustainability monitoring, integration of these approaches will produce more accurate and relevant results. Participatory action research is a reflective approach used by groups of stakeholders to identify and understand problems and challenges (SEAT 2009). Moreover, when the views of all stakeholders have been gathered together, they can be included in an overall framework for reference, learning and reflection (Bell & Morse 2008; Reed et al. 2006). Tools to evaluate the management options that emerge from this process in a multi-stakeholder, participatory framework are developed. To avoid bias arising from initial group composition, focus group data were triangulated through semi-structured interviews with key informant representatives identified (Prell et al. 2007).

The SoS workshop was held in May 2011 to evaluate the preliminary results on the sustainability issues that were identified from our previous steps, and this workshop was also a forum for confidence and relationship building with local stakeholders, support from whom was vital to follow-on activities. The key informants from stakeholder groups along the value chain of striped catfish and shrimp systems were invited to participate in the workshop. The criteria for key informants selection were i) operate/business scale level; ii) geographic conditions; iii) management level; iv) the key informants from scoping survey; and v) sharing of production and areas. In total 62 key informants came to participate in the workshop. They were divided into six different working groups, with nine people in the smallest group and fourteen in the largest group ensuring enough for group discussion and also to limit general bias of results (Table 2.3).

Table 2.3. Cross-table of stakeholder numbers by group at the SoS workshop

Stakeholder groups:	Species	#participant	Where?
Group 1: Catfish farmers		9	SocTrang, Can Tho, An Giang, Dong Thap provinces
+ Large-scale	Catfish	4	
+ Medium-scale		5	
Group 2: Shrimp farmers		11	SocTrang Province
+ Large-scale	Shrimp	6	
+ Medium-scale		5	
Group 3: Hatcheries		9	Dong Thap, Can Tho provinces
+ Catfish hatcheries	Catfish	3	
+ Shrimp hatcheries	Shrimp	6	
Group 4: Iput suppliers		10	SocTrang, Can Tho, Dong Thap provinces, Ho Chi Minh
+ Chemical companies	Catfish/ Shrimp	2	
+ Chemical traders		5	
+ Feed companies		3	
Group 5: Processors & Post harvest		9	SocTrang, Can Tho, An Giang, HauGiang provinces
+ Trading Middleman	Catfish/ Shrimp	2	
+ Fisheries Processor		7	
Group 6: Professionals		14	SocTrang, Can Tho, An Giang, Dong Thap, Bac Lieu provinces, VASEP
+ Govt. Fisheries Dept.	Catfish/ Shrimp	9	
+ Media sector		3	
+ Research sector		2	

Three exercises were timetabled between the various presentations; one conducted by all individual participants independently and two as a group exercise within stakeholder groups (Appendix 2). The second exercise was requested to clarify main findings and any knowledge gap in the results from phase 1 and phase 2 of the presentations, and this workshop allowed triangulation as we presented our understanding up to that point. Whilst, sustainability perceptions by individual participants were identified by the first exercise; and based on the preliminary results of sustainability perceptions of all people in the same group the main sustainability issues and their corresponding measurement tools by each stakeholder group were discussed in the third exercise. Results from the first exercise (individual) fed directly into the third exercise (group); the first being concerned with identification of sustainability issues and the third with identification of corresponding measurement tools.

2.3.4. Phase Four: Farm transition survey

The fourth phase was aimed at understanding changes of farming practices over time, mainly comparison between the integrated farm survey and this survey. This phase also contributed to evaluate the state of the system, and to revise perceptions of sustainability addressed from the integrated survey and SoS workshop.

a). Sample-frame of farm transition survey

Based on a list of 442 integrated farm surveys (212 catfish farms, 230 shrimp farms) in late 2010, we conducted interviews to assess a transition of farming practices over 2-3 years. Interviews were conducted in two steps i) step 1: a conducting interviews with all IFS farms by telephone survey (TLS) to get a general assessment of the farm changes; and ii) step 2: based on preliminary results from TLS, the farms who had some significant changes were selected randomly to interview directly (IDS) to verify the results of TLS and also to learn more about the farming movements (Table 2.4).

✧ ***Sample-frame of telephone survey:*** Information on farming practice from IFS database such as farm phone-number, farm areas, information on production activities were reviewed. Each survey site will have its own characteristics of natural conditions and socioeconomics related to farm activities, thus to facilitate the effective data collection, we checked relevant farm data and classified interviewed farms under the district. All IFS farms in a district were interviewed completely before moving to next district, as follows:

- Striped catfish farms surveyed were distributed in the seven MKD provinces, the telephone interviews were carried out in sequence from upstream districts of An Giang and Dong Thap provinces to the downstream districts of Tra Vinh and Soc Trang provinces. A total of 212 striped catfish farmers in IFS survey were contacted by telephone from May to June 2012, but the number of catfish farms who responded was 131 (representing 62%).

- Shrimp farms surveyed were located in four coastal provinces in the MKD. TLS were carried-out in mixed-mangrove forest shrimp farms in Ca Mau province to semi-intensive shrimp farms in Ben Tre province. A total of 230 shrimp farmers in IFS survey were contacted by telephone from March to April 2013; however, the number of shrimp farms contributing information was 189 (representing 82%).

Table 2.4. Sample size of telephone and in-depth farm survey

Species	Telephone survey (TLS)		In-depth farm survey (IDS)	
	N	Sample size	N	Sample size
Striped catfish farms	212	Small (110); Medium (64); Large (38)	22	Small (13); Medium (4); Large (5)
Shrimp farms:	230		30	
Black tiger shrimp	210	Intensive (20) Semi-intensive (60) Improved-extensive (60) Mixed mangrove-shrimp (30) Rice-shrimp rotation (30)	26	Intensive (4) Semi-intensive (8) Improved-extensive (6) Mangrove-shrimp (4) Rice-shrimp (4)
White-legged shrimp	30	Semi-intensive (30)	4	Semi-intensive (4)

✧ ***Sample-frame of in-depth survey:*** After the TLS was completed, the preliminary results from the TLS showed the status of farm changes. Based on these results, farms that changed over time were randomly sampled for direct interview. The sample sizes of IDS were distributed unevenly among groups of catfish farm scale or shrimp farm system as it as was dependent on the number of farms that answered the TLS and the status of farm changes, as follows:

- 22 catfish farms were randomly sampled from a list of TLS farms which had significantly changed over time for the IDS (i.e. face-to-face interviews) and data cross-checking, comprised of 5 large-farms, 4 medium-farms and 13 small-farms. The IDS farms accounted for 17% of TLS farms, and interviews were conducted from February to March 2013.

- 30 shrimp farms representative of the farm change status over time by each system were randomly sampled for the IDS and data cross-checking, of which 4 were intensive farms, 8 semi-intensive farms, 6 improved extensive farms, 4 mixed mangrove–shrimp farms, 4 rice-shrimp farms and 4 white-legged shrimp farms. The IDS farms accounted for 16% of TLS farms, and the interviews were conducted from May to June 2013.

b). TLS and IDS data collection

Structured questionnaires for the TLS (Appendix 3) and a topic checklist for IDS (Appendix 4) were developed and standardized through the trial farm surveys.

✧ ***Telephone survey:*** before the telephone survey, farm information was reviewed which could lead to a better understanding of farm conditions and production in order to increase the effectiveness of interview questions, such as reducing surplus questions and efficient use of interview time. Based on the living habits of local people, interviews were often conducted by telephone between 9-11AM or 2-4PM. A telephone interview lasted between 10 and 25 minutes, depending on the ability of respondents, level of farm changes and free time of respondents for interviews. Information on farm production of the last crop were collected and used for data analysis.

✧ ***In-depth survey*:** at the survey sites, we conducted a quick interview with local officers using Rapid Rural Appraisal techniques (FAO 1997) and checklist questions to know an overall situation on the survey sites before conducting the actual face-to-face survey at selected farms. During the farm interviews, information from the TLS were checked again, and information collected from local officers was also cross-checked with interviewees. Information on the farm production of the last production cycle was collected and used for data analysis.

In addition, to improve interpretation and stimulate discussion related to the transition of farming practices over time, interviews were also conducted with a number of stakeholders in catfish and shrimp value chains using a checklist of questions (Appendix 5). Key informants from two shrimp hatcheries, two catfish hatcheries, two shrimp traders, four processors, two shops of veterinary medicinal products, eight local staffs, one certified staff member and one bank officer were interviewed. Besides, the secondary data on the status of farming and related documents were also collected at the local fisheries office on the survey site.

2.4. Data management and analysis

2.4.1. Database and data management

Both quantitative and qualitative data derived from the scoping survey, TLS and IDS were coded and entered into the corresponding databases designed in the MS Excel 2007 (Microsoft Corporation, USA). The fields in the databases were designed in groups with similar information in the questionnaires structures to help facilitate the inspection of data entry and data checking. Data from IFS was entered into a MS Access 2007-database designed by Murray et al. (2011). All questionnaires were checked and completed before entering into the databases. After completing the data entry stage, the databases were checked using quick check tools to correct typing mistakes. Also, the data checking step aimed to identify information gaps that could be filled-in by telephone. In addition, various data AHPNS disease progression and farm gate price were also entered and stored in data-sheets in MS Excel 2007 for further data analysis.

2.4.2. Data analysis and interpretation

Data analysis was performed by specific topic to answer research questions and data from the databases were exported to relevant statistical software packages such as SPSS 21 (SPSS Inc., Illinois, USA) and MS Excel 2007 for statistical analysis. Descriptive analysis was used to estimate the frequency of responses, mean and standard deviation of the factors. Chi-square (X^2), Kruskal-Wallis H and Friedman's test were applied to check significant difference of qualitative factors among farm categories, or among factors that need to be compared together. While, one way-ANOVA and independent sample T-tests were applied to check significant difference of relevant quantitative factors among farm scales/systems. The significant differences are indicated by $*P<0.05$.

Information about the scoping survey and SoS workshop were synthesized and used to describe the value chain. The global value chain (GVC) approach is used to understand business relationships between actors in the supply chain (Gereffi et al. 2005); revealing the structure of business relations related to information, product, and financial flows through the chains. Top-down and bottom-up approaches were applied to make a stakeholder analysis (Reed et al. 2006). Based on the guidelines of Bell & Morse (2008), a simple matrix was developed to identify and compare sustainability issues by different stakeholder groups. The Driving force-Pressure-State-Impact-Response (DPSIR) framework approach was applied to interpret analyses of responses to cope with the sustainability issues identified (Smeets & Weterings 1999; Bell & Morse 2008).

2.5. Limitations of the research design and implementation

Sample-frame: a multiphase stratified random sampling strategy was applied to select the study sites across the MKD, and a purposive sampling was applied to select the farms for the interviews. However, sample-frame also faced limitations, such as limitation on availability of secondary data related to farm category, which can cause difficulties to sample-frame design.

Sample size: the constraints of time, finance, and trained labour force have caused difficulties to the sample-size, such as: i) sample size of farm survey was limited compared to the total population. However, the sample size still ensured the representativeness of the industries because farms were selected using a stratified random sampling process from the ten provinces that contributed more than 98% and 70% of total production of catfish and shrimp in Vietnam, respectively; and ii) limitation on the number of stakeholders who were representatives of their group participated the workshop.

Data collection and management: i) the study conducted mainly surveys by face to face interviews value chain actors, but focused primarily on farming sector. A State of system workshop was used to evaluate perceptions on the sustainability issues (SIs) by different stakeholder groups; however, the number of participants was still limited and it also affected by the results that cover a large range; ii) this study based on synthesis of secondary/primary data collected by recall methods so the information in several cases was still limited because of non-record keeping practices in most existing farms; iii) the study sites mainly focused on catfish and shrimp farming, many farmers had a lower educational level, and the answers to most of the questions were based on estimation of the respondents so their estimations were also large variations; iv) a major challenge was obtaining the data from commercial actors (i.e. seafood processors, aqua-feed companies, chemical/drug companies; input suppliers and traders) and thus the need for a high degree of trust/strong relationship between the researcher and the researched; Kelling (2012) also faced difficulties to obtain accurate data from EU processing, wholesale and distribution sectors; v) a production chain from pond to plate, can only reach sustainable development when it has participation from both sides, i.e. importers and producers. However, this study focused on exploration of the stakeholder groups in the MKD and lacked of data/information surveys from the importing actors such importers, retailers and consumers, which limited our conclusions from a truly a global picture; vi) the survey time was the same time as AHPNS outbreak and low catfish price, so it could effect to responses that inevitably was drawn to those issues; vii) a simple matrix table was used to aggregate key sustainability factors for the value chain; but, the results were more qualitative than quantitative.

CHAPTER 3

Development trends for the international trade in farmed seafood species in the Mekong Delta

3.1. Introduction

Vietnam is currently ranked among the top ten seafood exporters in the world (VASEP 2011; Fisheries Directorate 2014). In 1999, Vietnam contributed 1.8% to the World seafood export value, increasing to 4.9% in 2011, with annual growth rates of 16.9% (FAO 2012; FAO 2013b). Fishery products contributed 5.3% of the total national export value and were the fourth biggest national export commodity (after crude oil, garments and footwear) in 2012 (Nguyen 2008; GSO 2013). Aquaculture plays an important role in fisheries development in Vietnam. It has developed quickly since 2000 and by 2013 contributed around 55% of national fisheries production (Fisheries Directorate 2014). Shrimp and striped catfish are the two main farmed species exported contributing 46% and 26% of seafood export value, respectively in 2013 (Fisheries Directorate 2014). Their products were exported to 82 and 136 countries, respectively (VASEP 2011; VASEP 2012); with Japan, EU and USA initially the main markets.

The MKD is comprised of 13 provinces, 8 of which are coastal to the East Sea and the Gulf of Thailand. The Mekong River runs through the MKD via two major rivers: the Mekong and Bassac rivers with a length of approximately 230km each and a combined catchment of approximately 40,000km^2 (Van Zalinge et al. 2004; Vu & Phan 2008). Although the MKD only accounts for 12% of total land area in Vietnam, this region plays an important role in the agriculture sector; contributing almost 60% of national rice production (GSO 2012; GSO 2013). With its diverse and productive river basin, the MKD is popularly referred to as the food basket and center of aquaculture in Vietnam (Khoi

2007; Phan et al. 2009; De Silva 2012). In 2013, aquaculture in the MKD accounted for 71% of national aquaculture production. Striped catfish, shrimp, tilapia and giant freshwater prawn (GFP) were the main farmed species in the MKD, accounting for large culture areas, a large number of farmers and contributed 1.62 billion tonnes to aquaculture production in 2013 (Fisheries Directorate 2014). In 2013, the MKD contributed 76% of national shrimp raw material and the entire striped catfish production to export. In addition, 77% of national tilapia production and 58% of national giant freshwater prawn production respectively were produced there, and mostly consumed by the domestic market (GSO 2013; Fisheries Directorate 2014). With large areas of saline intrusion, shrimp is a target farmed species in the coastal areas, whereas the large and dependable volumes of riverine freshwater have been important for striped catfish farming development. Besides this, a huge rice-field area, floodplain area and rivers are also advantages for aquaculture development, especially for economically valueable species such as tilapia and GFP (Vu & Phan 2008; Nguyen et al. 2009). These four species have become more important in the aquaculture sector plans until 2020 for both the MKD and Vietnam as a whole (MARD 2009b; Nguyen et al. 2009). While shrimp and striped catfish production have a continued export focus, tilapia and GFP are considered crucial to diversification to meet domestic demand but with expectations of expansion to export in the longer-term (MARD 2009c; MARD 2009b; GOV 2013).

Demand for seafood products in the world has been increasing (Smith et al. 2010; FAO 2012). The world trade in fish and fishery products grew significantly in value terms, rising from US$8 billion to US$125 billion during the period 1976–2011 (FAO 2012; FAO 2013b). Capture production has tended to be stable (Young et al. 2011; FAO 2012), so it is considered that global demand for aquatic food will most likely be satisfied by aquaculture production (Valdimarsson 2007; Subasinghe et al. 2009; Asche & Guttormsen 2009;

Bosma & Verdegem 2011; De Silva 2012). Considering the important role of farmed species for seafood export, this chapter attempts to describe the development of value chain actors for the main farmed species in the MKD, and to identify factors leading to the different development status among farmed species.

This chapter is divided into two main parts, the first half of the chapter (section 3.1. to 3.5) provides the information on the primary actors or chain actors who were directly involved in the transformation of inputs into outputs of the farmed seafood species. The second half of chapter (section 3.6 to 3.9) contributes an overall picture about the indirect actors (external actors or networks, excluded actors, and non-participants). Both of the two main categories of actors play important roles in the value chain coordination forms, because the changes in position of different chain actors are connected in relation to the vertical linkages and horizontal elements in the value chain (Bolwig et al. 2010). The first half of the chapter attempts to assess the development trends of four farmed seafood species and major chain actors (hatcheries, grow-out farmers, feed manufacturers, and seafood processors) directly involved in within-chain exchanges (Bolwig et al. 2010). It also contributes to identifying the main constraints of the production systems during their development, that related to the sustainability issues for analysis of pangasius and shrimp value chain in the following chapters. The first part of the chapter begins with a review of the status and development of the farmed species. An assessment of four species cultured in the MKD, the countries farmed seafood 'hub', namely Giant Freshwater Prawn *(Macrobrachium rosenbergii),* Tilapia *(Oreochromis niloticus)*, Striped catfish (*Pangasianodon hypophthalmus*) and Penaeid shrimp *(Penaeus monodon & Litopenaeus vannamei*) is presented. Secondly, it presents an analysis of the practices and obstacles during the development process. Thirdly, growth of the processing sector and support services is examined to identify the issues related to the production and trading of farmed species.

The second part of the chapter aims to bring together insights related to the organization of the vertical and horizontal dimensions of the value chain – food safety, government support, cooperation between farmers. This part focuses on the participation in value chain in turn related to the rest of actor categories who are external actors or networks, excluded actors and non-participants (see details in Bolwig et al. (2010)). The second part begins with a review of the social and environmental impacts that are important issues related to the sustainable aquaculture development. This is followed by a review on the current production quality and consumption management activities. Thirdly, the roles of facilitating institutions for farmed species production and trading are described. Finally, the value chain of the two key export commodities (Striped catfish and Penaeid shrimp) is presented.

Generally, Giant Freshwater Prawn and Tilapia are mainly farmed with a local domestic market orientation, and both of these are potential export candidates in the future (VIFEP 2009b; MARD 2010; GOV 2013); whereas, Striped catfish and Penaeid shrimp are already established and key export commodities (Nguyen et al. 2009; Fisheries Directorate 2013b). This chapter provides an overview of the development trend of seafood farmed species which includes four main farmed species (i.e. striped catfish; giant freshwater prawn; brackish-water shrimp; tilapia), and practices of the four categories of actors who participate in the value chain and organization of the value chain are reviewed. The following chapters focus on the Striped catfish and Penaeid shrimp, which are major seafood farmed species being traded for export.

3.2. General status and development of farmed species in the MKD

Aquaculture in the MKD has grown significantly in both culture area and production in the recent years (Figure 3.1), reaching around 9.7% and 22.2% of annual growth rates between 2000 and 2010, respectively (Nguyen et al. 2009). This suggests immediately that a process of intensification has also occurred, i.e. faster growth of production compared to land use. The aquaculture sector has developed quickly as a positive result of the new policy "*Decree 09/2000/NQ-CP*" that allowed transfer of low yield agricultural land to aquaculture production (i.e. rice farming in the coastal area transferred to shrimp farming; fruit garden/orchards along river side to striped catfish farming; and rice farming in the inland area to GFP farming) (MARD 2009b). Since 2000 this region also has had large areas of land which have been transferred from rice farming to shrimp farming as described in more detail in the following sections. The successful artificial breeding of farmed species and adoption of mass production in the early 1990's was a driving force for the rapid growth of the aquaculture sector. The availability of markets, especially export markets, has also been one of the key factors contributing to the fast growth of this industry. In addition, the improvement of culture techniques gradually moving from extensive to semi-/intensive systems, government support of rural infrastructure improvement (i.e. irrigation canals, roads and electricity), technical training and consultation programmes, and international trade promotion programmes have also contributed to the fast growth of aquaculture (Nguyen & Dang 2009; MARD 2009b; Nguyen et al. 2009; De Silva & Nguyen 2011).

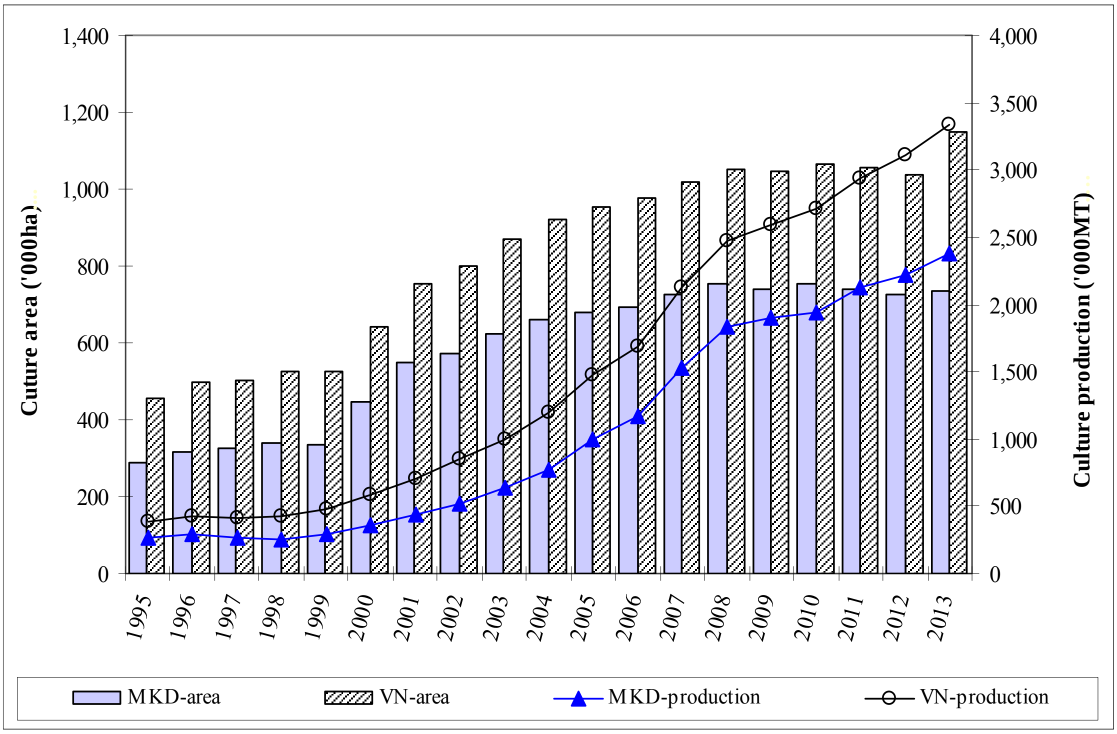

Figure 3.1. Development trends in culture area & production in the MKD and Vietnam

Source: GSO (2012), Fisheries Directorate (2014)

Many species, of both lower and higher economic value have been farmed and developed in the MKD since the 1950s. Before the 1980s, most culture production was used for domestic consumption because of a "*trade embargo*" after the war (Nguyen et al. 2009). Since the establishment of the "*Doimoi policy*" in 1986 (GOV 1986; MARD 2009c; MARD 2009b; Nguyen et al. 2009), expansion of aquaculture has been promoted to support national food security and foreign currency earnings for Vietnam. Culture has been concentrated on several farmed species such as shrimp, hard clam, scallops, mud crab and marine fish (goby, mullet and sea-bass) in brackish-water areas; and the carp family, tilapia, GFP, snakehead fish, African catfish, walking fish, silver barb, river catfish and striped catfish, and special species (i.e. eel, frog, turtle) in freshwater areas. Since the mid 1990s, farmed species have been developed for export purposes, of which shrimp and striped catfish were the two main species to achieve this status, whereas other species such tilapia, GFP, bivalve species and carp family species were mainly cultured for domestic consumption. Since 2000, the shrimp (*P.monodon, L.vannamei)*, striped catfish (*P.hypophthalmus*), GFP (*M.rosenbergii*) and tilapia (*Oreochromis sp.)* have been developed particularly rapidly in term of culture area and production in the MKD (Table 3.1). Thus, these four species have become important in the structure of the aquaculture sector in the MKD (MARD 2009b; Nguyen et al. 2009). The farmed area for these species has increased dramatically, especially for the striped catfish which reached an annual growth of 9.95% between 2001 and 2010, levelling off after this time; while the farmed areas of the shrimp and GFP had the lowest annual growth rate, at 3.33% and 7.38%, respectively (Nguyen et al. 2009). At the same time, tilapia has been cultured mainly in integrated aquaculture system (i.e. polyculture and integrated farming with livestock), used mostly for household consumption and local domestic markets, and consequently production statistics are not well established. In recent years, tilapia farming has developed as cage or pond-based monocultures.

Table 3.1. Culture area and production by major farmed species in the MKD

Species*	**2001**		**2005**		**2010**		**2013**	
	Area[a]	Prod.[b]	Area[a]	Prod.[b]	Area[a]	Prod.[b]	Area[a]	Prod.[b]
Shrimp	422.06	99.68	556.92	225.80	566.90	335.29	601.85	415.57
Catfish	2.32	46.11	3.91	371.48	5.44	1,049.03	5.95	1,150.00
Tilapia	3.00	10.00	10.10	32.70	15.00	60.00	16.57	50.99
GFP	4.01	1.45	6.39	2.94	7.62	6.16	11.15	5.03
Sub-total	*431.39*	*157.24*	*577.32*	*632.92*	*594.96*	*1,450.48*	*634.96*	*1,621.58*
%/MKD	*78.89*	*35.38*	*84.87*	*63.12*	*78.98*	*74.76*	*86.57*	*70.68*

**Shrimp (P.monodon/L.vannamei), Striped catfish (P.hypophthalmus), GFP - Giant freshwater prawn (M.rosenbergii) and Tilapia (Oreochromis sp.); [a]Culture area ('000ha); [b]Culture production ('000tonnes). Source: VIFEP (2009a, 2009b); Nguyen et al. (2009); MARD (2010), Fisheries Directorate (2014).*

Corresponding to increased farmed area, the cultured production of the four farmed species has also grown quickly, with annual growth rates of 28% in the period 2001-2010, contributing 71% of the MKD aquaculture production (Table 3.1). Striped catfish farming in particular has developed dramatically in terms of production, reflecting increases in intensification levels and technique improvement (Nguyen et al., 2009). Shrimp, tilapia and GFP have also increased their production at the same time, with a high annual growth rate compared to the growth rate of culture area; and the key factor driving force for this trend has been improvement in culture techniques (i.e. feeding, pond management, seed availability).

3.3. Development trends of farmed species in the MKD

3.3.1. Development trends of farmed striped catfish

a). General development trend

River catfish including the Mekong river catfish, *basa (Pangasius bocourti) and* Striped catfish*, tra (Pangasianodon hypophthalmus)* have been cultured in small cages and family ponds respectively, using fingerlings from wild-capture in An Giang and Dong Thap provinces since the 1960s (Nguyen & Dang 2009; De Silva & Nguyen 2011). There were few changes up to the latter part of the 1990s, when striped catfish farming began to grow dramatically as a result of the successful artificial propagation techniques for striped catfish and mass scale seed production since 1998 (Nguyen & Dang 2009; Belton et al. 2011).

Intensive striped catfish culture has been developed and improved in terms of productivity and management skills since 2000, as farmers gradually shifted from farm-made feeds to commercial feeds (De Silva & Nguyen, 2011). Intensive catfish culture along the Mekong and Bassac rivers started in An Giang and Dong Thap provinces where traditional catfish farmed area and seed availability sources were already established. Since 2005, catfish culture in cages and pens has all but disappeared and shifted to culture in ponds reflecting the significant improvements in pond culture techniques and marked increases in productivity (Nguyen & Dang 2009; De Silva & Nguyen 2011). Nguyen & Dang (2009) reported that available seed sources all year-round, low infrastructural investment, short culture cycles and high profit were the main factors driving the move to, and development of pond models compared to cage and pen. Moreover, slower fish growth, higher fish mortality, and frequent disease outbreaks that lead to reduced economic efficiency in cages model compared to ponds were also reasons for this movement from cage to pond. The cage and pen culture activities intensified problems related to water-flow in the river which could resul in increased disease occurrence and reduced growth (De Silva & Nguyen, 2011). Consequently, the cage and pen culture of striped catfish was almost obsolete by 2007. Since then, the sector has been almost exclusively based on pond culture practices along the Mekong Rivers (De Silva & Nguyen 2011), and catfish culture in ponds is still developing (Figure 3.2). Intensive culture of striped catfish in ponds has expanded gradually to other provinces in the MKD close to the river mouths that were historically limited by culture area for catfish development since 2005.

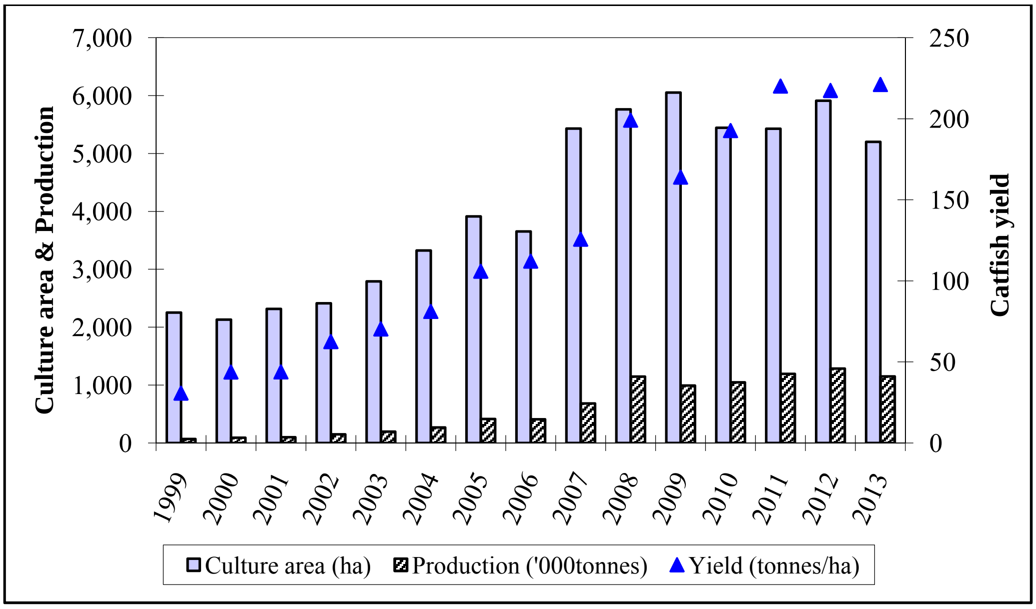

Figure 3.2. Development trends in striped catfish culture in the MKD
Source: Nguyen et al. (2009);Fisheries Directorate (2011, 2012, 2013, 2014)

Currently, 10 of 13 provinces in the MKD have developed striped catfish farming. Among them An Giang and Dong Thap are the two main provinces where catfish farming increased rapidly and collectively contributed 55% to total catfish production in 2012 (Fisheries Directorate 2013a). The important differences in the intensity of culture in the different provinces are the amount of land used and natural conditions; the coastal provinces have a limitation on land used for striped catfish compared to inland provinces.

b). Growth of striped catfish hatcheries

The artificial propagation of striped catfish was first started in 1978; however, it was not sufficiently reliable for mass seed production and the activity remained undeveloped until 1995 (Nguyen & Dang 2009). Before 1996, striped catfish culture depended heavily on wild-fry sources (Nguyen & Dang 2009; Belton et al. 2011). Study on induced spawning of striped catfish was started again in 1995 by Can Tho University (CTU), and successful techniques for the artificial propagation of striped catfish were primarily established in 1996 (Belton et al. 2011). The supply of privately produced pangasius seed (*P.hypophthalmus)* was established in 1998 after quickly adopting hatchery-based spawning techniques (Belton et al. 2008; Nguyen & Dang 2009). Nguyen & Dang (2009) reported that techniques for inducing spawning were fully achieved and transferred to commercial hatchery operators since 2000. Moreover, the ban on fishing wild-fry implemented by the Government in 2000 led to the reinforcement of hatchery production system (Belton et al. 2008). Since then, the seed production of striped catfish has increased rapidly in private sectors (i.e. at private hatcheries), from 52 hatcheries in 2002, increasing to 172 hatcheries in 2009. This has since (has reduced to 140 hatcheries by 2012) with a total seed production of 4.6 billion fingerlings satisfying demand of the farming sector. Dong Thap and An Giang provinces that have good natural conditions for hatcheries and nurseries had also been the main area of catfish seed production with 87 and 23 hatcheries in 2012, respectively (Fisheries Directorate 2013a). Striped catfish is spawned throughout the year, but the peak breeding period is May to July (Bui et al. 2010). Corresponding to the rapid growth of the striped catfish intensive farming, the seed demand was also high and increasing since 2000. Nguyen & Dang (2009) noted that the increase in seed demand has created concerns on seed quality that is highly influenced by the hatcheries' knowledge of broodstock quality management. Poorer quality seed has been related to the practice of multi-spawning of broodstock during the period time of high demand from grow-out farmers (Belton et al. 2010). The authors also noted that many grow-out farmers believed there to be poor management at hatcheries during periods of peak production. The reduction of seed quality also came from relatively low rate of brooders addition or replacement, brooders from the same source and undiversified cross breeding between males and females (Bui et al. 2010; Le & Le 2010).

c). Growth of striped catfish farms

Striped catfish is cultured in deep ponds with high productivity (Phan et al. 2009; Nguyen & Dang 2009) and the sector remains characterised by a large number of individual farmers and small holdings. In 2009 most farms were less than 0.5ha (68% of the total), and some had land with areas of 0.5-1ha (14%) (Figure 3.3). Many farms dominated in terms of small farm size (i.e. ≤1ha/farm); and most were owned and operated or managed by families (Phan et al. 2009; De Silva & Davy 2009b; De Silva & Nguyen 2011) but there are clear trends to consolidation of the sector. For example, Khiem et al. (2010) showed that though smaller enterprises accounted for 89% of total catfish farms in An Giang province, the relative increase in production area was related to expansion of large-scale farms (≥10ha/farm) since 2006. The larger farms emerging (Phan et al. 2009; De Silva & Nguyen 2011; Bosma & Verdegem 2011; Trifković 2013) have been primarily associated with pangasius processors striving to establish vertically integrated systems to actively ensure raw material for their processing (De Silva & Nguyen 2011; Bush & Belton 2012;

Hansen & Trifković 2014). VASEP (2011) noted that large-farms which are mostly owned and operated by processors now supplied 50-70% of raw catfish production (Bush & Belton 2012; Hansen & Trifković 2014). In contrast, the number of small-farms has decreased because of increasing input costs and unstable farm gate prices leading to economic losses and inability to access increased financial investment (De Silva & Nguyen 2011; Bush & Belton 2012).

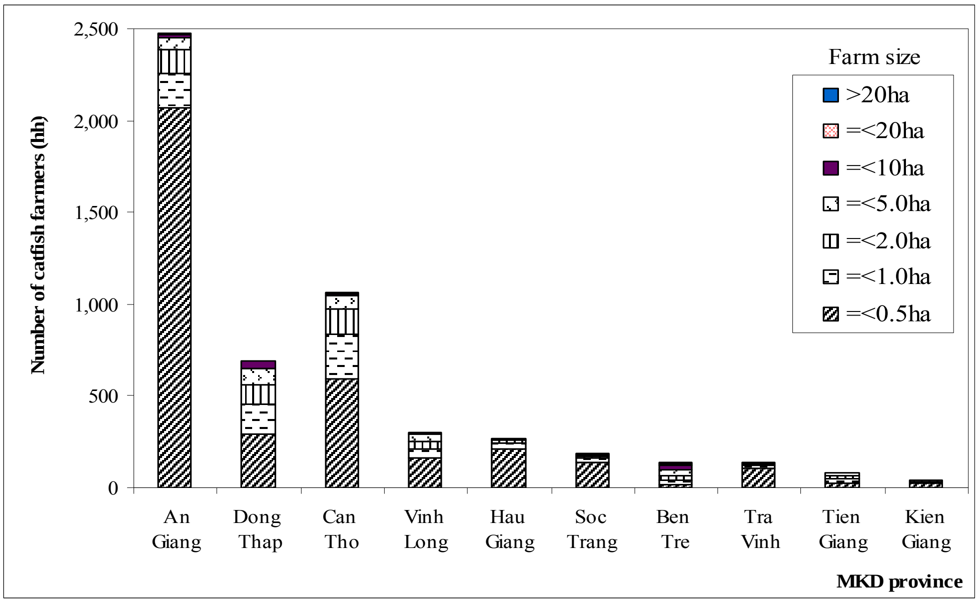

Figure 3.3. Distribution of striped catfish farmers in the MKD by farm size and number in 2009. *Source: Provincial Dept. of Fisheries (2009)*

3.3.2. Development trends of farmed shrimp

a). General development trend

In the 1970s, extensive shrimp culture based on wild seed started in the mangrove-forest areas along the coastal zones in the MKD (Nhuong et al. 2002; Nhuong et al. 2003). The shrimp farmed area in the MKD reached 70,000 hectares by the beginning of 1970s (Nhuong et al. 2002). During 1975 to 1990, shrimp culture remained extensive on the MKD and focused on the domestic market. During this period, destruction of mangrove-forest for shrimp ponds in the MKD also took place (Nhuong et al. 2003; Phan & Populus

2007); around 75,000ha of mangrove forest were reduced to exploit fuels and develop agriculture and shrimp culture. A step change occurred in shrimp culture around 1987 (Nhuong et al. 2003), when international trade spurred expansion in the early years of the 1990s (Tran et al. 2013). Development of shrimp culture in this time was also driven by the introduction of artificial hatchery production, gradual improvement in culture technology for grow-out farming, and broader Government economic reform (*Doimoi* policy) (Nhuong et al. 2002; Nhuong 2011; Tran et al. 2013). Hatchery development occurred mainly in Central Vietnam where Nha Trang University introduced the technology to local hatcheries and conditions were favourable for its spread to the private sector. By the middle of the 1990s, shrimp farming faced serious epidemic diseases in the MKD, and the industry came to a halt. After that, shrimp disease declined as a result of effective improvement in the seed quality and management practices but it still caused significant economic damage to farmers (Nhuong et al. 2003).

Since 2000, the shrimp industry has developed rapidly in both farmed area and production volume as a positive result of the Decree 09/2000/NQ-CP allowing farmers to convert low producing and saline rice fields, and salt pans in the coastal areas into shrimp ponds. The area farmed for shrimp increased from 171,820ha in 1999 to 422,060ha in 2001, and it reached 601,850ha in 2013 (Figure 3.4). According to MOFI (2006), the total conversion of agricultural land to shrimp culture was around 310,000ha during the period 1999 to 2005, in which 42% came from low yield rice land conversion. Since 2005, shrimp farming has continued to grow but mainly as improved-extensive and semi-intensive culture systems instead of the traditional extensive system (Figure 3.6). However, culture techniques were still limited, particularly in terms of farm infrastructure and access to good quality seed, and high risk of disease has persisted particularly in the more intensive systems. Large shrimp mortalities have occurred over a wide area in the MKD since 2008 and are still causing serious losses for shrimp farmers (VIFEP 2009b; Nguyen et al. 2009; DoAH 2012). Shrimp farming has developed in 8 of 13 provinces in the MKD, of which Ca Mau province has the largest farmed area, accounting for 45% of shrimp farming areas in the MKD. However, the main shrimp system in Ca Mau was mixed mangrove-shrimp, rice-shrimp rotation system (i.e. the wet season is used for rice farming, and shrimp is farmed in the dry season in the same ricefield), and improved-extensive system (i.e. shrimp was cultured all year round in the former paddy-fields, with artificial seed stocked but no feeding). Soc Trang, Bac Lieu and Ben Tre provinces have positions of strength in shrimp farming development, of which the main systems are semi-intensive. The other provinces have less area under shrimp farming, and the main shrimp systems are improved-extensive and semi-intensive. Ca Mau, Bac Lieu and Soc Trang provinces contributed most shrimp production to the region, accounting for 68% of the MKD shrimp production in 2013 (Fisheries Directorate 2014).

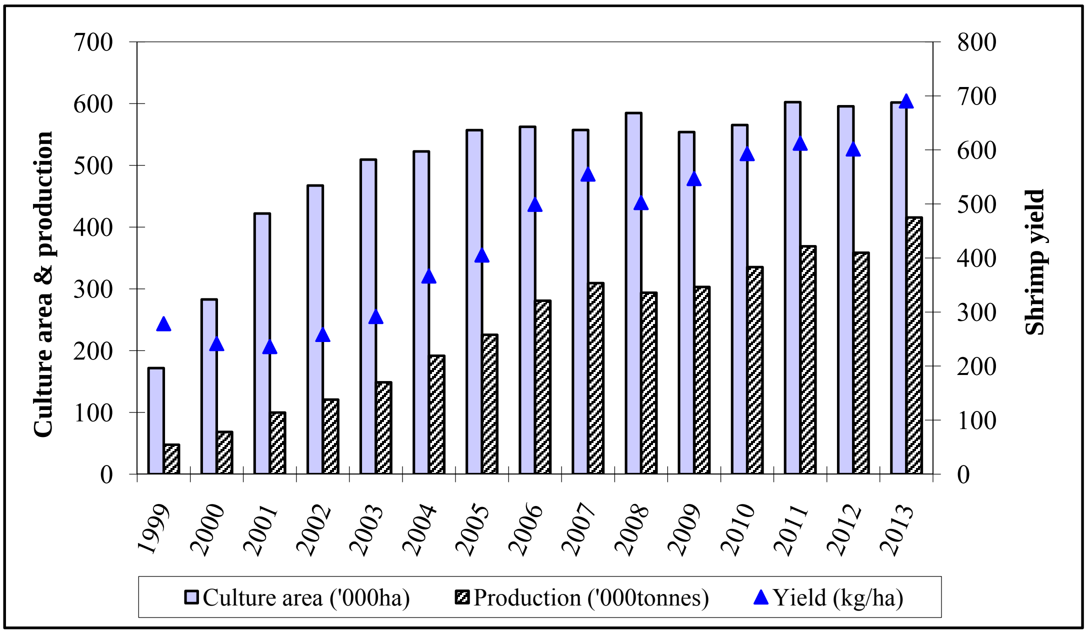

Figure 3.4. Development trends in shrimp culture in the MKD
Source: Nguyen et al. (2009); MARD (2010); Fisheries Directorate (2011, 2012, 2013, 2014)

White-legged shrimp (*L.vannamei*) farming has been developed in the north and central Vietnam since 2002. As a result of successful trial models, it was planned for promotion in the Central and North of Vietnam (VIFEP 2009b; MARD 2009b). Several farms in Ben Tre and Tien Giang provinces bought white-legged shrimp seed from the hatcheries in Central Vietnam and introduced culture of white-legged shrimp to the MKD in 2007. Based on the positive results and pressures from seafood processors to diversify away from reliance on black tiger shrimp, white-legged shrimp farming was allowed by Ministry of Agriculture & Rural Development (MARD) to develop in the MKD since 2008, with a total culture area of 1,400ha,which by 2013 had increased rapidly to 41,120ha (Figure 3.5). Black tiger shrimp disease outbreaks have become more serious recently and are the main reason leading many semi-/intensive farmers to switch to white-legged shrimp culture (Briggs et al. 2005; Lebel et al. 2008; Lebel et al. 2010). To date, the black tiger shrimp industry depends heavily on wild brood-stock sources. The quality of this source is still unstable and is not controlled effectively; while white-legged shrimp brood-stock is imported and quality control is generally considered to be better. Yamprayoon and Sukhumparnich (2010) noted that black tiger shrimp was too susceptible to disease with the slow growth syndrome that led to the unavailability of good quality brood-stock, while white-legged shrimp farming became more popular due to easy access to specific pathogen free[2] brood-stock. Shrimp farmers also enjoy rapid turnover because of the shorter farming period (De Silva & Nguyen 2011).

[2]Specific-pathogen-free (SPF) is a term used for laboratory animals that are guaranteed free of particular pathogen (see more in http://en.wikipedia.org/wiki/Specific_Pathogen_Free). The specific pathogen free (SPF) *Litopenaeus Vannamei* has capacity to produce quality seeds with faster growth and higher survival rates for commercial farm (Briggs et al. 2005; Barman et al. 2012)

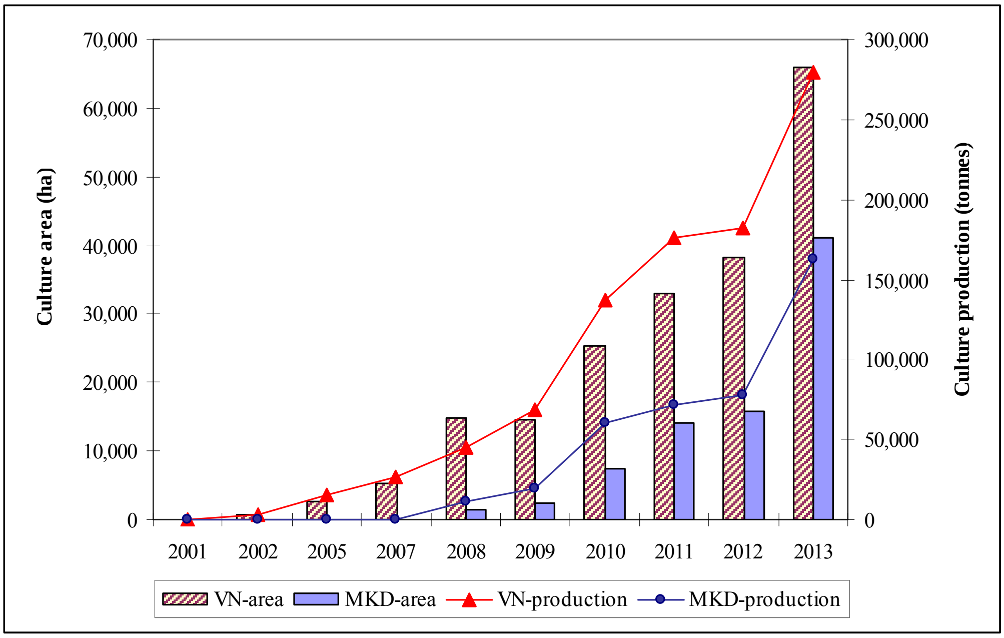

Figure 3.5. Development trends in white-legged shrimp culture in the MKD and Vietnam

Source: Nguyen et al. (2009); VIFEP(2009); Fisheries Directorate (2011, 2012, 2013, 2014)

b). Growth of shrimp hatcheries

The techniques of artificial shrimp hatcheries from nearby countries were applied successfully in Vietnam in the middle of 1980's. Khanh Hoa province was the first place to succeed in artificial seed production, and the hatcheries in Khanh Hoa continued to dominate in Vietnam for almost a decade (Lebel et al., 2002). The hatcheries at this time had low capacity, about 1-5million post-larvae (PL) per year, and in 1994 a total of 1.4 million PL were produced throughout the country (Nguyen et al. 2009). At the beginning of the 1990's, reproduction techniques were improved and transferred to neighboring provinces in central Vietnam. Consequently, the central provinces have become the main sources of shrimp post-larvae production and supply until now. The rapid leap in the technology for artificial shrimp seed production is a primary factor that determined the development of the shrimp industry in Vietnam (Nhuong et al. 2003). Due to limitations in techniques and natural conditions for establishing breeding hatcheries, the artificial reproduction of shrimp in the MKD only developed after 2001 (VIFEP 2009b). The number of hatcheries and larvae production of the provinces in the MKD has increased since then, with 862 hatcheries & nurseries producing 3.95 billion post larvae in 2001, increasing to 1,280 hatcheries producing 12 billion PL in 2007 (Nguyen et al. 2009), which has been stable until 2012 (Fisheries Directorate 2013b). However, the hatcheries in the MKD still do not produce sufficient seed for the grow-out shrimp farms of this region due to high demand from the large culture areas. Moreover, the initial dominance of shrimp hatcheries in Central Vietnam were also a factor that inhibited hatchery development in the MKD and they remain, the main source of post-larvae. The continued import of larvae from Central Vietnam has exacerbated problems of seed quality management and disease control because existing local officials have not enough equipment and capacity to monitor the quality of imported seed sources (Nguyen et al. 2009; VIFEP 2009c).

c). Growth of shrimp farms

There are four different models of shrimp farming classified according to pond size, seed source and stocking density, water and feed management, and production yield (Table 3.2), including mixed mangrove forest-shrimp coexisted, rice-shrimp rotation, improved-extensive, and semi-/intensive farming in the coastal areas.

Table 3.2. Comparison of the characteristics of shrimp farming in the MKD

	BTS			**WLS/BTS**
Items	**Mixed mangrove-shrimp**	**Rice-shrimp rotation**	**Improved extensive**	**Semi-/intensive**
Pond size	>=0.5ha	>=0.3ha	>=0.3ha	>=0.4ha
Seed source	Natural/Artificial	Artificial	Natural/Artificial	Artificial
Stocking density	1-3 PLs/m^2	1-7 PLs/m^2	1-7 PLs/m^2	>10 PLs/m^2
eFCR	None	<1.2	None	>1.2
Production yield	200-250kg/ha	300-500kg/ha	200-250kg/ha	>1,000kg/ha
Water depth	1.2-1.5m	0.5-1.0m	0.5-1.0m	1.0-1.5m
Water exchange	Based on tide cycle	Limited water exchange	Based on tide cycle	Only top up water
Culture method	Polyculture	Monoculture	Monoculture	Monoculture

BTS: black tiger shrimp, WLS: white-legged shrimp. Source: modified after VIFEP (2009c), Nguyen et al. (2009)

The distribution of area among types of shrimp farming has changed significantly during the period 1999-2013 (Figure 3.6). From 2001 to 2005, the culture area increased quickly (MOFI 2006), but subsequently grew more slowly. The annual growth rate of semi-/intensive was the highest, as many farmed areas of the improved-extensive system have been upgraded to semi-intensive systems. However, semi-/intensive systems still accounted for a relatively small proportion (<15%) of the MKD farmed shrimp area in 2013.

According to VIFEP (2009b), the rice-shrimp rotation, mixed mangrove-shrimp and improved-extensive systems required lower levels of investment and intensification; they are often owned, operated and managed by small-farmers, while more intensive farming involved large-scale farmers or corporate companies. This reflects the high number of shrimp farmers still at a small-scale level (Tran et al. 2013). Improved-extensive and rice-shrimp rotation systems are the two main shrimp systems accounting for 77% of the MKD shrimp farmed area in 2013. Although these two shrimp systems only accounted for 35% of the MKD shrimp production, they play an important role in solving unemployment for local people in the rural coastal areas, and provide employment for more than 200,000 labourers in rural areas, based on an average of 1 labourer per ha (Nguyen et al. 2009).

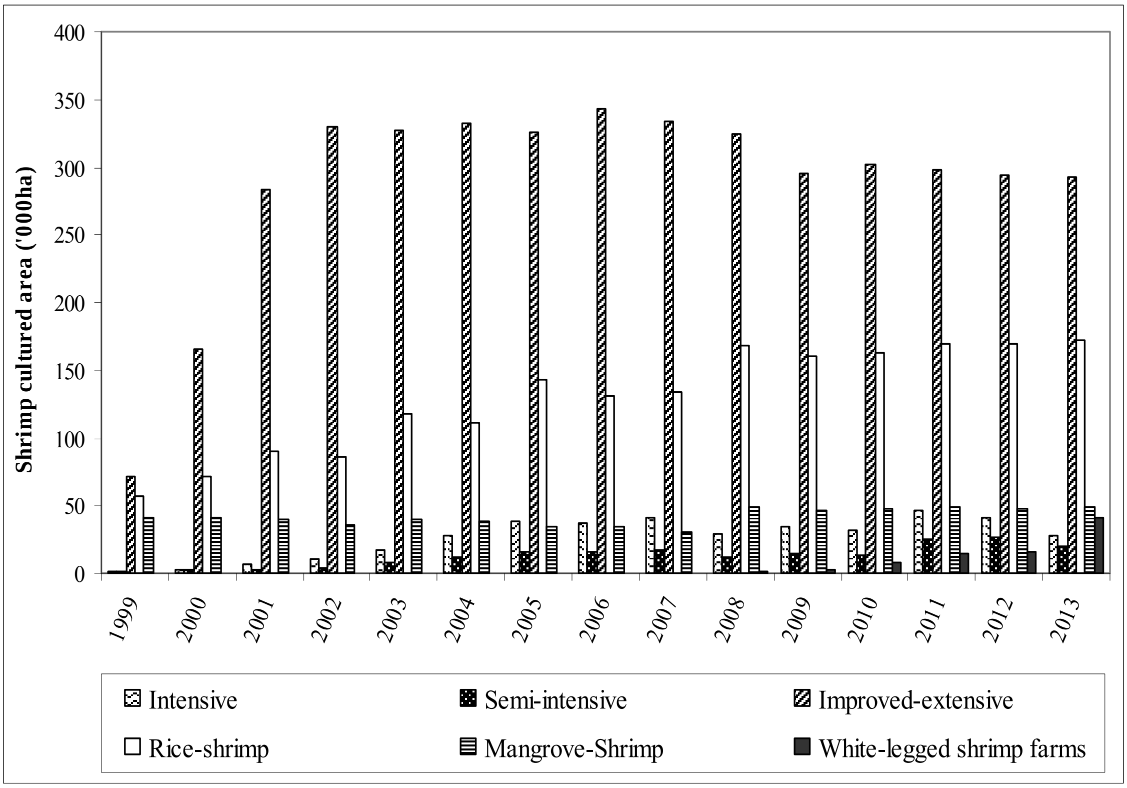

Figure 3.6. The shrimp culture area by farming systems in the MKD

Source: Provincial Dept. of Fisheries 2009-2012, Nguyen et al. (2009), Fisheries Directorate (2012, 2013)

3.3.3. Development trends of farmed giant freshwater prawn

a). General development trend

In the early 1980s, farmers began to stock GFP (*M.rosenbergii*) wild-seed in their rice paddies (Nguyen et al. 2006), and this dependence on juvenile prawns collected from wild-capture persisted up to 2000; the instability of wild-seed sources was a significant obstacle to the further expansion of prawn farming systems (Nguyen et al. 2006). After this time hatchery produced juveniles have become more available, growth of GFP has surged (Figure 3.7).

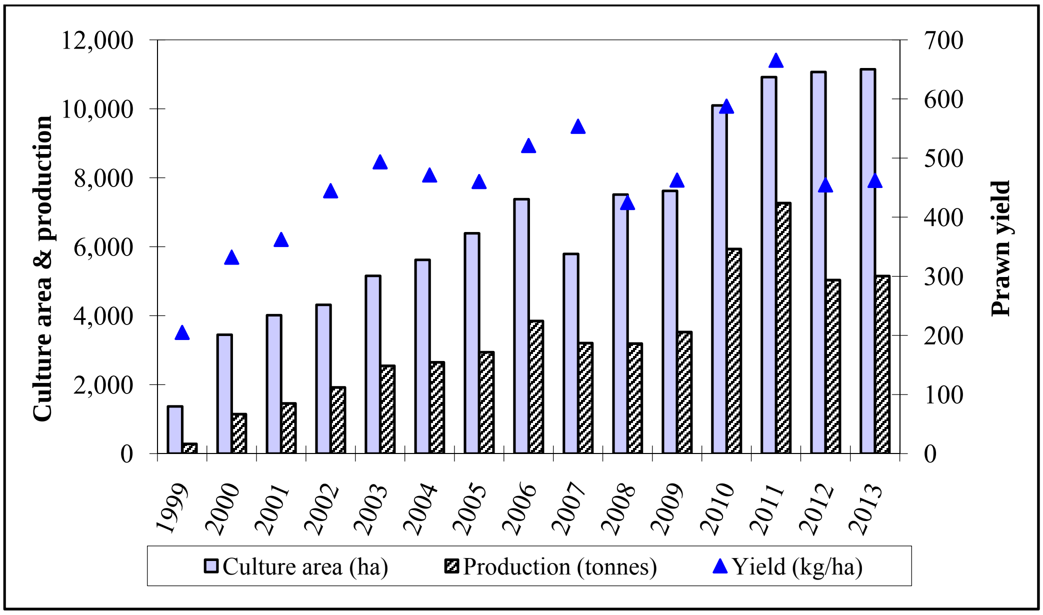

Figure 3.7. Development trends in prawn culture in the MKD

Source: Nguyen et al. (2009); VIFEP(2009); Fisheries Directorate (2011, 2012, 2013, 2014)

However, lack of a stable seed and good brood-stock sources (i.e. insufficient supply of wild brood-stock and genetic deterioration) are still significant obstacles to the slow development of GFP farming in the MKD (VIFEP 2009c; Nguyen et al. 2009). Additionally, the farming of prawns depends heavily on natural conditions (i.e. the quality of flood water, high level of water in the flood season, etc.), but recent flood seasons have been unstable and water levels low. Most farmed GFP areas are located in agricultural areas (i.e. rice-prawn rotation and rice-prawn concurrence), but the quality of supply water is gradually reducing due to negative effects from agricultural activities such as pesticide residues, resulting from increasing intensification of rice production (i.e. three rice-crops per year) (Nguyen, *pers.comm., 27/9/2011*).

b). Growth of giant freshwater prawn hatcheries

Reproduction techniques of GFP were firstly carried out successfully by the Research Institute for Aquaculture No.2 (RIA2) in 1992 (Tran et al. 1998). Brood-stocks come mainly from wild-capture, but overfishing was leading to problems with this source

(Wilder et al. 1998; Nguyen et al. 2003; Nguyen et al. 2006). Moreover, the unstable quality of wild brood-stock could make for poor quality of seed, and various larval diseasere was also a major factor hampering the success of prawn hatcheries at that time (Nguyen et al. 2003; Nguyen et al. 2006). Therefore, the mass production of prawn seed remained difficult until the end of the 1990's (Nguyen et al. 2003); the prawn hatcheries in the MKD had little consistent production until after 1998, and was held back by a shortage of seed that still heavily depended on wild-seed sources. The lessons learnt from previous studies has led to the development of new seed production technology based on the 'green water system' by CTU in the end of 1990s. Since 2000, successful 'green water system' techniques were transferred to hatcheries in both public and private sectors (Nguyen et al., 2003). Since then, GFP seed production developed rapidly in the MKD with more than 100 hatcheries producing more than with 100 million PLs by 2006 (Nguyen et al. 2009). These endeavors met with various degrees of success, with hatcheries facing technical and management-related difficulties such as high mortality rate at the hatcheries and quality of brood-stock sources related to genetic deterioration leading to slow growth and disease in seed production (Nguyen et al. 2006; Nietes-Satapornvanit et al. 2011; Nietes-Satapornvanit 2014).

c). Growth of giant freshwater prawn farms

Since the early 1980s, the first GFP culture method in An Giang and Dong Thap provinces in the MKD was based on the recruitment of seed into farms through sluice gates with the changing of the tides (Nguyen et al. 2006); seed would then be trapped and allowed to grow to full size. After that, the success of artificial seed production technology in hatcheries, rice–prawn farming has intensified and management practices have become very diverse. GFP is currently cultured in many ways (Table 3.3), including improved-extensive systems in rice fields (i.e. integrated rice-prawn farming, alternation with rice farming/rice-prawn rotation) similar to the extensive system, but with added artificial seed with lower stocking density and supplementary feed that complements natural feed, pen culture in the flooding plain areas and semi-intensive culture in ponds. However, the rice–prawn farming is the most important production system in freshwater areas (Nguyen et al. 2006).

Table 3.3. Technical characteristic of various prawn culture models

	Integrated rice-prawn	**Rice-prawn rotation**	**Pen Culture**	**Pond culture**
Pond size (ha)	0.1-0.7	0.68-2.93	35-900m^2	0.38
Seed source	Artificial	Artificial	Artificial	Artificial
Density (PL/m^2)	1.5-5	1.5-15	62	10-15
Productivity (kg/ha)	42-566	100-1500	1,420-15,710	1,200-1,500
No. of crop/year	1	1-2	1	1-2
Culture time (months)	5-7	6-8	5-6	5-6
Feeding	Home-made /Pellet	Home-made/Pellet	Home-made/Pellet	Pellet

Source: modified after Nguyen et al. (2003), Nguyen et al. (2006)

3.3.4. Development trends of farmed tilapia

a). General development trend

Tilapia has been farmed in Vietnam since the 1950s with the main species being *O.mossabicus* and their hybrid. From 1970 to 1990, tilapia species, *O.niloticus* was imported from Taiwan; by the early 1970’s it had became the main species for farming due to good growth rate and fish size and was mainly cultured in polyculture system such as VAC (garden-pond-livestock) (MARD 2010). From 1993 to 2000, the Research Institute for Aquaculture No.1 (RIA1) imported several strains including Thailand GIFT generation V, *O.Swansea*, *O.Aureus* from Philippines, and red tilapia from Thailand/Taiwan for genetic programmes. The successful generation of RIA1 studies brought a chance for tilapia farming development in Vietnam, however, before 1995 the main farmed tilapia was still mixed-sex species. Since the middle of the 1990's, farmed tilapia in Vietnam has developed with both mono-sex and mixed-sex species (MARD 2010). The total farmed area of tilapia was around 16,000ha including freshwater and brackish-water areas in the MKD (Table 3.4). Tilapia has been farmed in ponds, rice-fields and cages (Nguyen et al. 2009).

Table 3.4. Development trends in tilapia culture in the MKD

	2005	2011	2012	2013
Pond (ha)	10,129	10,559	16,086	16,569
Cage (m^3)	314,053	129,892	134,720	138,762
(# cage)	*1,963*	*1,082*	*1,123*	*1,156*
Total production (tonnes)	31,797	36,110	50,986	51,011
Production in pond (tonnes)	*24,113*	*28,057*	*42,633*	*41,992*
Production in cage (tonnes)	*7,684*	*8,053*	*8,353*	*9,020*

Source: Nguyen et al. (2009); MARD (2010); Fisheries Directorate (2011, 2012, 2013, 2014)

There were some provinces that had a very large tilapia farmed area in the MKD such as Long An with a farmed area of over 4,000ha mainly based on improved-pond monocultures, stocked at around 10 fingerling/m^2 and achieving eFCRs of around 1.2. Vinh Long province also had a farmed area of around 2,000ha, mainly polyculture; Hau Giang had 1,667ha, and Tien Giang had 1,200ha (MARD 2010). Additionally, the MKD has about 1,150 cages of farmed tilapia, mainly located on the main river channels in Dong Thap, An Giang, Vinh Long, Can Tho and Tien Giang province, that are former pangasius cages which were sold to new entrepreneurs who then produced tilapia (Nguyen & Dang 2009). So, the entrepreneurs producing tilapia were newcomers, and cage culture of tilapia was mainly based on red strains (Nguyen, *pers.comm., 9/9/2011*).

b). Growth of tilapia hatcheries

Since 1993, RIA1 has imported several strains from Thailand, the Philippines and Taiwan for genetic programmes (MARD 2010). The breeding of tilapia was also successfully conducted by RIA2, the CTU and Nong Lam University in the late 1990s. The mono-sex hatcheries and particularly the improved strains have supported the development of tilapia in the South of Vietnam. For example, a genetically improved strain of red tilapia at RIA2 has been positively evaluated (with better growth rate and lower FCR) by farmers, but the supply of the improved tilapia seed has been low (at 5-10% of requirements) so far (Nguyen, *pers.comm.,* 9/9/2011). The result, then, was applied in some Western regions, the reproduction of GIFT tilapia is now mainly in Tien Giang and Vinh Long provinces. MARD (2010) reported that the South of Vietnam contained around 100 tilapia hatcheries (including 90 mixed-sex species and 10 mono-sex hatcheries) in 2004. However, the quality of GIFT tilapia fingerlings coming from these hatcheries was generally not good. Therefore, the lack of a stable supply of seed, especially mono-sex sources and seed quality were the main constraint to the further expansion and development of tilapia culture (MARD 2010). Moreover, an existing brood-stock source with a high inbreeding rate and lower genetic diversification is also a key obstacle for further development (Pham 2010). To overcome barriers, improved strains of tilapia (i.e. higher growth, lower FCR, more resistant to diseases and better survival) and improved culture techniques should be supported and implemented (Nguyen, *pers.comm.*, 9/9/2011). Several programmes to improve strains of tilapia for artificial seed production have been implemented by research sectors in the MKD; however, the results are still limited for expanding or are at the on-going development stage.

c). Grow-out tilapia farms

Tilapia is cultured together with other fish species (i.e. polyculture) or cage culture in the MKD. Total farmed tilapia covers around 16,000ha but at low production, with yields ranging from 2-6 tonnes/ha in pond practices (Phan et al. 2011). To date, tilapia are also raised in cages in some MKD provinces with about 1,150 cages (MARD 2010; Fisheries Directorate 2014). According to our survey in 2010, each tilapia farm owns 1-5 cages containing 105m^3 of water; stocking density depends on fingerling size but is usually around 5kg/m^3 and productivity can reach 65kg/m^3 with harvested fish size ranged from 300-500gram/fish (Phan et al. 2011). Until now, a shortage of good fry production and poor brood-stock productivity were significant constraints to commercial tilapia production (Gupta & Acosta 2004; Pham 2010). In addition, lack of attention given to marketing (e.g. lack of international markets), economic factors and other business aspects have also been identified as constraints to success of commercial tilapia farming (MARD, 2010).

3.4. Growth of trade in farmed seafood

Striped catfish and shrimp have contributed an increasing proportion of Vietnam's exported fishery products over the last decade, whereas in comparison, tilapia and GFP have hardly featured in the statistics. Farmed species, mainly shrimp and striped catfish, have brought huge export value from seafood export and have had a rapid growth since 2001. In 2001, the export turnover of both species reached only US$787.62 million (accounted for 44% of seafood export turnover), but has since increased to US$4.86 billion (73%) in 2013 (Figure 3.8).

Striped catfish has shown the highest growth in seafood export value, reaching an annual growth rate of 61.44% compare with that of shrimp (12.20%) since 2001. Whereas, the export turnover of tilapia and GFP were still low, with US$1.26 million and US$11.23 million in 2008, respectively; however, these are two potential species to be developed in the future. Tilapia and GFP have been mainly consumed domestically rather than exported. Besides, the main constraints leading to slow growth of farmed tilapia and GFP described in the above sections, MARD (2010) and VIFEP (2009) pointed out other factors constrained exports including i) the small harvest size of farmed tilapia, often around

400gram, while the required size for export is around 600gram (Phan et al. 2011); ii) unstable production because of more fragmented tilapia/prawn farming areas and lack of a detailed master plan for development; iii) high demand from local markets for live tilapia and prawn; iv) net profit of tilapia is lower than for alternative species. Net returns of US$2,000/ha/crop for intensive tilapia production compared poorly to shrimp farming (US$8,000) and striped catfish farming (US$20,000) (Phan et al. 2011); and v) high market competition also exists for both tilapia (especially China) and GFP (especially Bangladesh).

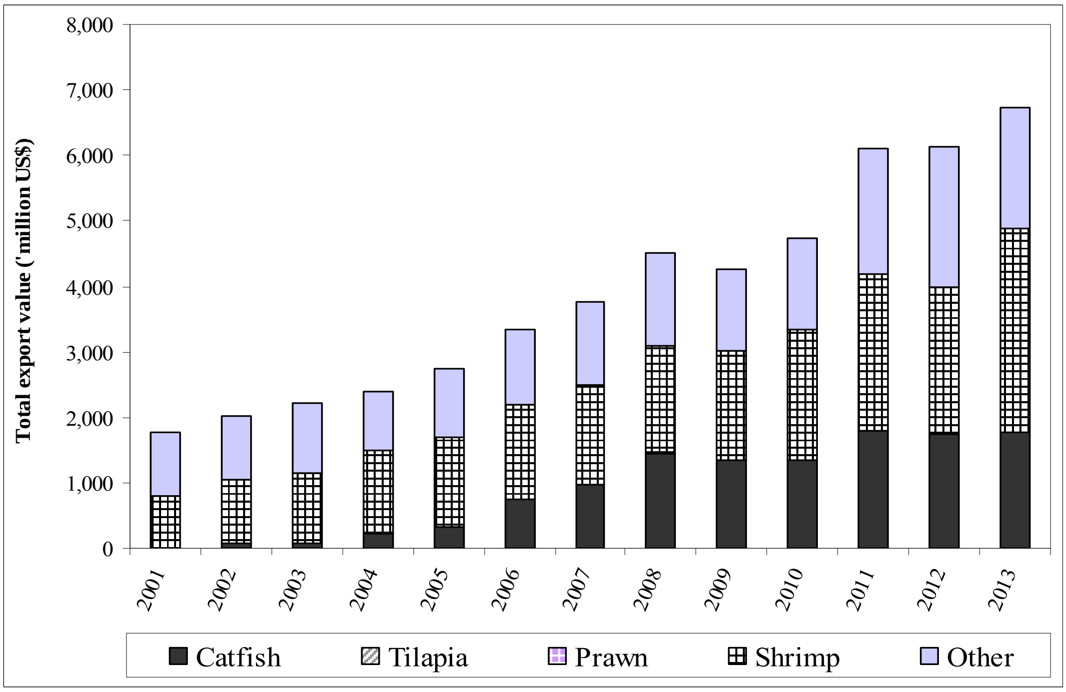

Figure 3.8. Trend lines of the Vietnam seafood export turnover by major species

Other products came mainly from wild capture. Source: VASEP (2010), VASEP (2011, 2012, 2013)

There have been significant changes in export markets over recent years, for example in the market destinations for striped catfish; the US market has tended to reduce quickly and the markets of the EU, the Eastern European countries such as Russia, Ukraine, and some other markets (Mexico, Brazil, Australia and ASEAN) have increased since 2001 (Figure 3.9). The main reason for market change resulted from trade restrictions imposed by the

US (i.e. antidumping duty imposed since 2002) that gave the impetus and increasing opportunities (e.g. increasing the worldwide advertising) for the catfish sector to develop new markets (Bush & Duijf 2011; Belton et al. 2011; De Silva & Nguyen 2011). Moreover, the striped catfish has become a strong competitor in the European whitefish market, because of its highly competitive prices and its substitutability for other types of whitefish (Little et al. 2012). The EU has gradually become the most important market for striped catfish. New markets have emerged, such as Australia together with many other countries which accounted for 41% of striped catfish export value in 2010, and 44% in 2013. Striped catfish has competed effectively in virtually every global market it has entered (Little et al. 2012). Recently, striped catfish entered the list of top ten most consumed seafood in the US in 2009, and it now competes successfully with a wide range of farmed and wild-caught whitefish in various market segments (Little et al. 2012). Moreover, the diversified markets could lead to potentially reduce price instability, risks of shocks in specific markets (e.g. heavy dependence on the US market before 2003) and trade fraud between exporters. Since 2008, the US market has recovered and increased due to increasing demand for seafood products with a cheaper price during the period of World economic crisis. However, at the same time the EU market has been gradually decreasing as a result of increasing technical barriers, high competition from the Alaska Pollock species that is already available with MSC trademark, negative consumer perception of pangasius affected by negative media impacts, and reduced spending power for seafood consumption by customers affected by the Eurozone crisis (VASEP 2011; CBI 2012a; Beukers et al. 2012; Fisheries Directorate 2013a; VASEP 2014a). Generally, the EU market share has been in decline since 2008 and the US market is regaining share, but the pangasius market is characterised by increased diversification of its markets (Nguyen & Dang 2009; Bush et al. 2010; De Silva & Nguyen 2011).

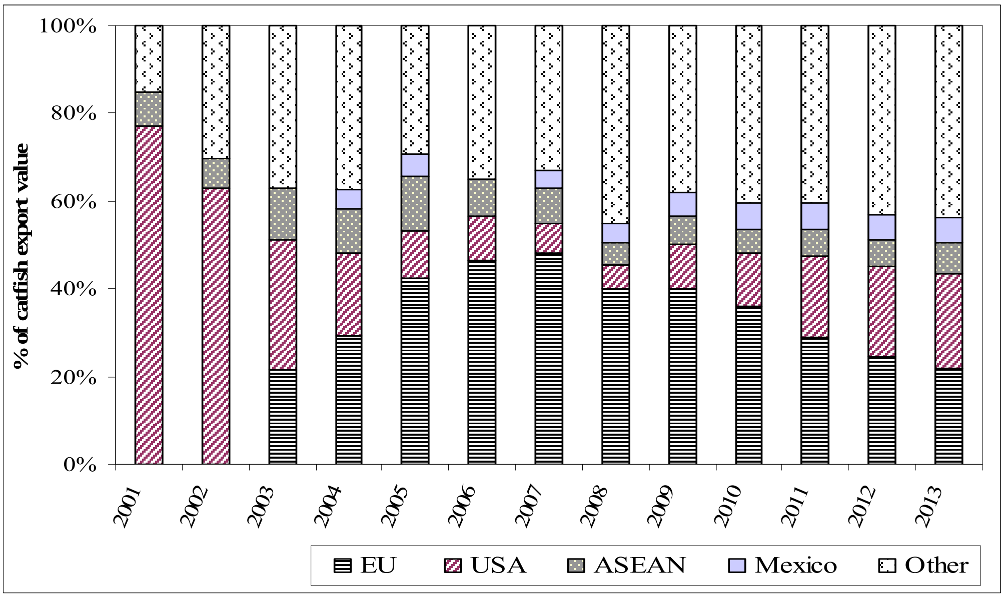

Figure 3.9. Market share movement of Vietnam catfish export in value

Source: VASEP (2010), VASEP (2011, 2012, 2013)

With regard to shrimp exports, there was a decrease in the Japanese and US markets while that of the EU market increased, with many other markets showing some increase also (Figure 3.10). The anti-dumping events between the US and Vietnam were the main reason for reducing export of Vietnamese shrimp products to the US markets; however, this was an opportunity for accessing new markets, especially the rapid growth of the Chinese market share since 2008 (VASEP 2012; VASEP 2014a). Zhang (2014) noted that the exports of Chinese shrimp products peaked in 2006, and then declined especially in 2008, while the domestic shrimp consumption was strongly grown. Meanwhile, both Chinese farmed and wild shrimp recorded growth of imports since 2008, especially of farmed shrimp. More than 80% of them were imported from ASEAN countries, as one of the positive results of the ASEAN-China tariff reducing plan. Recently, the Japanese market was gradually decreasing due to technical barriers (e.g. residue levels of ethoxyquin), the weaker *Japanese yen* halted import growth, and hard competition with other exporters (VASEP 2011; VASEP 2012; Fisheries Directorate 2014; VASEP 2014a).

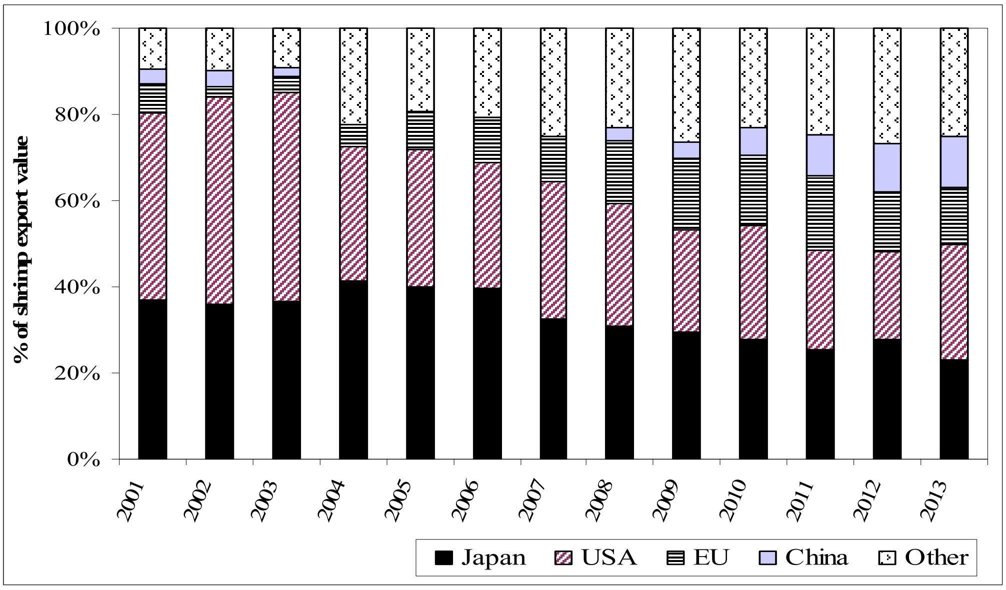

Figure 3.10. Market share movement of Vietnam shrimp export in value

Source: VASEP (2010), VASEP (2011, 2012, 2013)

✧ ***Market access barriers for seafood products:*** the Vietnamese seafood exports have begun and developed quickly since the last decade. During this time, Vietnam's fisheries sector has been confronted with several challenges in boosting exports and increasing competitiveness. Requirements on food hygiene and environment imposed by importers are the main challenges that focus on level of antibiotic and chemical residues in seafood products (MARD 2009c; Tuan et al. 2013; VASEP 2013). The chemical and antibiotic products used during the production cycle from farms to processing lines helped to increase production efficiency and preserve products (Dinh 2006; Rico et al. 2012; Rico et al. 2013). However, the chemical and antibiotic products may have negative impacts on human health and the environment if they are used in high amounts or have persistant high residues (Dinh 2006; Nguyen et al. 2009; Gildemeister 2012; Rico et al. 2013; Tuan et al. 2013). The importers such as the US, Japan and the EU markets are concerned about chemical use, therefore they imposed strict regulations on permissible levels of antibiotics and chemical residues in seafood products (Dinh 2006; Rico et al. 2012; Rico et al. 2013). Additionally, tariffs and trade policies of importing countries are also barriers to Vietnam's seafood exports; for example, trade restrictions after the anti-dumping event led to the reduction of catfish exported to the US market until approximately 2005 (Nguyen 2010; De Silva & Nguyen 2011). In general, there are some challenges and implications for Vietnam seafood exporters (Dinh 2006; MARD 2009c; Tuan et al. 2013), as follows i) a complex process for seafood exporters to understand the food hygiene and environmental requirements in individual importing markets. To export products, seafood enterprises are faced with sophisticated and ever changing layers of standards set by national and international governmental bodies; ii) the diversity of standards in place in export markets is very large (Corsin et al. 2007; Bostock et al. 2010; Ponte et al. 2011). Although there are some common trends in food safety regulations in importing countries, they have not adopted common product standards, processor inspection requirements. As Vietnamese enterprises expand their export markets, the diversity of requirements they need to meet also increases; iii) hygiene and environmental standards have become increasingly stringent in response to scientific evidence and consumer concern. For example, the producers and processors sought clarification about maximum residue limits for ethoxyquin, which caused rejection of shrimp in Japanese market in 2012, as there were 39 cases of rejection of shrimp from Vietnam and India by Japan due to the presence of this compound at levels of more than 0.01ppm (Karunasagar 2013); iv) costs of compliance for the Vietnamese seafood industry are significant and impact on its competitiveness as well as its ability to gain market access; and iv) tariff and trade policy that used to protect local producers of importing countries are still barriers for seafood exports.

3.5. Growth of processing sectors

3.5.1. Growth of seafood processing plants

The export of seafood from Vietnam began at the end of the 1970s, with export values at US$16.60 million in 1979. The Sea Products Import-Export Join Stock Corporation (SEAPRODEX) was the first company allowed to export fisheries products to the Japanese market, was established in 1978. However, until the mid 1980s, all seafood processors were state-owned and all export trade was a state monopoly, with the main products coming from wild-capture. Since the establishment of the '*Doimoi policy'* in 1986, the Vietnamese government has encouraged the privatization of state-owned companies. Seafood products have grown gradually in terms of export volume and value, reaching US$175 million in 1989 with around 100 seafood processing plants (Tuan et al. 2013). Up to the beginning of the 1990s, all private seafood processors were required to export their products through SEAPRODEX (Kagawa & Bailey 2006; Tuan et al. 2013). In the period from 1985 to 1990, frozen products increased with an annual growth rate of 26%, increasing to 32% per year in the period of 1990-1995. Frozen products increased continuously and by 2000 accounted for 86% of the total processed products with shrimp alone accounting for almost one quarter (23%), followed by squid, fish and molluscs. Dried products were also component of processed, exported product (Nguyen et al. 2009; VIFEP 2009c). Corresponding to the rapid growth of the aquaculture sector since 2001, as a positive result of the new policy "Decree 09/2000/NQ-CP" and accessibility to the international seafood markets, seafood processing plants grew in both total output and technologies, with the diversification of products and more attention to value-added products. Standards for food safety equal that met international requirements were considered and issued. By the end of 2002, there were 246 processing enterprises in Vietnam, of which 211 were frozen processing plants with a Almost 69% of processing enterprises were located in the south of Vietnam, 27% in the Centre and 4% in the North. Frozen raw products were still the main output of processing due to limitations in processing technology for value added products at this time. In 2003, over 60% of enterprises had met the requirements for food safety with around 100 processing enterprises in Vietnam included in the first list of fishery exporters into the EU, with Vietnam fishery products present in over 75 countries and territories. The seafood processing sector continued to increase and expansion of the export market diversified during the last decade. By 2008, Vietnam had 470 seafood processing plants, of which 269 qualified to export to the EU; this increased to 429 in 2010. Tuan et al. (2013) noted that there was a significant increase in the number of seafood processors and their production capacity per day during 2002 and 2009, with annual growth rates of 10.7% and 12.3%, respectively.

Many seafood plants acquired food safety certifications (e.g. GAP, BAP, SQF) required by their major trading partners, and most applied product quality controls such as International Standards Organization (ISO), Hazard Analysis and Critical Control Point (HACCP), and Good Manufacturing Practices (GMP) (Dinh 2006; VASEP 2011). MKD is the main area of seafood processing plants as it has grown in parallel with farming, with the main products coming from shrimp and catfish industries (Figure 3.11). In 2002, there were 143 seafood processing plants in the Southeast provinces and MKD, with an average production capacity reaching nearly 15.5tonnes/plant per day. After that, the fast growth of the aquaculture sector led to an increase in the processing sector, and it reached 317 seafood processing plants with an average capacity of 18.4 tonnes/plant per day (Nguyen et al. 2009; Tuan et al. 2013). However, less effective planning and management of the processing sector has recently led to several problems such as operating under capacity, trade fraud in terms of buying raw products for processing and selling finished products (Nguyen et al. 2009; VIFEP 2009a; Tuan et al. 2013).

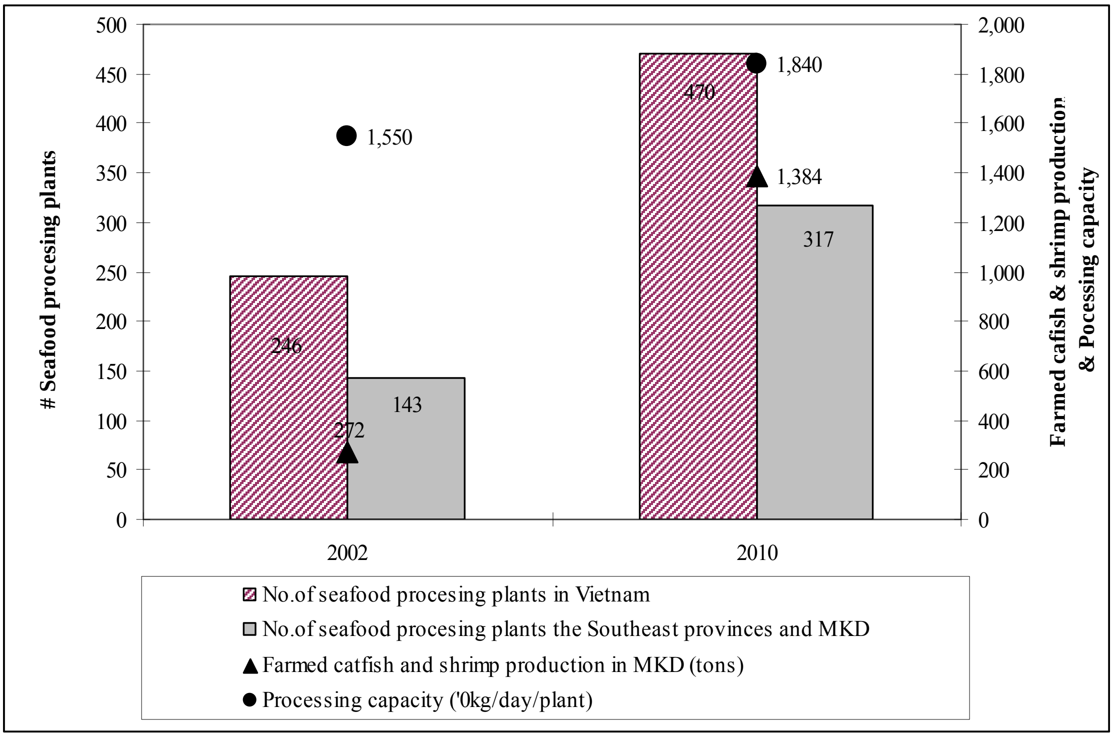

Figure 3.11. The growth of seafood processing sector in Vietnam and MKD

Source: Nguyen et al. (2009), VIFEP(2009), Tuan et al. (2013)

3.5.2. Growth of aquafeed processing plants

The animal feed processing sector has developed rapidly in Vietnam since the 1990s with the growth of the livestock industry. Stanton Emms & Sia (2009) reported that there were 250 feed factories in Vietnam, of which 15 were large feed producers owned by foreign companies or joint ventures (including Cargill, CP, Proconco, UP, ANT, Tomboy and Grobest) that produced about 50% of total manufactured animal feed. However by 2013, more than 60% of the raw materials used for feed processing were imported (Pham et al. 2010; CBI 2012b; Tuan et al. 2013); and this percentage has increased since 2000 due to problems in Vietnam's cereal and oilseed industries. This sector is also underpinned by demand for wheat, which cannot be grown in Vietnam, but is a primary input (i.e. wheat flour) for the rapidly growing livestock and aquaculture feed industry. In 2000, the total value of imported wheat was US$77.8 million, which soared to 763.8 million by 2012 (GSO 2013). Moreover, local availability of inputs (e.g. rice bran, soybean, fishmeal & fish oil) for feed production, particularly the protein rich ingredients, is limited in terms of quality and quantity used for feed processing (Pham et al. 2010; Tuan et al. 2013). The same authors indicated that more than ten types of ingredients out of twenty-two were imported by feed enterprises, and the animal feed sector depends more on imports for protein inputs than those for energy. In recent years, the heavy dependence on imports of raw materials, high import taxes and low domestic yield of these inputs have been considered the causes of the high livestock feed prices. Therefore, the industrial feed prices were around 10-15% higher than in other countries in the region, such as Thailand and China which produce comparatively more of the raw materials they require (CBI 2012b). High livestock feed prices directly affect producers as they result in higher production costs, especially when the prices of livestock products cannot increase sufficiently to cover the increased costs (Pham et al. 2010).

Aquaculture feeds in the MKD are mainly available in two forms: home-made and commercial. Up to 2008, the MKD had a total of 78 commercial feed factories and about 1,599 distributors (Nguyen et al.2009). The total production of pellet feed produced in the MKD was 140,500 tonnes, accounting for 26% of the demand, and the remaining feed was home-made or imported from outside MKD provinces (i.e. Ho Chi Minh, Dong Nai and Binh Duong provinces). Can Tho, Dong Thap, Tien Giang and Long An provinces have become the main locations for production of pellet feed for fish and shrimp in the MKD. Provincial Department of Fisheries reports showed that almost all provinces in the MKD, apart from those self-insufficient in feed production, imported a large amount of feed from other factories (e.g. CP, Cargill, UP etc.) in the southeast provinces where the industrial zones were located. The feed companies firstly established in the southeast provinces (i.e. HCM city and Dong Nai), because this area had industrial zones with better infrastructure and policies for attracting investment of foreign feed companies (e.g. CP, UP, Cargill). The companies began with livestock feeds and then expanded to aqua-feeds as the sector developed. In general, the situation for aqua feeds is the same as livetock feeds sector in terms of constraints on the imported and local domestic raw material sources (Nguyen et al. 2009; Tuan et al. 2013). Thus, this issue is a main constraint to the reduction of competition capacity in trading in the international markets and the future development of aquaculture (Nguyen et al.2009). Feed cost accounted for around 80% of total production cost (Phan et al. 2009), directly affecting producers' operations during periods of increasing feed prices and unstable markets (Pham et al. 2010).

3.6. Social and environmental impact

3.6.1. Social impact

The aquaculture sector has developed rapidly in recent years, generating significant employment opportunities and income to rural communities, as well as becoming a significant foreign exchange earner for Vietnam (Vu & Phan 2008; Nguyen et al. 2009). For example, the shrimp industry has brought about great social and economic benefits and generated jobs, created income for coastal communities as well as improved local infrastructure (Nguyen et al. 2009; Tran et al. 2013). Shrimp farming, in particular, resulted in direct benefits to coastal regions where people had fewer livelihood options. Since 2000, many people who produced salt and rice inefficiently have moved to shrimp farming, in so doing have diversified their livelihood, and enhanced their living standards. In addition, shrimp farming also brings about growth of services such as seed and feed supply, etc., creating new jobs and increased income of the local people (Nhuong et al. 2003). However, encouraging the poor households to participate directly in shrimp farming could be risky as shrimp farming is a complex technology and requires high investment that is beyond the poor's resources (Nhuong et al. 2003; VIFEP 2009; Nhuong 2011). On the other hand, the most important complaints about the negative impacts of shrimp farming sector were i) the shrimp households who obtained continuous losses from shrimp crops after several years could not re-invest in aquaculture, consequently they had to sell or to lease their lands and fell into poverty (Le 2009; Nguyen et al. 2009); ii) the poverty situation, reduction in free surface water and lower quality of public water, as well as the need to diversify species for aquaculture have become the main reasons for overfishing which caused rapid depletion of natural aquatic resources (Le 2009; Ha & van Dijk 2013); and iii) the conflicts around water use among stakeholder groups e.g. between rice-farmers and shrimp farmers (RIA2 2009; Tuan et al. 2013) and a negative impact on fishing, which represents an important source of livelihood for the poor (Irz et al. 2007).

Recently, the striped catfish development has become a significant source of export earnings (Nguyen 2008; VIFEP 2009a), and it also reportedly supports the livelihoods of around 100,000 individuals and provides an additional 170,000 jobs in the processing sector, mostly women in 2009 (Nguyen et al. 2009; De Silva & Nguyen 2011). De Silva & Nguyen (2011) indicated that obviously a highly intensive farming system in striped catfish farming tends to generate high revenues and can bring large profits to all stakeholders along the value chain during a period of high product price. As well as the positive impacts, aquaculture also had some negative impacts during the development process. For example, the immediate effect of the anti-dumping decision was a decline in the farm gate price of striped catfish to below production costs, leading to the loss of an estimated 8,000 jobs (Zweig et al. 2005). Bush et al. (2009) noted that as a negative impact of the US antidumping event, the striped catfish sector may have lost between 14-63% of its market share, with a 3-10% reduction in real income (Brambilla et al. 2009);

and 10% of workers at the processing plants were made redundant (Nguyen et al. 2004). De Silva & Nguyen (2011) indicated that during the time of low fish prices, many catfish farmers suspended farming or some farms left the sector due to poor economic performance (Nguyen et al. 2009; Vo et al. 2010).

3.6.2. Environmental impact

The rapid development of Vietnam's aquaculture has caused several environmental issues in the short and long-terms (Nhuong et al. 2002; Nhuong et al. 2003; Anh et al. 2010a; Anh et al. 2010b; Pham et al. 2011), such as mangrove forest degradation, biodiversity loss, ecological imbalance and disease epidemics (Le 2009; Ha et al. 2012). One of the most serious environmental problems has resulted from the pressure of expanding aqua-farming on natural resources in coastal areas, especially mangrove forests. During the period 1983-2000, the total area of shrimp farming in the MKD increased by 35 times, with the loss of 15,000 hectares of mangrove forest annually (Nhuong et al. 2003); and many of the mangroves lost in the 1990s were due to aquaculture development. After 2000, deforestation slowed down in response to strict government measures, and the recognition that sediment zones in mangrove forests are not suitable for shrimp farming (Binh et al. 1997; Dinh 2006).

Environmental pollution has increased in many zones of intensive aquaculture (Nguyen et al. 2009). With the development of intensive farming, the use of shrimp feed, drugs and chemicals increased proportionately (Nhuong et al. 2003), resulting in excess shrimp feed and untreated waste polluting rivers and coastal habitats, destroying the ecological balance and reducing biodiversity. In addition, the spread of epidemic diseases has been a key concern, as the outbreak of disease can be connected to environmental factors, as well as insufficient quality control of shrimp seed. Recent studies showd that more than 75% of shrimp farms confirmed that the main reasons leading to shrimp disease came from the bad seed quality (Nhuong et al. 2002; Nguyen et al. 2009; RIA2 2009; VIFEP 2009b; Le et al. 2011); thus low quality shrimp seed may have contributed to massive loss of shrimps in the MKD in recent years.

On the other hand, as a result of the rapid growth of the aquaculture industry the water pollution, degradation of land resources, soil erosion, over exploitation of natural resources and threats to the ecosystem are among the challenges (Bosma et al. 2009; Anh et al. 2010b). For example, with the concentrations of intensive catfish farming along the Mekong Rivers, effluents from striped catfish ponds have become a potential pollutant source (Cao et al. 2010; Truong et al. 2011). The major issue is associated with high pond sludge levels in catfish ponds amounting to around 8,000m^3 of sediment per hectare for each growth cycle of 8-10 months (Anh et al. 2010b) which pollutes surface waters if drained or pumped directly into water bodies without treatment (Cao et al. 2010; Truong et al. 2011; Phan et al. 2013). Although striped catfish farms are located mainly along the Mekong Rivers that can help to carry wastes to minimize pollution, localized pollution of water has been recorded in several culture areas that are far from main river streams, such as catfish farming areas at Chau Phu district in An Giang province and Tieu Can district in Tra Vinh province (Bosma et al. 2009; Phuong et al. 2009; Nguyen et al. 2013). However, De Silva et al. (2010) noted that the quantity of potential discharge from the striped catfish farming sector was relatively small compared to the potential run-off of nitrogen and phosphorus from fertilizers used in rice farming. Hence, in order for Vietnamese seafood exports to remain competitive it is necessary for the industry to improve and demonstrate good environmental performance through the adoption of environmental management systems through the life cycle of seafood production and processing.

3.7. Product quality and consumption

3.7.1. Post-harvest issues

The system for shrimp traders who buy shrimp from grow-out farmers has also developed in terms of numbers and trading network together with the farming system (Nguyen et al. 2009). There were around 1,000 shrimp wholesalers operating in the MKD in 2007. These shrimp wholesalers play an intermediary role in the purchase of raw materials/production from the local grow-out producers and sell them to processing plants. In practice, the gathering and processing network also extends to lower levels of trading (i.e. shrimp collectors). The shrimp collectors often live on the farm sties in the remoter areas where collectors come to buy shrimp at the farm gate, which are then sent up a trading level (i.e. shrimp wholesalers) in the local town. Relatively few collectors sell their production directly to processors due to limitations on equipment for storing and transferring (Phan et al. 2011; Le et al. 2011; Vu et al. 2013). Whereas, semi-/intensive shrimp farms mainly sold shrimp to wholesalers (88% of their production), collectors were responsible for purchasing almost 70% of the shrimp from other systems (Le et al. 2011; Tran et al. 2013). Shrimp farming areas are complex with many canals, often located in remote areas far away from processing plants with difficult access for transportation, so the intermediate shrimp traders (i.e. wholesalers and collectors) can play an important role in the shrimp supply flows. Nguyen et al. (2009) noted that shrimp collecting networks had been very positive, with an important contribution to better production of processed seafood. However, limitations of this system lie in the small-scale facilities of most traders, and maintenance as well as rudimentary transportation equipment, lack of knowledge of food hygiene and safety etc. The collection network has proven to be very dynamic over time and has worked effectively to meet the demand needs of the seafood processors in the

MKD, especially given the fragmented and small-scale nature of most shrimp production on the MKD. With more than 200,000 shrimp farms, processing plants must rely on a lengthy chain of traders to move shrimp from ponds to their factories (Tran et al. 2013). Shrimp processors faced constraints on food safety and quality control along the value chain of the pond to their factories, particularly when the product comes from many farms and complex intermediate networks (Le et al. 2011; Tran et al. 2013). In the longer term, the requirements on aquatic products' quality and safety will be stricter, and thus current intermediate networks must be improved and replaced by the wholesale seafood or markets centres in each province. The wholesale markets for seafood need to fulfil important functions and create favorable conditions for local stakeholders (i.e. farmers, traders, processors, managers) for selling/buying shrimps and controlling shrimp quality (Nguyen et al. 2009; Phan et al. 2011). Wholesale seafood markets were developed in and proved a critical platform for development of international trade. The Mahachai Talay Thai market was an auction wholesale market for seafood coming from the nearby fish landing port as well as for farmed shrimp from many provinces in Thailand. This market continues to be an important location for the seafood industry and a processing hub, facilitated by its status of a major port (Nietes-Satapornvanit 2014).

By way of contrast, most catfish grow-out producers now sell directly to pangasius processors. Cuyvers & Tran (2008) found that after the catfish war between US and Vietnam in 2003, more than 80% of live striped catfish was directly sold to the processors and less than 20% to the traders, whereas in 2010 the ratio was 99% and 1% respectively (Le 2011). Traders were important for smaller-scale farmers to access processors taking responsibility for quality (colour, size, and weight) and covering transportation losses. Another study in 2010 also found that almost all surveyed farms sold live catfish directly to processors rather than via traders (Phan et al. 2011; Nguyen et al. 2013). Processors own or sub-contracted harvest teams transport fish live usually by boats; a figure of 5% is used to cover mortality of fish (Khoi 2011).

Other farmed species in the MKD such tilapia and GFP are often harvested and sold directly to traders at the farm gate before transfer to local urban markets or big cities. Tilapia and GFP are often marketed live, limiting harvest volumes on each occasion. The movement of product from producers through different intermediaries to consumers is facilitated mostly by the traders (Nguyen et al. 2009; Phan et al. 2011). In generally, in the MKD provinces, production prices depend on the market, while the linkages between farmers and buyers are still weak, and verbal arrangements are quite easily broken when markets are unstable. There are no formal contracts on risk-sharing, some traders are fraudulent when measuring and weighing and such trading methods do occur, affecting the interests of grow-out producers (Nguyen et al. 2009). These factors may also contribute to the slow expansion and development of tilapia and GFP culture in the MKD.

3.7.2. Quality control of fishery products

National Agro-forestry-fisheries Quality Assurance (NAFIQAD) is the national competent authority for fishery food safety assurance and quality control in Vietnam. They deal with local governments, provincial Fisheries Departments, processing/export companies and other relevant institutions and organizations. In 2003, the remit of the center’s work was expanded to include veterinary matters (fish and shrimp disease control). The control of sanitary conditions and food safety at seafood processing plants and preliminary treatment facilities is regulated by six NAFIQAD branches along the country. In the early days, regional NAFIQAD centers focused on the management of output quality, i.e. the management of products in the processing facilities. Recently, there has been increased control on inputs that focus not only on raw material sources of processing plants, but also provides quality control from grow-out farms to processing stages. Moreover, MARD (2009a) promulgated regulations on drug, chemicals and antibiotics banned/or limitedly using for manufacturing and trading in the aquaculture sector, the regulations are enforced to all stakeholders along value chains and they are monitored by local fisheries authorities to meet requirements from importers on food safety. The regulations have also positively contributed to the strong growth of the aquaculture sector over the last two decades.

Besides, most seafood processing plants have a quality control unit (i.e. laboratory and specialized staff) that is responsible for self-control in the quality of raw materials and their finished products. On the other hand, the quality control is also considered and implemented by farmers, who have increased their knowledge about management practices and food safety through technical training courses. In general, the management of quality, hygiene and safety of aquatic food now complies with international norms and standards, the evidence being that key products such as catfish and shrimp have entered stricter markets, such as the EU, Japan and US markets. Up until now, some 269 processing enterprises qualified for export to the EU, of which 133 enterprises are in the MKD (Tuan et al. 2013). However, along with these achievements there is also the less effective mechanism of coordination and co-operation between regional NAFIQAD agencies and local fisheries departments that leads to difficulties in implementing the State's management of aquatic products, seafood quality, hygiene from rearing, catching and processing stages. The State's management agencies in at Provincial level are short of qualified, experienced human resources, facilities and funding for the implementation of food quality, hygiene and safety control (Nguyen et al. 2009; Tuan et al. 2013).

3.7.3. Status of standards and traceability application

The Ministry of Agriculture & Rural Development (MARD) developed sectoral standards for aquaculture since 1990. The main purposes were for regulation of culture systems in terms of hatcheries and grow-out operations, feed/chemical/drug use and culture conditions, and to help the aquaculture industry improve on quality and food safety. However, the enforcement of sectoral standards was limited and the programmes were considered leading the standards to be abandoned and a reorientation of effort (Vu & Don 2008). MARD has carried out many related research projects with an aim to improve the quality of farmed fish, and the national sectoral standards for aquaculture products are the results from these studies. Additonally, to meet the requirements of food safety demanded by international markets, several regulations on banned/or limited use of drugs, chemicals and antibiotics for manufacturing and trading in aquaculture were promulgated by MARD. In recent years, many attempts have been made to apply these standards in aquaculture (Vu & Don 2008; Nguyen et al. 2009). Although many studies and programmes were carried-out or are being implemented, their results are still limited and less effective. Fisheries Directorate (2010) pointed out that certification systems such as GlobalGAP and GAA-BAP are needed as a priority activity in order to reach the market requirement in the strategies for aquaculture development up to 2020. The Fisheries Directorate developed VietGAP documentation for both catfish and shrimp farming systems, in the short term, encouraged farmers to apply with the expectation that it will be enforced in the longer term. Recently, in An Giang and Can Tho provinces, for example, 526ha of striped catfish farms were certified in 2010 (Nguyen, *pers.comm., 21/1/2011*) by GlobalGAP and Safe Quality Food. Additionally, in the MKD seven pangasius processing plants have achieved GlobalGAP certification for their catfish farms. According to some processors' assessment, the production cost based on the GlobalGAP's process increased only 3% compared with its usual, whereas its value increased to 12% (Fisheries Directorate 2013). Recently, around 40 catfish processing plants have applied to the Aquaculture Stewardship Council (ASC) standards, of which 28 processors achieved the ASC for their grow-out farmed areas (VASEP 2014b). The Fisheries Directorate (2013) reported that around 10% of total striped catfish production reached the ASC standard in 2012 and it will increase to 50% in 2015. Moreover, there have been many farmed areas of catfish and shrimp that belong to seafood enterprises such as Hung Vuong, Nam Viet, Hung Ca companies etc., that are applying the GAA-BAP and GlobalGAP guidelines to their farms.

3.8. Roles of facilitating institutions

3.8.1. Management and supporting sectors

There are two key actor groups providing support for aquaculture sector development in the MKD, the public sector (i.e. DOFs at national and local levels, VINAFIS, VASEP) and the private sector (i.e. aquaculture companies, input suppliers, and post-harvest actors). Both public and private sector actors played important roles in aquaculture development in the MKD. While the roles of government are cast as providing the economic, political, and infrastructural conditions necessary for private investment; the private sector, in turn, is tasked with the responsibility of driving the integration of producers into higher-value markets via business relationships and associated provision of market information, technical advice, and logistics and other services (Khoi 2011; Tuan et al. 2013). The Directorate of Fisheries (DOFI) is a national public administration; and the other institutions of the fisheries sector, including technical departments, research institutions, educational institutions, and provincial advisory departments implement DOFI’s directions. Moreover, there are socio-political organizations and professional societies that also play an important role in organizing and encouraging enterprises to develop their business and production, such as the Vietnamese Association of Seafood Exporters and Producers (VASEP) and the Vietnamese Fisheries Society (VINAFIS).

Seafood exports began from the end of the 1970s, however the growth of seafood export was quite slow until the late 1990s and also faced several challenges such as overfishing, backward technology processing, lack of knowledge on the food safety and quality, weak trade promotion activities, unprompted development and lack of horizontal integration among processors, and less competitive capacity in the international markets, the challenges lead to very poor business performances (VASEP 2013). VASEP, a non-governmental organization, was established in 1998 to make the horizontal linkages among seafood processors, and to promote growth of Vietnam's seafood industry and to facilitate the smooth export of seafood products internationally (Cuyvers & Tran 2008). VASEP also provided essential market information; watched trends and developed national strategies for the seafood industry so that each of their members can better determine its orientation for development; organized and implemented trade-promotion activities and short-term training; and supported the business expansion of their members (Le 2011). VASEP represented and protected its members' legitimate rights and interests in regard to governmental authorities and third-party bodies (Tuan et al. 2013). VASEP initially had 54 member seafood processors that were State-owned, but by 2013 had expanded to 273 members mainly from the private sector (VASEP 2013). VASEP established committees for seafood sub-sectors to share experiences and co-operate in order to deal with current problems and to keep up with specialization trends in seafood processing and export activities. VASEP freshwater Fish Committess (VFFC) linked the pangasius processors and exporters to solve trade and technical barriers, market volatility and overcome difficulties caused by the economic crisis. While VASEP Shrimp Committee (VSC) often introduces action programmes for enterprises to cope with complaints and claims on shrimp quality. The VSC also coordinated with enterprises to solve difficulties after the shrimp anti-dumping case and dealt with the shrimp countervailing duty lawsuit against the US. The VSC was proactive in meeting and negotiating with partners in importing markets when barriers were imposed to prevent purchase of Vietnamese shrimp products.

VINAFIS, a civil society organization of people working in the fisheries sector, was established in 1982 and has played an important part for fisheries development in Vietnam. VINAFIS has a nation wide network at the provincial level where most of the members are fish farmers, processors, and aquaculture input suppliers. It provides market information, such as prices of raw material in the national and international markets to its members (Tuan et al. 2013). In addition, VINAFIS regularly gathers recommendations from member committees to submit to the Government and relevant regulatory agencies in an effort to suggest measures to develop fisheries production and reduce burdens for members. For example, suggestions on financial support for the catfish sector during the low fish price and economic crisis were taken by government to support VINAFIS members to overcome difficulties and strengthen their operations. Catfish farms received US$268.03 million of total loans from State banks in 2011, increasing to US$374.52 million in 2012, while the loans of seafood processors were US$608.22 million and US$720.48 million, respectively (Fisheries Directorate 2013a). However, a widespread belief exists among its members that to be more effective, this association must take a stronger lead in the contract negotiations of farmers with processors (Khoi 2011).

3.8.2. Organization of production

Around 80% of the aquaculture farms in the MKD are privately owned by farmers who have developed their skills through experience rather than any formal education (Tran et al. 2003; Nguyen et al. 2009; Phan et al. 2009; Tran et al. 2013). The importance of cooperation among producers in the agriculture sector has been gradually recognized after many crop losses (Nguyen et al. 2009; Le 2011), encouraging farmers to form groups. The same authors also reported that farmers faced a number of technical and managerial constraints such as production technology knowledge, market information, access to credit, and business relations; moreover, they limit their participation in an export-oriented supply chain (Subasinghe et al. 2009). Hence, the establishment and improvement of farmers' organizations are a base for the involvement of farmers in coordinated supply chains that provide access to export markets (Umesh et al. 2009; Bosma & Verdegem 2011; Tran et al. 2013). Additionally, farmers through organization, gain economies of scale in accessing services and markets (Khoi 2011). Umesh et al. (2009) indicated that farmers groups create potential for cooperative action which changes the position of the farmer in the value chain and influences the business environment. Farmers' groups also improve information exchange and sharing among group members. Such groups help members enhance their technical skills and save on production costs by working collectively and activities include purchase of seed and other inputs (feed, chemical, pond preparation, water pumping, harvesting) together (RIA2 2009). Most of the cooperation between farmers now are established in terms of cooperatives and farmers groups (Nguyen et al. 2009). At the present, MKD has around 115 cooperatives, an increase of 75 cooperatives compared with 2003, and 352 farmers groups (i.e. lower level of the cooperative model), an increase of 136 groups since 2003. Cooperatives are legally bound institutions that requires higher management levels, while rmembers' awareness is often limited; in general, the economic cooperative activities model is still limited and less effective (Nguyen et al. 2009). Many farmers' organizations (farmers' clubs and cooperatives) in the aquaculture sector were established after 2000; however, they still did not show clear positive outcomes in terms of improved economic performance for members through effective cooperative action. The main reason for this were perceived as i) poor cooperative management skills: leader teams often have lower education levels and lack of management skills to develop and manage cooperatives; ii) lack of cooperative actions: this remained very limited among members, the main actions still focused on developing technical skills and production information sharing, and a lack of vertical linkages with other actors and trust between members remained; iv) uncompleted cooperative structures: many cooperatives had incomplete management teams such as lack of an accountant; and iii) lack of appropriate policy supports (financial and technical supports). Generally, due to the low educational level of cooperative leaders and limitation of their operational management skills, the farmers' organizations should be begun with the 'farmers group' level that can be a pre-cooperative. The leader teams of farmers' groups can be strengthened in term of organization on the cooperation actions and group management over time, and then the farmers' groups could be upgraded to the cooperatives through 'functional upgrading' tools (Nguyen et al. 2009; RIA2 2009). However, there are several examples of successful cooperatives or farmers' organisations such as the Thoi An pangasius cooperative in Can Tho province that has good vertical linkages with Hung Vuong pangasius processor through contract farming system (Anh 2014), shrimp farmers' organizations in India that create strong vertical integrated linkages with input suppliers (seed and feed suppliers) (Umesh et al. 2010). Therefore, vertical dimensions can be an important cooperative action leading to sustain the farmers' organizations. Stockbridge et al. (2003) states that three main factors that influence the effectiveness of organizations include individuals (i.e. ability, motivation to work role), the organization (i.e. leadership, group relation, systems and structures), and the environment (economic, physical, technical, cultural and social aspects). Increasing demand for higher value internationally traded export species, such as shrimp has led to more integrated production-distribution chains and coordinated exchange between farmers, processors and retailers (Reardon et al. 2009; Bolwig et al. 2010; Kassam et al. 2011; Trifković 2013).

Recently, vertically integrated production that is co-operation among stakeholders along the value chain has tended to increase, mainly for striped catfish systems in An Giang, Dong Thap and Can Tho provinces (Khoi 2011), and intensive shrimp farming in Soc Trang, Ben Tre and Tien Giang provinces (RIA2 2009). Many businesses can achieve a competitive advantage and improve performance by developing cooperative relations with buyers, suppliers, competitors and other firms (Khoi 2011). For example, several business promotion programmes of the processors were set up with the striped catfish farmers that became contracted farms improving availability of raw material for processors. Thus, production costs could be reduced and traceability improved in line with the international standards and consumer demand (Cuyvers & Tran 2008). Ha et al. (2013) noted that an intensive farmers group was better able to establish favourable terms in vertical contractualisation with up and downstream chain actors, and thus making it easier for them to negotiate improved terms of access to markets and technical support. Cooperative arrangements for producers that are supported by exporting processors are successful in providing access to international markets (Pham et al. 2011). Moreover, collective action through participation in farmers' organizations can provide an effective mechanism to assist small-scale producers overcome these challenges and contribute to and influence modern market chains and trade (Srinath et al. 2000; Umesh et al. 2010; Kassam et al. 2011). To promote collective action and farmers' organisations development as a strategy to achieve market access for small-scale farmers, the Government must promote the provision of market services such as training, extension and market information services. The government must also intervene to either facilitate the development of those services that are critical for small-scale farmers and markets to develop or to provide those services themselves (Bolwig et al. 2010; Kassam et al. 2011).

3.9. Striped catfish and shrimp value chains

3.9.1. Striped catfish value chain

a). Value chain configuration

The value chain of striped catfish covers all stages that a product or service passes through. It can be divided into five functional stages: input provision, production, transformation, trade and consumption; and each stage is characterized by certain processes and activities (Kai 2006; Khoi 2007; Le 2011). Figure 3.12 outlines the actors and processes of the value chains of striped catfish at the time of this study. They include primary and support activities for domestic and export markets. Primary actors who are directly involved in the transformation of inputs into outputs include seed suppliers (hatcheries, nurseries, seed/brood-stock traders); farmers (individual, contracted, and company's farms/or corporation); export agents; local traders; and processing plants/export firms. The indirect actors who facilitate the activities of the primary actors include feed/chemical and drug suppliers; service providers; input suppliers; and supporting actors (state agencies, society associations, research sectors). Most catfish production is directly sold to seafood processors through a contract signed one month before harvesting between farmers and processors. Thus, the farmers and processors have played important roles in the value chain in the MKD. Demand in terms of quantity and quality is mainly determined by the processors, which places them in a powerful position as 'lead actors' in the mapped section of the value chains. Jespersen et al. (2014) found that the processors may operate different forms of coordination upstream: own-farm production (hierarchy), relational or captive coordination of suppliers depending on the nature of relationship (preferred suppliers or contracted farmers) and market coordination with independent farmers. Generally, product supply flows from left to right, but the product price decision flow will be from right to left in Figure 3.12. Jespersen et al. (2014) noted that the pangasius value chain is driven by the retailers and importers, with levels of driving differing according to the end-market the value chain feeds into, but generally moving from lower towards higher levels. The main coordination mechanisms between exporters and importers is based on market mechanisms, but moving towards captive coordination due to buyers' increase focus on quality, safety and sustainability and increased monitoring of suppliers.

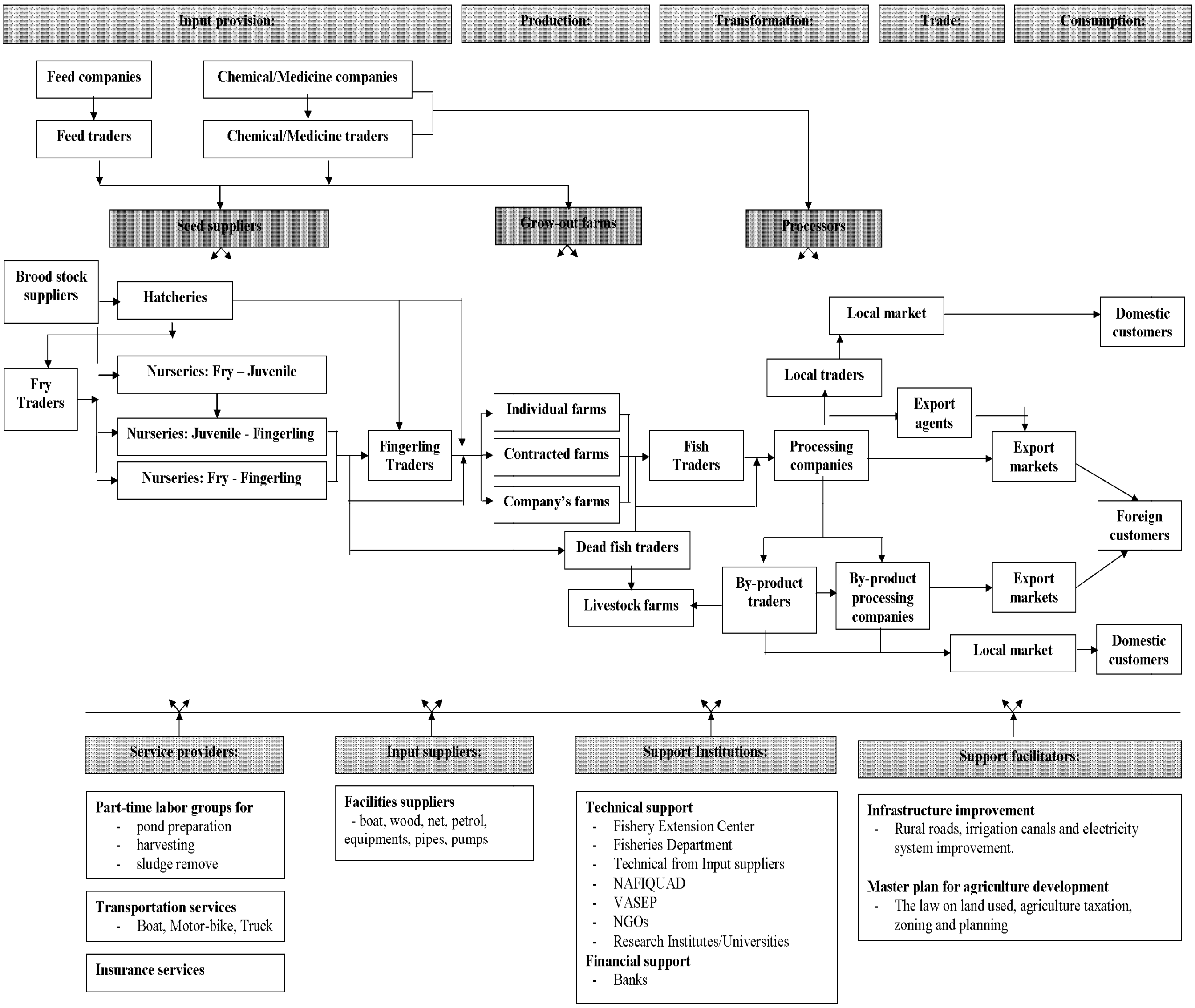

Figure 3.12. Value chain map of striped catfish in the MKD

b). Catfish marketing channel and benefit sharing

During the time of this study, most catfish production was exported and farmers often sold their production directly to the pangasius processors (Figure 3.13). More than 95% of total catfish production was traded and consumed through this way (Vo et al. 2009b; Vo et al. 2009a; Le 2011; CBI 2012b). Thus, the main marketing channel for striped catfish in the MKD was "*Farmers -> Processors/Exporters -> International markets*".

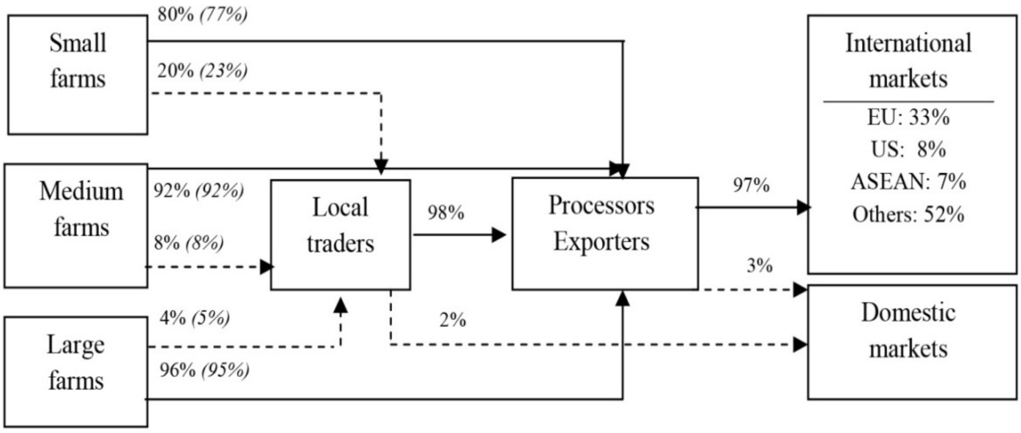

Figure 3.13. Marketing channels of striped catfish farmed in the MKD

(solid line: main channel; dotted line: supplemental channel; italic number: percent of surveyed farms; regular number: percent of total fish production trading. Source: IFS (2011) and Scoping survey (2010))

The value chain analysis of this marketing channel shows that the total added value along the chain was US$0.322/kg, of which grow-out catfish farmers shared 41%; and processors took 59% (Table 3.5). Total net added value was US$0.187/kg, farmers received 71%, and processors (29%). Although processors got a lower share of the net added value per kg of marketable fish, they earned money over a shorter period of time than the farmers. Individual catfish farmers had limited capacity to produce fish compared to that of the processors, and thus they had less power in terms of price negotiation and lower profit within whole value chain. With higher production capacity, the processors get the highest net profit in the whole chain in the MKD.

Table 3.5. Analysis of economic efficiency by main catfish marketing channel

	Formula	Catfish farmers	Processors /Exporters	Total
Selling price (US$/kg)	*(1)*	0.95	1.14	
Buying cost (US$/kg)	*(2)*	0.82	0.95	
Added value (US$/kg)	*(3)=(1)-(2)*	0.13	0.19	0.32
- Share of added value (%/total)		*41.07*	*58.93*	*100.00*
Added cost (US$/kg)	*(4)*	0.00	0.14	
Net added value (US$/kg)	*(5)=(3)-(4)*	0.13	0.06	0.19
- Share of net added value (%/total)		*70.64*	*29.36*	*100.00*
Production (tonnes/actor/year)	*(6)*	285.01	18,671.88	
Net profit ('000US$/actor/year)	*(5)*(6)*	37.75	1,027.85	

Source: IFS (2011) and Scoping survey (2010)

Catfish exports not only creates jobs and income for Vietnamese stakeholders, but also for stakeholders in importing markets. For example, a market channel of catfish supply to Spain (*from farmers to customers*), shows that the net added value per 1kg of fresh fish to consumption converted from pangasius frozen fillet was US$0.933/kg, of which the distributors in the Spanish market got 56%, followed by retailers (16%) and importers (8%), while the Vietnamese processors received 6% and the farmers 14% (Figure 3.14). Until recently there was a lack of vertical cooperation in the supply chain and business support organisations, thus the farmers were the most vulnerable actors in the value chain and often faced higher risks, such as the low farm gate price than other actors along value chain. Therefore, sustainable development needs to incorporate the establishment of cooperation between actors along whole value chain.

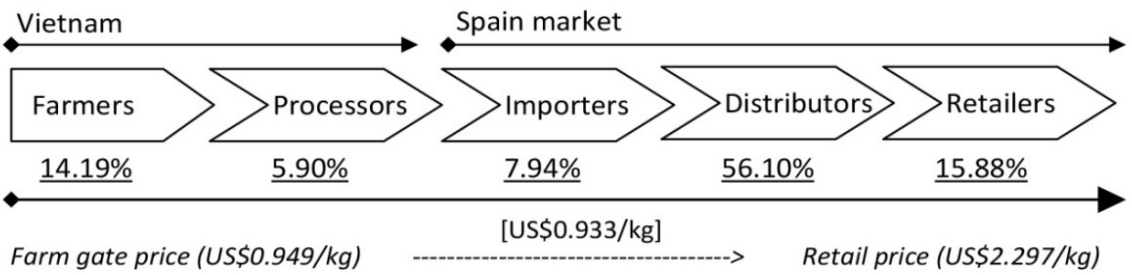

Figure 3.14. Market channel and share of net added value of catfish to Spanish market

Source: based on data from CBI (2012b), Beukers et al. (2012), IFS (2011) and Scoping survey (2010)

3.9.2. Brackish-water shrimp value chain

a). Value chain configuration

Similar to the pangasius value chain, the value chain of shrimp can be divided into the five main functional stages of input provision, production, transformation, trade and consumption; and each stage is characterized by certain processes and activities (Vo 2003; Le et al. 2011; CBI 2012b; Vu et al. 2013; Tran et al. 2013). Figure 3.15 presents an outline of the actors and processes in the shrimp value chains in the MKD. They include primary and support activities for domestic and export markets. Primary actors who are directly involved in the transformation of inputs into outputs and include seed operators (hatcheries, nurseries/seed traders, and brood-stock traders); grow-out farmers (individual, contracted, and company's farms/or corporation); shrimp traders (collectors, and wholesalers); and processing plants/export firms. Indirect actors who facilitate the activities of the primary actors include feed/chemical and drug suppliers; service providers; other input suppliers; and supporting actors (state agencies, society associations, research sector). At the present, the farmers, wholesalers and seafood processors have played important roles of the value chain. However, the demand in terms of quantity and quality is often determined by the processors, which places them as 'lead actors' in the value chains. The processors may operate two main different forms of coordination upstream levels: i) own-farm production (hierarchy), and market coordination with independent farmers; and ii) relational or captive coordination of suppliers depending on the nature of relationship (preferred traders or contracted traders) and market coordination with independent traders. Meanwhile the traders can be characterized by their roles in either (1) market coordination with independent farmers and (2) the relational or captive coordination depending on the nature of relationship (preferred farmers or contracted farmers). The product supply flows from left to right, but the product price decision flow will be from right to left in the chain map. Similarly to the catfish sector, the shrimp value chain is also buyer-driven, and the main coordination mechanisms between exporters and importers are based on market governance form, but appear to be moving towards captive coordination due to the buyers' increasing focus on quality, safety and sustainability and increased monitoring of suppliers.

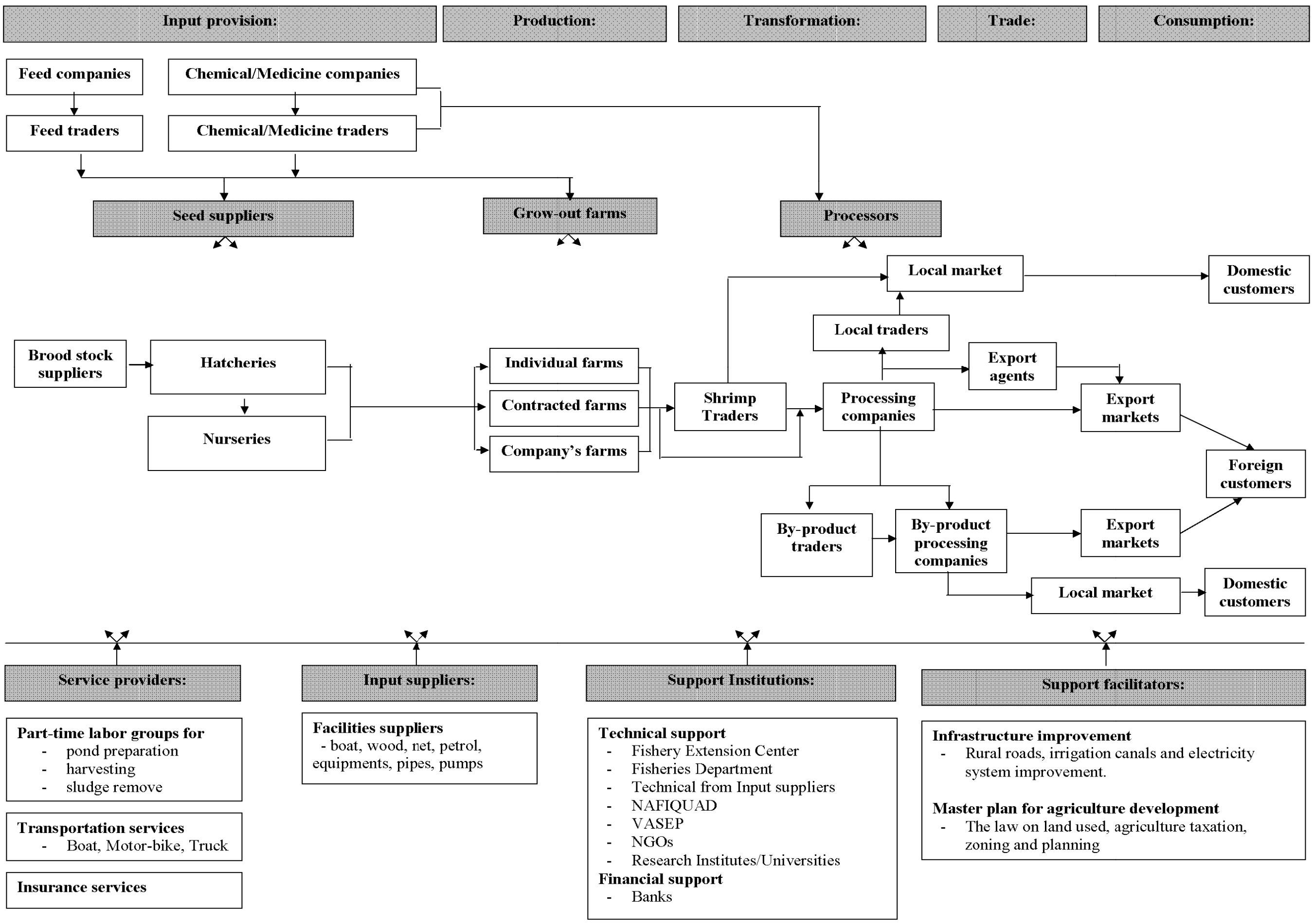

Figure 3.15. Value chain map of shrimp in the MKD

b). Shrimp marketing channel and benefit sharing

Most shrimp production was exported (>83% of shrimp production) and was often bought from wholesalers/traders and then moved to the processors (Le et al. 2011; CBI 2012b; Vu et al. 2013). The marketing channels for different shrimp systems varied; while intensive farms sold a large amount of their production directly to processors, other systems sold shrimp through intermediaries (Figure 3.16). However, wholesalers were a key actor overall with more than 70% of total shrimp production passing through them to processors.

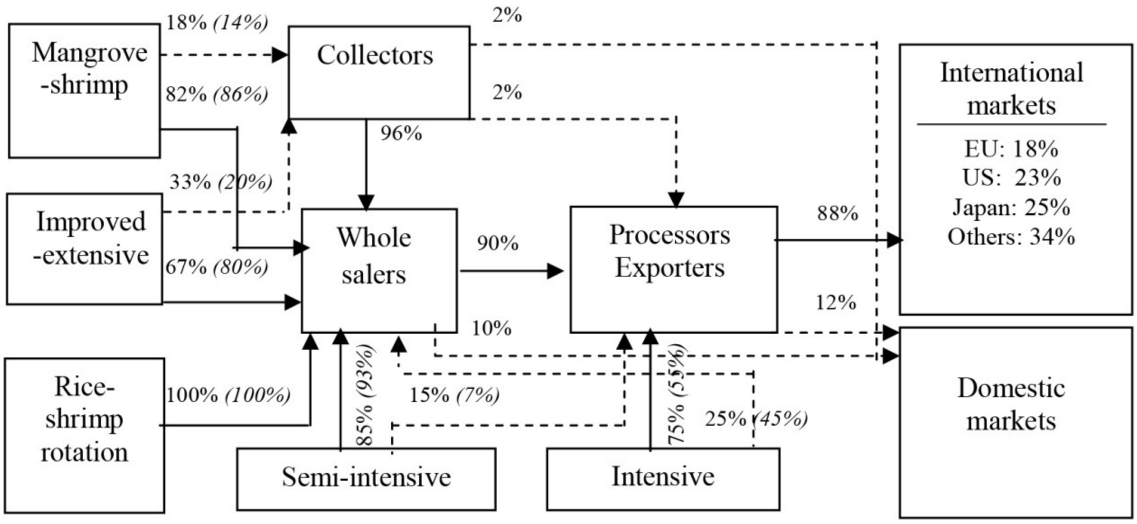

Figure 3.16. Marketing channels of shrimp farmed in the MKD

(solid line: main channel; dotted line: supplemental channel; italic number: percent of surveyed farms; regular number: percent of total shrimp production trading. Source: IFS (2011) and Scoping survey (2010))

Value chain analysis of the main marketing channel shows that total added value along the chain was US$5.6/kg, of which grow-out shrimp farmers shared 58.30%; wholesalers 6.44%; and processors 35.31% (Table 3.6). Total net added value was US$4.03/kg of which the farmers received 80.81%, followed by wholesalers (2.98%) and processors (16.21%). Although both processors and wholesalers got a lower share of the net added value per kg of shrimp, they could earn money in a shorter period of time and lower risk than the shrimp farmers that the shrimp farms spent around 4-5 months for black tiger shrimp and 3-4 months for white-legged shrimp culture to harvest their shrimp, while the traders and processors can earn money during 2-3 days for wholesalers and around a month for processors. Individual shrimp farmers had lower capacity to produce shrimp compared to wholesalers and processors, and thus were less able to negotiate on price and gained lower profit over the whole value chain. Value chain analysis showed that processors gained most of total net profit of the whole chain.

Table 3.6. Analysis of economic efficiency by major shrimp marketing channel

	Formula	Shrimp farmers	Whole -sellers	Processors /Exporters	Total
Selling price (US$/kg)	*(1)*	6.23	6.59	8.56	
Buying cost (US$/kg)	*(2)*	2.97	6.23	6.59	
Added value (US$/kg)	*(3)=(1)-(2)*	3.26	0.36	1.98	5.60
- Share of added value (%/total)		*58.25*	*6.44*	*35.31*	*100.00*
Added cost (US$/kg)	*(4)*	0.00	0.24	1.32	
Net added value (US$/kg)	*(5)=(3)-(4)*	3.26	0.12	0.65	4.03
- Share of net added value (%/total)		*80.81*	*2.98*	*16.21*	*100.00*
Production (tonnes/actor/year)	*(6)*	2.69	269.10	6,083.33	
Net profit ('000 US$/actor/year)	*(5)*(6)*	8.77	32.34	3,979.61	

Source: IFS (2011) and Scoping survey (2010)

Shrimp exports also resulted in benefits for stakeholders in import markets. For example, a market channel of shrimp supply to the Spanish market shows that the net added value per 1kg of shrimp consumed that was converted from frozen Head-on Shell-on (HOSO) shrimp was US$9.75/kg, of which the distributors in the Spanish market got 42% of the share, followed by retailers (8.4%) and importers (8.4%), while the Vietnamese processors received 7% and the shrimp farmers 33% (Figure 3.17). The farmers were the most vulnerable actors in this value chain and faced higher risks than the other actors along value chain, such as the risks of shrimp disease. Sustainable development, therefore, needs to establish cooperation for mutual between actors along the whole value chain.

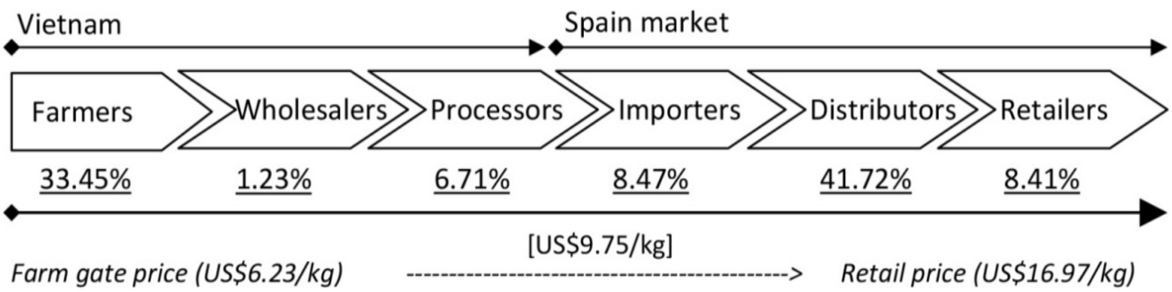

Figure 3.17. Market channel and share of net added value of shrimp to Spanish markets

Source: based on data from Beukers et al. (2012), CBI (2012b), CBI (2013b), CBI (2013a), GLOBEFISH (2013), IFS (2011) and Scoping survey (2010)

3.10. Discussion and conclusions

3.10.1. Growth of export orientated farmed seafood species

Information related to the development of the major farmed species (striped catfish, shrimp, tilapia and giant freshwater pawn) has been identified through sequence analysis of the value chains. MKD is the major region for the aquaculture sector and plays an important role in the overall fisheries structure and Vietnam's seafood exports with help from government investment since 2000. Shrimp and striped catfish production are mainly farmed for export, thus, they are target farmed species and more investment has been expended, to serve the export of fishery products. Also, in the master plan up to 2020, both remain key species for development for export purposes. Trade restrictions on striped catfish and shrimp exports to the US market provided opportunities for both industries in seeking new markets (Nguyen 2010; De Silva & Nguyen 2011). Moreover, the highly competitive striped catfish prices and its quality compared to whitefish are driving forces for success on market access recently (Little et al. 2012). Diversified markets could potentially lead to reduce price instability, risks of shocks in specific markets and trade fraud among processors/exporters. Meanwhile, the production of tilapia and GFP has also expanded, but has limited production in comparison with shrimp and catfish, and are mostly domestically consumed. The reasons for limited development of tilapia and GFP systems are inconsistent hatchery performance that in turn lead to unstable seed production; high domestic demand; and unstable grow-out production (i.e. more scattered farmed area and unstable production because lack of detailed master plans), and lack of market or high competition from other country producers such as China (tilapia) and Bangladesh (prawn) (Tran et al. 1998; Pham 2010; MARD 2010). Although the Government strategy is more focused on catfish and shrimp for export, both GFP and tilapia were identified as desirable species for diversification (VIFEP 2009; MARD 2010).

Farmed species production is still dominated by numerous household-based operations, especially for shrimp, tilapia and GFP systems, which accounted for around 80% of total grow-out farmers per each species; while striped catfish farmers operated and managed by families accounted for around 60%. Vertical linkages between value chain actors are still limited, and the relationship between them was commonly by verbal agreements rather than enforceable contracts. The grow-out farmers and seafood processors played important roles in the value chain of striped catfish and shrimp systems, while traders of tilapia/prawn and grow-out producers are key value chains actors of tilapia and GFP systems. The demand in terms of quantity and quality is also determined by the shrimp/catfish processors and tilapia/GFP traders which place them in a powerful position as 'lead actors' in the mapped sections of the value chains. However, the weak position of grow-out producers combined with processing over-capacity means that processors are increasingly taking a more strategic interest in the sustainability of their supply through contract farming arrangements and development of their own farms. Therefore, actors, especially small producers may have little influence, but the high number of this group and their continued role in supplying a large proportion of raw material for processing for export make it important. On the other hand, to ensure products meet the standards, attention should be paid to issues of sustainable development, as the appropriate solution is from the first link of the value chain, especially small-scale groups which are often actors to challenges such as the compliance with the food certification (Umesh et al. 2009; Subasinghe et al. 2009; Pham et al. 2011; Bosma & Verdegem 2011). Hence, appropriate management measures are required to ensure cultured systems continue to develop in a sustainable manner. Strengthening of value chain linkages should be considered as a priority activity in future development.

3.10.2. Striped catfish and shrimp: value chain coordination

a). Value chain configuration

Development of striped catfish and shrimp value chains has increased rapidly since 2000. Stakeholders involved in the value chain of the farmed species are highly diversified in the MKD, including chain actors or primary actors who involved directly in within-chain exchanges, and indirect actors (external actors or networks, excluded actors and non participants). Stakeholder participation in the striped catfish and shrimp value chains was highly diverse and complex, but farmers and processors were the two main actors that played important roles in production process of the value chain in the MKD. The largest net added value per kg of fish/shrimp produced was achieved by farmers, but they did not have an important role in the price-decision due to their small production capacity. In contrast, processors made less profit per unit volume of fish, the processors play important roles in regulating production and product prices due to their high production capacity. Product supply flows from left to right (i.e. *farms–>traders –>processors–>customers*), but the product price decision and money flows from right to left in the value chain cluster (i.e. *farms<–traders<–processors<–customers*); this also mentioned in the previous study on shrimp value chain by Tran et al. (2013). The same authors also noted that governing power to coordinate GVC will be from right to left in the value chain. In this view of GVC, the value chain of both shrimp and striped catfish can be buyer-driven value chains that are characteristic of labour-intensive consumer goods production in which large retailers, branding enterprises and trading companies control decentralized production networks (Le et al. 2011; CBI 2012; Trifković 2013; Tran et al. 2013; Jespersen et al. 2014).

Currently, a large amount of striped catfish and brackish-water shrimp production has been used as raw materials for processing and then for export (Le 2011; Le et al. 2011); thus, the role of seafood processors in the transformation stage and exporters at the trading stage in the value chain are very important and a key actor. Most value chain nodes of striped catfish and shrimp systems are the same; however, seed producers are relatively more complex and important in the striped catfish value chain, and intermediaries (i.e. wholesalers and collectors) are more important in the shrimp value chain. Striped catfish production is often directly sold to seafood processors by a contract that was signed before harvesting a month between farmers and processing plants, with 95% of farmed production following this way (Bush et al. 2009; Le 2011), and a small proportion of grow-out farmers (i.e. mainly smaller farms) sold their production through traders in cases of small quantity or low quality and/or selling at the period of oversupply. In contrast, around 5% of shrimp production was directly sold to shrimp processing plants and the rest of the production was often traded through intermediate networks such as shrimp collectors and wholesalers before reaching to processors (Vo 2003; Le et al. 2011). Up to present, the production of striped catfish and shrimp system is still dominated by large number of small-scale household-based operations (Phan et al. 2009; Bush et al. 2009; De Silva & Nguyen 2011; Tran et al. 2013), and the linkages between value chains' actors are still limited. The demand in terms of quantity and quality is determined by the processors that place them in a powerful position as lead actors in the mapped sections of the value chains (Khoi 2007; Le et al. 2011; Le 2011). Although seafood processors are very important in production supply flows, their business still depends on the contracts with buyers who affect strongly to decide demand/supply and product price of seafood market. However, the dependence of processors on importers supplying retailers is offset by their diversification of buyers and markets (Jespersen et al. 2014). Additionally, all the major markets for Vietnamese seafood export have now shrunk compared to a few years ago, and that market portfolio is now very diversified; this is a positive step to address problems and makes marketing planning such as strengthening of trade promotion and advertising activities.

b). Role of government in the value chain coordination

The findings show the value chain of both the striped catfish and shrimp are buyer-driven value chains. Value chain driven by the retailers and importers, with levels of driving differing according to the end-market the value chain feeds into, but generally moving from lower towards higher levels (Tran et al. 2013; Jespersen et al. 2014). The value chain analysis states that seafood exporters in Vietnam, and distributors in the importing countries capture the most added value of products. In contrast, the farmers are the most vulnerable actors in the value chain and often faced higher risks than other chain actors, such as risks of low farm gate price and shrimp disease. Currently, the seafood processors operate mainly two main different forms of coordination upstream levels on both these species: own-farm production (hierarchy) and market coordination with independent farmers; and the catfish sector is also characterized by relational or captive coordination of suppliers depending on the nature of relationship (preferred suppliers or contracted farmers) compared to shrimp sector (Jespersen et al. 2014).

Up to the present time, there has been a lack of vertical cooperation in the supply chain and business support organisations in both these species value chain (Nguyen et al. 2009; Nguyen & Dang 2009; Tuan et al. 2013). Sustainable development, therefore, needs to incorporate the establishment of cooperation between actors along whole value chain to reduce risks for the chain actors. To reduce the risks for the primary production-level, especially small-scale farmers, horizontal and vertical coordination of the value chain should be implemented and this is discussed in more detail in Chapter 5. Horizontal dimensions relate to coordination between producers and horizontal the support and interventions from the government. Vertical coordination focused on the vertical contractualisation between the chain actors is also suggested as a tool to reduce the risks for both these species. The integration of the vertical and horizontal coordination of the value chain is organized through four types of changes in the vertical 'position' of chain actors (inclusion into the chain, continued participation under new terms, exclusion and non-participation) (Bolwig et al. 2010).

Government agencies are important actors in the value chains because they set, monitor, and enforce the regulation on production and policy supports such as food safety standards and financial supports (Nhuong 2011; Tran et al. 2013). The government provides adequate laws, regulation and enforcement necessary for doing business of chain actors. Moreover, the government facilitate market access for small-scale farms in organization, technology and training (Van der Meer 2006; Khoi 2011). The governments appears to play a crucial role in helping industries improve their food safety and quality (Khoi 2011). Sevral case studies on the value chain governance of shrimp clusters in India (Umesh et al. 2010), the Surat Thani shrimp farmers club in Thailand (Kassam et al. 2011), the An Giang pangasius farmers' association organization (Khiem et al. 2010) and My Xuyen shrimp farm organizations (RIA2 2009) in Vietnam, dairy farmers' cooperatives in Ethiopia (Francesconi 2009) and in Kenya (Kilelu et al. 2013), fruit production in Ghana (Dannson 2004), and Fair trade coffee cooperatives in American countries (Ponte 2002; Lyon 2006; Ruben et al. 2009; Valkila & Nygren 2009), showed that food safety and quality assurance cannot be implemented successfully in a country without the support of its government Additionally, the public sector plays the important role of facilitating the inclusion of smallholders in global markets, through provision of market information, technical advice, and logistical and other services (Van der Meer 2006; Sriwichailamphan 2007; Henson et al. 2008; Amanor 2009; Khoi 2011). Hence, government intervention is suggested as a way to take control of risks and inequities in the value chain, that may conduct through master plans, minimum price control or financial regulations. The master plan generally provides the strategies for local government in relation to development of the detail plan for local aquaculture zoning and the policy-decision making (technical and financial supports; and relevant regulations on seafood producing). The master plan also allows the improvement of infrastructure in terms of irrigation canals (water supplying and draining), electricity networks and transportation services. Through the master plan, the local government agencies should make a detailed plan for the farming, processing and service sectors; and regulations to manage the operation at the farm level, processing level, and the operation of input supplying actors. World Bank (2012) notes that Governments in developing countries increasingly intervene actively in supporting private sector development. They can facilitate or stimulate private investment through supporting a conducive policy, legal, and institutional environment. Public investments in business supports can direct private investments towards areas of significant public interest where the private sector alone would generally underinvest. The Vietnamese government has intervened successfully in the rice leading to stable growth in relation to both production (production and farm gate rice) and export (markets and exporting price) as a good example. The master plan for rice production and export is more successful in terms of area-based management, intensification system, irrigation system and export markets (GSO 2013). The government of Thailand has been very proactive in legislating for the aquaculture industry with a long history of regulation and policy support that has resulted in a mature and highly disciplined industry. Proactive intervention in supporting private sector development has contributed to Thailand building a good reputation in international seafood markets (Ponte et al. 2014; Jespersen et al. 2014; Nietes-Satapornvanit 2014). Therefore, the interventions are needed to improve the awareness and ability of the existing actors to scan for new opportunities (World Bank 2006). The government promotes innovation as a policy instrument to mitigate negative external effects such as environmental pollution. Innovation is first of all the responsibility of businesses, but it is a government responsibility too (EU SCAR 2012).

Innovation is influenced by consumer preferences, government policies, and market factors at regional, national, and global level (Klerkx et al. 2010; Kilelu et al. 2013).

The master and detailed implementation plan for striped catfish and shrimp will affect all stakeholders along value chain as results of Government intervention and control on the production at farm-level, processing-level and operation of support actors. All chain actors have to follow the plan related to their business in terms of area-based management and the regulations on the operation (seasonal calendar, effluence management, chemical/drug use, animal health management, trading registration, production etc.). The chain actors in the aquaculture zones should be eligible for financial support such as access to the credit and receive preferential services supports (e.g. improvement of irrigation canals, electricity and road improvement, technical supports). However, there are different affects among chain actors, such i) farm-level: regulations on farm practices are more strict in relation to food safety and quality control; ii) processor-level: quota registration, fair trade (e.g. minimum price agreement on the farm gate price with producers and exporting price between processors), food safety and quality control, and requirements on the product traceability; and iii) input suppliers-level: strict regulation on the seed producing and quality, regulations on the feed ingredients use in feed manufacturers, and quality control on the chemical/drug manufacturers and trading. Previous studies reported that both shrimp and pangasius value chains are already heavily regulated by national agencies as well as by those in importing countries (Tran et al. 2013; Trifković 2013), it is similar to findings in other agri-food chain studies (Busch & Bain 2004). Recently, public regulations in producing countries and importing countries are particularly focused on food safety and standards; and thus the role of the government has changed from 'regulation maker' to merely 'regulations implementer' that has involved restructuring of its institutions as well as paying costs to implement private regulations (Islam 2008; Ha & Bush 2010). Public regulation on food safety has moved towards environment protection, but it is making production more expensive. Enforcement of these regulations is weak due to the high costs for farmers that are the costs of constructing sediment basins for waste water treatment (Trifković 2013; Hansen & Trifković 2014).

Government interventions can also impact on the different risk and vulnerability profiles of different producers in the pangasius and shrimp value chains, through i) the exclusion of participants in the value chain, especially independent small-scale producers or weak actors due to the increasing requirements for food safety and quality control, horizontal and vertical coordination forms, and transparency in the production; ii) the chain actors located outside the planning zone will be squeezed out of the value chains; and iii) use of a quota approach at production and processing levels may increase risks for some chain actors in competitive markets; and iv) minimum price management often lead to difficulties in achieving consensus on price, leading to difficult-to-solve conflicts between chain actors on benefit sharing. Krugman et al. (2010) notes that Governments interventions' to control minimum price at producer- and processor-levels, and minimum prices have been legislated for agricultural products like wheat and milk, as a way to support the incomes of farmers. Although minimum prices are intended to help some people, they generate predictable and undesirable side effects. In the case of the unwanted surplus or oversupply, a minimum price means that would be sellers cannot find buyers. The persistent unwanted surplus that results from a minimum price creates missed opportunities and inefficiencies that include inefficient allocation of sales among sellers, wasted resources, and the temptation to break the law by selling below the legal price.

CHAPTER 4

Farm scale and current farming practices of striped catfish and shrimp in the Mekong Delta

4.1. Introduction

Striped catfish are raised in deep ponds along the Mekong and Bassac rivers at a high level of intensity and investment; while shrimp farming takes place in the coastal areas in a greater diversity of farming system (Vu & Phan 2008; Nguyen & Dang 2009; Nguyen et al. 2009; Tran et al. 2013). Both of these species play an important role in Vietnamese aquaculture, and they not only contribute to significant export earning but also create jobs and increase the income of local people (Nguyen et al. 2009; De Silva & Nguyen 2011; CBI 2012b; Tran et al. 2013; Cannon & Johnson 2013). Small-farms owned and managed by families still dominate in the MKD (Phan et al. 2009; Tran et al. 2013). Aquaculture farms, especially small-farms are considered highly vulnerable in the value chain (Siar & Sajise 2009; Washington & Ababouch 2011; Tran et al. 2013). Despite this small-farms should be included in the future development of the aquaculture sector, because they account for more than 200,000 shrimp farms under improved-extensive systems and around 2,000 small catfish farms with farm-size less than 1ha (Phan et al. 2011; SFP 2013; Tran et al. 2013). Small-scale shrimp farmers are located mainly in the coastal areas, and their land is mostly used for shrimp culture. Shrimp culture is their main occupation and they have very few chances to diversify their livelihoods (Nhuong et al. 2003; Le 2009; Tran et al. 2013). Meanwhile, smaller catfish farms should be still maintained in the value chain, because the catfish processors need to buy 20-30% of raw material source from the independent farms who are mainly smaller scale farms (Bush & Belton 2012). Irz et al.

(2007) found little evidence that aquaculture contributes to the marginalisation of the smallholders and aquacultural income is clearly inequality-reducing. However, the possible solutions for the inclusion of smaller scale farms in the value chain could be horizontal coordination and vertical coordination (Umesh et al. 2009; Khiem et al. 2010; Khoi 2011; De Silva & Nguyen 2011). Hence, policymakers need to find suitable measures to support them in the planning processes (Dey & Ahmed 2005; De Silva & Nguyen 2011). An overview of the difference in farming practices among farm categories can provide valuable information to the policy makers, thus support policies and develop strategies suited to specific farm categories.

On the other hand, market trends for certified seafood products is increasing and customers pay more attention to control on the processes of products (Corsin et al. 2007; Reilly 2007; Yamprayoon & Sukhumparnich 2010). Recently, certification in the aquaculture sector has become mainly the realm of large-farms operated by seafood processors (Bush et al. 2010b; Belton et al. 2011; Trifković 2013). Some large-farms have achieved certification such as ASC, GAA-BAP and GlobalGAP to meet the requirements of their clients (Lam & Truong 2010; SFP 2013; Fisheries Directorate 2013b; Vu et al. 2013). Whereas, small-farms are not likely to achieve certification due to their limited capacity (Umesh et al. 2009; Khiem et al. 2010; Belton & Little 2011; Pham et al. 2011; Bush & Belton 2012; Trifković 2013; Haugen et al. 2013). They may not pursue certification as it may not be worth their while economically; the economic efficiency of certified production may not be much higher than uncertified production because of more costly investment and difficulties to reach strict standard criteria (Dey & Ahmed 2005; Oosterveer 2006; Khiem et al. 2010; Haugen et al. 2013; Tran et al. 2013). Assessment of the sustainability of catfish/shrimp farming seems to only be carried out through the certification programmes. From the current farming practices, analysis should be carried-out on which category of farms can potentially meet the standards and what the constraints are to success. Sustainable development of an industry will be affected by many value chain actors (Grunert et al. 2005; Vo et al. 2009a; Tran et al. 2013), on which grow-out farms are the primary producers of the value chain; and thus to understand their operation would provide the basis for policy-making process to create more appropriate strategies to support the development of the value chain as a whole. Therefore, this chapter aims to describe and assess the current farming practices of the two target species. The study attempts to analyse major factors, reflecting on the differences in farming practices among fish farm categories and shrimp farming systems. It also provides an assessment of distances between current farming practices and selected food standard criteria. Finally, this chapter gives insight into factors related to sustainability issues for the farm's operation.

4.2. Farm classification

4.2.1. Striped catfish farm category

Striped catfish is now cultured in super-intensive systems and the model is unique to Vietnam (Phan et al. 2009; De Silva & Nguyen 2011), with high stocking density in very deep ponds, high water exchange frequency and volume, and high productivity compared to pangasius farming in Bangladesh (Ahmed et al. 2010; Belton et al. 2011; Ali et al. 2012) and Thailand (Nietes-Satapornvanit et al. 2011). Based on actual production and business relations, catfish farms can be divided into three farm scales (Table 4.1); there are six basic elements in the classification of farm scale. The culture area, farm management regime and business ownership are important factors used for farm classification. Small- and medium sized farms are often independently operated, while large-farms are corporate companies under the seafood processors. Small-/medium farms are mainly managed by owners or family members; they often have small area and small annual production.

Table 4.1. Major indicators of striped catfish farm-scales classification

Indicators	Small	Medium	Large
1. Culture water area	≤1.5ha	0.5-10ha	≥2
- *Number of ponds*	*1-4*	*1-8*	*≥4*
2. Full-time labour[a]	0-4	0-10	≥ 10
3. Business ownership[b]	Household or Extended family	Household or Extended family or Company[c]	Company[c] or Corporate enterprise[d]
4. Management	Household or Extended family	Household or Extended family or Salaried manager	Company or Salaried manager
5. Registered trading name	No	No/Yes	Yes
6. Vertically integration	No	No	No/Yes

[a] family labours are not included; [b]land ownership is not included; [c]Farm is fully owned and operated by Aquaculture Ltd. company; [d]Farm is fully owned and operated by Seafood processor. Source: IFS survey (2011)

4.2.2. Shrimp farm category

Shrimp farming in the MKD is highly diverse, and there are differences between farm systems in terms of investment level, culture techniques and production efficiency (Vu & Phan 2008; Nguyen et al. 2009; Tran et al. 2013). So, the classification of shrimp farms, according to the criteria for striped catfish farms, is difficult and impractical. With a low level of investment, including mixed mangrove-shrimp, improved-extensive and rice-shrimp rotation systems, farms could meet the criteria of the small-farms classified as catfish farm category; however, with the high level of investment such as in semi-/intensive shrimp the application of these criteria is not feasible as some criteria are met but not others. Considering current shrimp farming practices and the master plan for Vietnamese aquaculture up to 2020, the shrimp farms can still be classified according to the type of farming system, and thus the focus of this study is an assessment only of farming practices under different systems. The farming systems can be distinguished based on the criteria presented in the Table 4.2. The main factors used for shrimp farm classification are based on technical characteristics including seed sources, stocking density, productivity, eFCR and water exchange regime.

Table 4.2. Major indicators of shrimp farm-systems classification

Indicator	BTS					WLS
	Intensive model	**Semi-intensive**	**Improved-Extensive**	**Mixed mangrove-shrimp**	**Rice-shrimp rotation**	**Semi-intensive**
1. Seed sources	Artificial	Artificial	Natural /Artificial	Natural /Artificial	Artificial	Artificial
- Density	*≥20pcs/m²*	*≥10pcs/m²*	*≥1pcs/m²*	*≥0.5pcs/m²*	*≥3pcs/m²*	*≥45pcs/m²*
- Bio-security	*PCR test*	*PCR test*	*No*	*No*	*PCR test*	*PCR test*
2. Feeding regime	Pellet feed	Pellet feed	Natural	Natural	Pellet feed	Pellet feed
- eFCR	*≥1.3*	*≥1.0*	*0*	*0*	*≥1.0*	*≥1.0*
3. Shrimp yield	≥4 tons/ha	≥1tons/ha	≥0.2tons/ha	≥0.2tons/ha	≥0.5tons/ha	≥5tons/ha
- Survival rate	≤95%	≤95%	≤50%	≤50%	≤90%	≤95%
4. Water exchange	Top-up	Top-up	Tidal cycle	Tidal cycle	Top-up	Top-up
- Aeration use	*Yes*	*No/Yes*	*No*	*No*	*No*	*Yes*
5. Management	Company[a]/ Salaried manager	Household/ Salaried manager	Household	Household	Household	Household/ Salaried manager

[a]Farm is fully owned and operated by Aquaculture Ltd. company or Seafood processor; BTS: black tiger shrimp; WLS: white-legged shrimp. Source: IFS survey (2011)

4.3. Current striped catfish farming practices

4.3.1. General information

a). Catfish farms characteristics

✧ ***Farm characteristics:*** Small-/medium farms have developed over ten years since 2001 with most farms not registering a trade name. In contrast, large-farms began to develop in 2004-2005 and nearly half registered a commercial trade name (Table 4.3). There was a significant difference *($P<0.05$)* in term of farm-size among the farm category, large-farms often had large areas with an average of more than 15ha while it was approximately 3.0ha in a medium farm and 1.0ha in the small-farm. Land holdings of small-farms were most likely to be owned by families (90%), and followed by medium (73%), while 47% of large-farms reported their land area belonged to aquaculture companies *(P<0.05)*. Additionally, 34% of large-farms reported that their land was owned by corporate companies (i.e. farms belonging to seafood processors). Some farms rented land for farm buildings with a contract length of around ten years. Small-farms were mainly operated by families while the proportion that was owner-operated of medium-farms was lower (81%). Around 47% of large-farms were managed by the owners, followed by salaried labours *(P<0.05)*. A high proportion of large-farms engaged salaried managers compared to small-/medium farms *(P<0.05)*.

Table 4.3. Striped catfish farming: Farm characteristics

Items	**Small** *(n=110)*	**Medium** *(n=64)*	**Large** *(n=38)*
Trading name (%)	0	6.25	47.37
Total land (ha)*	0.92±0.8	2.99±2.79	15.69±16.75
Water area (ha)*	0.38±0.26	1.88±1.47	10.44±12.12
Number of ponds*	1.7±0.83	3.52±1.75	11.32±8.22
Duration of operation (years)*	10.55±4.45	10.28±4.93	8.21±3.5
Farm established by owner (%)	98.18	92.19	84.21
Land ownership (%)			
*- Corporately owned **	*0*	*1.56*	*34.21*
*- Owned by family/company**	*90.00*	*73.44*	*47.37*
- Leased from State/private owner	*10.00*	*25.00*	*18.42*
Contract length (years)	8.50±6.57	7.73±4.58	14.40±7.70
Management type (%)			
*- By owner & salaried labour**	*0*	*6.25*	*10.53*
*- By owner family/company**	*100.00*	*81.25*	*47.37*
*- By salaried labour/absentee owner**	*0*	*12.50*	*42.10*
Pond conditions:			
- Reservoir water pond (%)	*0*	*0*	*0*
- Effluent storage pond (%)	*0*	*0*	*0*
Grow-out pond size (ha)*	0.23±0.14	0.62±0.41	0.77±0.29
*- Water depth (m)**	*3.81±0.68*	*4.38±0.78*	*4.37±0.62*

** significant differences (p<0.05); %: percent of survey farms; value: mean ±std. dev. Source: IFS survey (2011)*

✧ ***Pond infrastructures:*** All surveyed farms had no reservoir or sediment ponds, their ponds were mainly used for grow-out (Table 4.3). There were significant differences in grow-out pondsize in terms of area and water-depth among farm scale; large-farms had larger and deeper ponds than small-/medium farms *(P<0.05)*. Larger farms tended to be located on the riverside/inland islands, while the small/medium farms usually had small ponds in the primary/secondary canals.

b). The status of labour in farms

There was a significant difference in the roles of farm respondents, the small-/medium farms were mainly managed by owners, while the salaried managers tended to hold the main role in direct farm management of large-farms *(P<0.05)*. Most farm managers were men (>88 %), with the highest average age in small-farms and lowest in large-farms *(P<0.05)*. This may reflect the development of catfish farming starting from small-/medium scale with small ponds operated by family. After expanding and increasing the export markets since 2003, catfish farming has grown quickly and the large-farms have begun to develop rapidly and most large-farms were managed by salaried managers or technicians who had graduated from specialized universities.

Table 4.4. Striped catfish farming: Information on workers

Items	**Small** *(n=110)*	**Medium** *(n=64)*	**Large** *(n=38)*
Farm role (%)			
*- Manager**	*1.82*	*21.88*	*42.11*
*- Owner**	*95.45*	*70.31*	*44.74*
- Technician	*2.73*	*7.81*	*13.15*
Gender (%)			
- Female	*11.82*	*10.94*	*7.89*
- Male	*88.18*	*89.06*	*92.11*
Average Age*	47.38±11.71	42.97±10.56	37.92±10.69
Experience-years*	10.56±4.51	10.81±4.99	8.42±3.60
Hired full-time staff (%)*	65.45	96.88	100.00
Full-time hired staff:			
*- No.of. workers (pers.)**	*1.51±0.64*	*3.75±2.54*	*14.86±16.88*
- Working hours per day	*6.98±1.83*	*6.78±1.72*	*7.63±1.10*
Part-time hired workers			
*- No.of. workers (pers.)**	*8.00±3.01*	*10.57±6.29*	*15.20±8.23*
- Working hours per day	*7.72±1.40*	*8.00±0.00*	*7.17±2.04*

** significant differences (p<0.05); %: percent of survey farms; value: mean ±std. dev. Source: IFS survey (2011)*

Under the infrastructure conditions among farm category, large- and medium-farms relied entirely on hiring labour while the small-farms were still mainly worked by family members *($P<0.05$)*. Additionally, catfish farms also hired part-time workers at several periods of the production cycle for sludge removal or fish harvesting. The average working time of employees did not exceed 8hours/day, working conditions and labour welfare followed regulations in the labour laws. At present many small-/medium farms had no signed contracts with employees, relying on verbal agreements.

4.3.2. Technical aspects

a). Pond preparation and stocking

Catfish farms often allowed 1-1.5 months for fallowing ponds and pond preparation *($P<0.05$)*, and most farms carried out water treatment for fish ponds using lime and salt (>94%). Only 50% of farms had stored water before stocking, and the remaining farms supplied water into ponds and then stocked immediately. This could result in high fry mortality during the first month. Farms used hatchery seed purchased from private hatcheries, but most farms did not know the brood-stock source and there was little difference between farms scale in this respect, only 6% of large-farms known the brood-stock source (Table 4.5).

Stocking density was quite high, and averaged 42pcs./m^2, and the seed size was around 1.9cm in the fish body-depth. Small-farms had lower stocking densities than the large and medium farms *($P<0.05$)*, because their ponds were usually relatively smaller and shallow. The "simple batch production" method was applied by around 40% of the surveyed farms, this method was suitable for the small-farms that have very few numbers of ponds with small pond size. Over 53% of catfish farms applied the "multiple batch production with staggered stocking/harvesting" method where by different ponds were stocked at different times and thus had different harvesting times, because most farms often faced financial constraints with insufficient funds for simple batch production methods.

Table 4.5. Striped catfish farming: Pond preparation and stocking management

Items	Small *(n=110)*	Medium *(n=64)*	Large *(n=38)*
Pond preparation (%)			
- Water storage	*53.64*	*43.75*	*47.37*
- Water treatment	*98.18*	*98.44*	*94.74*
Days between stocking*	43.76±28.51	38.41±24.26	27.83±15.40
Artificial seed sources (%)			
- Hatchery - broodstock known	*0.00*	*0.00*	*2.63*
- Hatchery - broodstock unknown	*100.00*	*100.00*	*94.74*
- Own hatchery	*0.00*	*0.00*	*2.63*
Seed stocking (pcs/m^2)*	38.50±19.15	47.48±17.80	43.97±13.20
Seed size (in body depth, cm)	1.90±0.54	1.88±0.48	1.89±0.22
No.of ponds stocked together	1.20±0.47	1.42±0.85	1.92±1.10
Production scheduling (%)			
- Simple batch production	*46.36*	*32.81*	*42.11*
- Multiple batch production	*53.64*	*67.19*	*57.89*

** significant differences ($p<0.05$); %: percent of survey farms; value: mean ±std. dev. Source: IFS survey (2011)*

b). Feed management

Around 70% of surveyed small-/medium farms used commercial feed, while in large farms this increased to 90%. However, there were still many small-/medium farms using farm-made feed compared to large-farms (Table 4.6). Although farms still used farm-made feed, catfish farms have tended to increase their use of commercial feed compared to the previous surveys in 2008 of Phan et al. (2009) and in 2009 of Da et al. (2013). The shift from farm-made feed to commercial feed is linked to pressure from processors who prefer to buy fish produced using commercial feed. The production cycle, when using farm-made feed, is often 4-6 weeks longer than commercial feed (Phan et al. 2009), while the farms paid more attention to the turnover of investment and cost efficiency due to high interest rates and short time of loans. In addition, the lack of raw materials, especially fishmeal or trash fish for feed ingredients was also a driving force for changing trends (Nguyen et al. 2009; Tuan et al. 2013). The eFCR of commercial feeds was around 1.6 and there was a significant difference among farm scales *($P<0.05$)*, and eFCR of farm-made feed had also a distinct difference among farm categories *($P<0.05$)*. Small-farms used trash fish in their recipes, while large-farms mainly used fishmeal in their farm-made feed. As a result eFCRs of farm-made feeds from the small-farms was higher (2.77) than large-farms (2.01) *$P<0.05$)*. Some small-/medium farms used both commercial and farm-made feed for fish ponds, in this case, the farms did not use both of feed types simultaneously. Commercial feed tended to be used during the 1st and last month of the production cycle to ensure fish health and to increase fish quality, whereas farm-made feed was used in the interim period before harvest. The estimated amount of daily feed supplied was based on regular meals to appetite on feed packs. Larger farms tended buy feed directly from aquafeed processors more so than the small-/medium farms *($P<0.05$),* as when buying feed directly and not through traders/agents farms received promotional discounts leading to reduced production costs. Moreover, the large-farms often purchased feed in large amounts so they are also likely to receive preferential services from the aquafeed processors than small or medium farms.

The feed protein content varied between 22-30% and was dependent on the stage of fish growth. Generally payment for fish feed was on receipt although in some places farms can still buy feed under credit arrangements (i.e. delay payment term) through long-term relationships with aquafeed plants or traders/agents. Besides, 34% of large-farms had vertically integrated production so they could complete full payment after harvest, while this proportion for small-/medium farms was very low.

Table 4.6. Striped catfish farming: Feed management

Items	Small *(n=110)*	Medium *(n=64)*	Large *(n=38)*
Feed type (%)			
- Commercial feed	*70.00*	*70.31*	*89.47*
- Farm-made feed	*20.91*	*15.63*	*10.53*
- Both	*9.09*	*14.06*	*0*
Protein content (%)	25.39±1.75	25.8±2.74	26.26±2.38
Max storage days	10.03±4.83	8.38±4.72	7.76±4.13
eFCR estimation			
*- Commercial feed**	*1.64±0.21*	*1.70±0.34*	*1.64±0.12*
*- Farm-made feed**	*2.77±0.44*	*2.45±0.62*	*2.01±0.48*
Meal calculate method (%)			
- Regular meals to appetite	*92.73*	*89.06*	*84.21*
- % body weight by sample weights	*0*	*0*	*2.63*
- Biomass by volume estimation	*7.27*	*10.94*	*13.16*
Feed sources (%)			
*- Direct from manufacturer**	*48.18*	*51.56*	*76.32*
- Local manufacturer agent	*36.36*	*39.06*	*18.42*
- Local trader	*1.82*	*6.25*	*2.63*
*- On-farm agricultural by-product**	*13.64*	*3.13*	*2.63*
Payment terms (%)			
- Full cash on delivery	*50.00*	*57.81*	*44.74*
- Deposit and full payment after crop	*46.36*	*25.94*	*21.05*
- Others (e.g. vertical integration)	*3.64*	*6.25*	*34.21*

** significant differences (p<0.05); %: percent of survey farms; value: mean ±std. dev. Source: IFS survey (2011)*

c). Water management

Small-/medium farms were often sited far away from the Mekong rivers and they had to use water from river branches/local rivers or irrigation canals, while the water source for large-farms came from mainstream Mekong rivers (Table 4.7). Most farms did not conduct water settlement before stocking or before discharge into the environment. Only a small proportion of farms conducted water settling directly in the grow-out ponds 3-5 days before stocking. The high price of land is the main reason for this, and most land was used for grow-out ponds. Most farms exchanged water daily, mainly through partial drainage and water replacement and on average; farmers estimated they exchanged around 40% of the total volume daily. There were no significant differences in water exchange practices with farm scale, and almost no water is reused. This reflects that water was replaced daily with large water exchange volumes and without any waste-water treatment. However, the potential run-off of nitrogen and phosphorus from catfish farming sector is relatively small compared to that of fertilizers used in rice-farming sector (De Silva et al. 2010). Anh et al. (2010b) reported that pangasius production accounted for less than 1% of the total suspended solids (TSS), nitrogen and phosphorus loads in the MKD.

Table 4.7. Striped catfish farming: Water management

Items	**Small** *(n=110)*	**Medium** *(n=64)*	**Large** *(n=38)*
Main water source (%)			
- *River/river tributaries*	*81.82*	*92.19*	*100.00*
- *Primary canal*	*12.73*	*6.25*	*0*
- *Secondary canal*	*5.45*	*1.56*	*0*
Water storage method (%)			
- *None*	*88.18*	*81.25*	*76.32*
- *Settling pond for inlet water*	*11.82*	*18.75*	*21.05*
- *Sediment pond for effluent water*	*0*	*0*	*2.63*
Number of days of settling water	5.37±5.91	3.58±4.66	4.26±5.44
Water exchange (%)			
- *Top-up water losses only*	*10.00*	*4.69*	*5.26*
- *Partial water replacement*	*90.00*	*95.31*	*94.74*
Water replacement (%/volume)	*36.87±14.64*	*42.70±18.36*	*37.73±11.93*
Water exchange frequency (%)			
- *Daily*	*100.00*	*100.00*	*97.37*

** significant differences (p<0.05); %: percent of survey farms; value: mean ±std. dev. Source: IFS survey (2011)*

d). Effluent management

There were differences between methods of water management between upstream (An Giang, Dong Thap) and downstream farms (Soc Trang, Ben Tre). In the upstream area the pumped method was popular, while downstream water exchange based on the tidal cycle were common. Therefore, downstream farms can save electricity used for water exchange compared to upstream farms. Most farms report that waste-water was not treated and was drained directly into the same as water supplying sources *(P<0.05)*. There is no agreement of water effluent management from the local community; however, the government has regulations on water effluent management that allow water to be abstracted from one supplying source and the effluent be discharged to another water source. Although the government regulations are mandatory for catfish farms, the control and monitoring of implementing this regulation were practically very limited.

Most farms often pump out the sludge during and after the culture cycle, the method is mainly a sludge pump operated by divers. Sludge from fish ponds was removed 3-4 times per crop with the number of sludge removal times dependent on the stocking density, feed types and fish growth stage. Normally, the sludge was removed with higher frequency in the case of ponds using farm-made feed compared to that of pellet feed use. The sludge was mainly removed into orchards/gardens/cash crop fields (45% of catfish farms) followed by sediment basins (33%). This information did not fully reflect that the catfish farms have enough sediment basins or storages. Catfish farmers answered questions about effluent storage and disposal in a way that confirmed they followed Goverment regulations. The sludge was often removed wet as mixed water and bottom soil. During a production cycle there was 5,880m^3 of wet-sludge/ha removed from catfish ponds. In 2012, the striped catfish farmed area reached 5,911ha (Fisheries Directorate 2013b); thus the estimate of sludge removal from catfish sector per year can be 34.74million m^3. If the sludge is not managed, most will be released to adjacent water-bodies and becomes a potential source of pollution in the long run. Therefore, further impact reductions are possible through more efficient use of inputs and low-cost treatment, and consideration of the reuse of sediments in agriculture where appropriate (Anh et al. 2010b; Phan et al. 2013; Henriksson et al. 2014).

Table 4.8. Striped catfish farming: Effluent management

Items	Small *(n=110)*	Medium *(n=64)*	Large *(n=38)*
Water discharge method (%)			
- Pumped	*50.91*	*53.13*	*34.22*
- Based on tidal cycle	*36.36*	*40.63*	*57.89*
- Both	*12.73*	*6.24*	*7.89*
Main water discharge to (%)			
*- Same as source**	*86.37*	*79.69*	*86.84*
- Drainage canal	*4.54*	*10.94*	*10.53*
- Rice-field	*7.27*	*7.81*	*2.63*
- Orchard	*1.82*	*1.56*	*0*
Water effluent treatment (%)	0.91	1.56	0
Number of sludge removal (times/crop)	3.07±1.37	3.14±1.19	2.89±0.99
- Quantity of sludge removal ('000m^3/ha/crop)	*5.90±2.64*	*6.03±2.29*	*5.55±1.91*
Sludge fate (%)			
- Pump into rice fields	*12.73*	*9.38*	*7.89*
- Pump into orchards/cash crop fields	*45.45*	*35.94*	*36.84*
- Sediment basins	*25.45*	*37.50*	*50.00*
- Others	*16.37*	*17.18*	*5.27*

** significant differences (p<0.05); %: percent of survey farms. Source: IFS survey (2011)*

e). Fish health management

✧ ***Type of fish disease:*** Over 84% of farms confirmed that their fish pond lost production during the production cycle through fish mortality (Table 4.9). There were several causes leading to fish mortality, the main cause was from fish disease followed by bad water quality, feed quality and extreme weather. This result shows that more than 75% of farms faced the problem of fish disease affecting their farm production; there was a surprisingly lower proportion of small-farms with disease problem compared to medium and large-farms. This may be the case as small-farms only paid attention to serious fish disease, while the medium and large scale knew more about different types of fish diseases and are concerned about any fish disease faced. At the survey time, the main fish disease was the most common *Bacillary Necrosis of Pangasius (BNP)*, followed by the *Motile Aeromonad*

Septicaemia (MAS) and *Pale Gill and Liver*, all of them linked to high stocking densities, low seed quality and poor water quality.

Table 4.9. Striped catfish farming: Fish health management

Items	**Small** *(n=110)*	**Medium** *(n=64)*	**Large** *(n=38)*
Fish loss cause (%)	84.55	90.63	89.47
- Disease	*54.84*	*50.00*	*55.88*
- Water quality	*45.16*	*46.55*	*38.24*
- Feed Quality	*24.73*	*22.41*	*20.59*
- Extreme weather	*15.05*	*15.52*	*11.76*
Fish disease occurrence (%)	75.45	85.94	92.11
- Bacillary Necrosis of Pangasius	*95.18*	*92.73*	*88.57*
- Motile Aeromonad Septicaemia	*73.49*	*65.45*	*57.14*
- Pale Gill and Liver	*39.76*	*50.91*	*45.71*
Fish disease diagnostic service use (%)	66.36	64.06	78.95
- Diagnosis service by chemical supplier	*72.60*	*70.73*	*46.67*
- Professional diagnostic service	*17.81*	*34.15*	*33.33*
- Farm employ trained health specialist	*12.33*	*21.95*	*46.67*
Chemical used (%)	98.18	98.44	94.74
- Water & sediment treatment	*96.30*	*93.65*	*91.67*
- Disinfectant	*25.00*	*31.75*	*30.56*
Therapeutics (%)	92.73	87.50	97.37
- Antibiotics	*22.55*	*32.14*	*27.03*
- Feed supplements	*66.67*	*82.14*	*83.78*
- Probiotics	*18.63*	*33.93*	*8.11*

%: percent of survey farms. Source: IFS survey (2011)

✧ ***Fish disease management:*** More than 68% of the farms had used diagnostic services; the highest rate was in large-farms and followed by small and medium farms. At the time of this study, chemical/drug suppliers played an important role in supporting disease diagnosis. Additionally, the large and medium-farms also designated farm employees as trained health specialists. Many large-and medium-farms had technicians in charge of disease management and technical aspects, and they participated in regular training courses on fish health management held by the local fisheries station. The farms also received support for disease diagnosis from research institutions and technical training courses from professional bodies.

Fish disease prevention and treatment were also conducted by most farms; more than 94% of farms used chemicals during the production cycle and they were mainly used for water treatment. There were more than 91% of farms implementing therapeutics for fish disease and the main method of application was feed supplements to enhance fish health, followed by antibiotic use and pro-biotics use. Rico et al. (2013) noted that the use of antibiotic treatments was significantly higher in the Vietnamese pangasius farms compared to other farmed species in Thailand, China and Bangladesh. However, total quantities of antibiotics applied by the pangasius farmers were comparable or lower than those reported for other animal production commodities. The same authors also found a relatively high prevalence of disinfectant use on the pangasius farms.

4.3.3. Economic aspects

a). Harvesting management

Fish were harvested at 900-1,000 grams/fish after 7-8 months production with an average fish survival rate reaching 76% (Table 4.10). There were no significant differences in harvest time and survival rate among farm category. There were no significant differences among farm scales in terms of fish yield (*$P>0.05$)*, reflecting the uniformly investment, high stocking densities and intensity of feeding giving rise to similar levels of productivity.

Over 77% of farms reported that their fish was often harvested and sold directly to the pangasius processors but there were still many small-farms selling their production through traders during oversupply periods. Selling harvested fish directly to the processors reduces intermediary costs, however, the processors often request large amounts and strict fish quality (i.e. white/yellow flesh rate, and antibiotics residuals). At the present, the processors use or purchase raw materials from four main sources: i) from their own farms (around 50% of total raw production), ii) contract farms (large farms or cooperatives), iii) aquaculture Ltd. companies; and iv) independent farms (small/medium). The raw material from contract farms is purchased preferentially, followed by aquaculture Ltd. companies. Processors tend to buy fish from independent farmers during shortages of raw material and when urgent orders need to be fulfilled such as when demand rises in "lower quality' markets in Russia, Ukraine, the Middle East and South America (Bush & Belton 2012). Moreover, the processors cannot control the quality of inputs (fingerlings, feeds) and usage of drugs on independent farms, and independent farms are less acquainted with export quality requirements and regulations (Khoi 2011; Bush & Belton 2012). Maintaining smaller scale farms in the value chain, requires closer horizontal and vertical coordination (Umesh et al. 2009; Khiem et al. 2010; Khoi 2011; De Silva & Nguyen 2011).

Table 4.10. Striped catfish farming: Harvesting and marketing

Items	**Small** *(n=110)*	**Medium** *(n=64)*	**Large** *(n=38)*
Mean crop grow-out days	212.91±43.30	220.78±48.07	210.53±30.8
Survival rate[a] (%/SD)	76.04±12.17	76.02±10.17	77.14±6.45
Harvest size (kg/fish)	0.98±0.22	0.98±0.11	0.93±0.09
Yield (tonnes/ha)	264.97±177.84	316.83±192.97	290.73±168.11
Fish sold to (%)			
- Traders	*22.73*	*7.94*	*5.41*
- Processors	*77.27*	*92.06*	*94.59*

** significant differences (p<0.05); %: percent of survey farms; value: mean ±std. dev; Source: IFS survey (2011)*

b). Economic efficiency

Striped catfish farming is relatively variable job over time, during a production cycle, fish price fluctuates leading to unstable production efficiency. To explore factors explaining economic performance per a production cycle, a cost-benefit analysis was applied to two disaggregated farm groups; Group 1 who lost money or achieved negative net returns and Group 2 who made a positive net return. Comparison between the two farm groups showed that there was a difference in production efficiency between two groups. Most farms have a relatively high harvest (≥247tonnes/ha) (Table 4.11). Although the fish yield of group 1 was higher than that of group 2, the farms from group 1 still lost money. The main reasons were higher production cost and lower fish price, and their production cost was higher than the fish price at harvest time leading to lost profit. It reflects that the fish price at harvest time is the most important factor affecting profitability efficiency.

Table 4.11. Striped catfish farming: Economic efficiency

Items	**Small** *(n=110)*	**Medium** *(n=64)*	**Large** *(n=38)*
Group 1: negative net return (n)	*67*	*40*	*19*
% of total farms	*60.91*	*63.49*	*54.29*
Yield (tonnes/ha)	276.40±199.94	333.69±177.28	300.03±137.69
Gross revenue (‘000 US$/ha)	216.39±170.76	258.42±137.95	248.15±128.80
Total cost (‘000 US$/ha)	270.08±213.81	352.26±211.92	308.92±146.68
Net return (‘000 US$/ha)	-53.68±70.44	-93.84±101.68	-60.76±73.40
*- Production cost (US$/kg)**	*0.99±0.23*	*1.07±0.25*	*1.03±0.13*
*- Fish price (US$/kg)**	*0.78±0.08*	*0.78±0.1*	*0.82±0.21*
Group 2: positive net return (n)	*43*	*23*	*16*
% of total farms	*39.09*	*36.51*	*45.71*
Yield (tonnes/ha)	247.16±136.84	287.50±218.65	279.69±202.65
Gross revenue(‘000 US$/ha)	215.78±120.59	281.96±225.75	306.65±225.23
Total cost (‘000 US$/ha)	184.91±106.49	235.66±178.67	259.51±196.56
Net return(‘000 US$/ha)*	30.87±46.34	46.3±57.73	47.13±48.01
- Production cost (US$/kg)	*0.77±0.15*	*0.83±0.09*	*0.93±0.15*
- Fish price (US$/kg)	*0.89±0.14*	*0.96±0.12*	*1.09±0.09*

** significant differences ($p<0.05$); value: mean ±std.dev., exchange rate 20800 VND/1US$. Source: IFS survey (2011)*

Table 4.11 shows all scales of catfish farms faced economic losses, the small-/medium farms accounted for around 60% of total farms and large farms (54%). This suggests that performance was relatively independent of farm scale; and was linked to other attributes such as management (e.g. feeding, stocking) and timing of fish sales in the economic cycle (that greatly affected the farm-gate price achievable). This gives evidence for the likely characterisitics of consolidation of the sector, and suggests that smaller scale farms can still maintain themselves in the value chain if they can improve their farming practice and management.

4.3.4. Catfish farm certification and sustainability issues

a). Main certification issues of catfish farms

To make an assessment of which farming practices meet major certification standards, a number of standard criteria of the GAA-BAP, GlobalGAP and ASC were selected and presented in Table 4.12[3]. Comparisons between selection criteria and current practices by farm scale shows that many farms have achieved several standard criteria such as eFCR (≤1.68), stocking density (≤38kg/m^2), no banned chemical/drug and wild-seed source use, working hours per day (≤8), community relations, property rights and biodiversity protection. However, there are still many standard principles/criteria that farms could not meet such as i) the criteria on effluent management (most farms release their waste water without treatment, and have no sediment basins or lack of evidence on the sludge treatment, water use >5,000m^3/tonnes of fresh fish, no water monitoring). The sediment basin or pond to collect sludge from fish ponds is a mandatory requirement by the GAA-BAP standard (GAA 2010); and/or the farms have to show an evidence that sludge is not discharged directly into receiving waters or natural ecosystem (ASC 2010; GlobalGAP 2011); ii) registration of farms (many farms have not registered a legal farm name); iii) fish meal control (farms cannot control fishmeal/oil ingredients); iv) fish mortality management

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[3]The information on the bracket present indicators of the current farming practices

(fish mortality >20%); iv) labour arrangements (lack of written contracts and reliance on verbal arrangements); v) farm hygiene; and vi) record keeping requirement.

Current practices of small-/medium catfish farms tended to be quite weak in relation to indicators compared to the standard criteria such selection of site, employment conditions, storage and disposal of supplies, effluent management, microbial sanitation, pest management, fish health and welfare, and traceability recordkeeping. Large-farms also faced the same issues, but they were generally at a higher level in relation to indicators to meet the standard criteria. Moreover, with a higher capacity of infrastructure (large farm-size, feed/chemicals storage, pond construction, water supply system) and financial resources, large-farms were better able to improve their operations towards standards than small or medium farms. Existing farms needed considerable investment and also required support from the local officers (e.g. technical support, guidelines on trading name registration and certification of property rights) to meet the standards criteria. These would likely lead to increased production costs; that a financial constraint for small and medium farms. Certification fee is also a constraint for small-/medium farms and are proportionately more expensive for smaller operations, because auditing costs are not related to farm size. Additionally, small-farms may not have enough land for restructuring their farms to follow criteria such as using land for reservoir and sediment basins, storage of input material and living quarters for labourers. Therefore, the capacity of small- and medium-farms to meet the standards for certification is very difficult compared to the large-farms. To overcome this issue, small/medium should be linked into groups, and then work together to obtain group certification.

Table 4.12. Comparison of selected standard criteria and current catfish farming practices

	Standards category and criteria[a]	Current farming practices[b]		
		Small *(n=110)*	**Medium** *(n=64)*	**Large** *(n=38)*
I	**Aquaculture production guidelines**			
1.	Selection of site: *Farms registered as required by national legislations*[1]	All farms not yet registered	94% of farms not yet registered	53% of farms not yet registered
2.	Feeding practices: *Farms shall accurately monitor feed inputs and minimize the use of fishmeal/fish oil* [2]*, and eFCR*[3]*<=1.68*	70% of farms used commercial feed with eFCR 1.64. Fish meals/oils sources were not monitored.	70% of farms used commercial feed with eFCR 1.70. Fish meals/oils sources were not monitored.	89% of farms used commercial feed with eFCR 1.64. Fish meals/oils sources were not monitored.
3	Fish health and welfare:			
	- Operations on farms that involve fish are designed/operated with animal welfare issue[1,2,3] *- Employees shall be trained to provide appropriate levels of husbandry*[1,2,3] *- Stocking density*[3] *(SD)<=38kg of fish/m*^{2} *at any time; and fish mortality*[3] *(FM)<=20%*	- Fish disease diagnostic service used (66%); therapeutics applied (93%) - Staffs were trained on technical skills. - SD: 26.49kg/m^2; FM: 23.95% at harvest.	Fish disease diagnostic service used (64%); therapeutics applied (88%) - Staffs were trained on technical skills. - SD: 31.68kg/m^2 and FM: 24% at harvest.	- Fish disease diagnostic service used 79%); therapeutics applied (92%) - Staffs were trained on technical skills. - SD: 29.07kg/m^2 and FM: 23% at the harvest.
4	Pest management (escapees)			
	- Certified farms shall take measures to minimize escapes of farm stock[1,2,3] *- Evidence that inlets/outlets to culture systems and all confinements are equipped with net mesh appropriately sized to retain the stocks in culture preventing fish of any size to escape* [3]	- Ponds are repaired and prepared after each crop. - Every pond had its own supplying/drainage systems (98%). Net is used to protect and avoid escapes of farm stocks.	- Ponds are repaired and prepared after each crop. - Every pond had its own supplying/drainage systems (91%). Net is used to protect and avoid escapes of farm stocks.	- Ponds are repaired and prepared after each crop. - Every pond had its own supplying/drainage systems (92%). Net is used to protect and avoid escapes of farm stocks.
II	**Social and legal issues**			
1.	Property right and regulatory compliance: *Farms shall comply with national laws and environmental regulations*[1,2,3]	Land owned by farms (90%) Farm managed by owner (100%)	Land owned by farms (74%) Farm managed by owner (88%)	Land owned by farms (82%) Farm managed by owner (58%)
2.	Community relations: *Farms shall strive for good community relations and not block access to public areas and other traditional natural resources used by local communities*[2,3]	Open access to use the same water sources. Local people was high priority hired to work in the farms	Open access to use the same water sources. Local people was high priority hired to work in the farms	Open access to use the same water sources. Local people was high priority hired to work in the farms

3.	Forced labour: *Compliance with labour laws in the country where pangasius is produced.* *- Child labour: age of workers >=18*[1,2,3]	65% of farms hired labours, with verbal agreements only. - Non child labour	97% of farms hired labours, with verbal agreements only. - Non child labour	All farms hired labours, of which 47% signed contract with labours. - Non child labour
4.	Employment conditions: *Farms shall comply with national labour laws to assure adequate worker safety, compensation and, where applicable, on-site living conditions. (8 hours/day; salary paid at a premium rate to the normal salary)*[2,3]	Labours with mean working hours per day was 6.98. Labour fee salary was around US$96.15/full-time labour/month, around US$4.81 /part-time labour/day.	Labours with mean working hours per day was 6.78. Labour fee salary was around US$96.15/full-time labour/month, around US$4.81 /part-time labour/day.	Labours with mean working hours per day was 7.63. Labour fee salary was around US$96.15/full-time labour/month, around US$4.8 /part-time labour/day.
III	**Environmental management system**			
1.	Storage and disposal of supplies: *Fuel, lubricants and chemicals shall be stored and disposed of in a safe and responsible manner*[1,2,3]	100% of farms had storage, but this was small area in their house or small storage	100% of farms had storage, but this was small area in their house or small storage	100% of farms had storage, this was large storage in the farm
2.	Soil and water management: *Farm located in approved aquaculture development areas*[1,2,3]	Farm located in approved aquaculture development areas	Farm located in approved aquaculture development areas	Farm located in approved catfish development areas
3.	Effluent management:			
	- Evidence that sludge is not discharged directly into receiving waters or natural ecosystems[1,2,3] *- Farms shall monitor effluents to confirm compliance with effluent water quality criteria*[2]. *- The water used/ton of fish*[3] *is <=5,000 m^3.*	- 25% of farms removed sludge to sludge basin; agriculture field (58%). - Waste water without treatment was drained (91% of farms). - Water use/crop was 5,301m^3/ton.	- 38% of farms removed sludge to sludge basin; agriculture field (45%). - Waste water without treatment was drained (91% of farms). - Water use/crop was 5,903m^3/ton.	- 50% of farms removed sludge to the sludge basin; agriculture field (45%). - Waste water without treatment was drained (97% of farms). - Water use/crop was 5,684m^3/ton.
4.	Microbial Sanitation: *Waste/animal manure shall be prevented from contaminating pond waters*[2,3]	Farms was collocated with family house, local communities	Farms was collocated with family house, local communities	Farms was separated to workers house, local communities
IV	**Food safety and chain-related issues**			
1.	Drug and chemical use: *Use veterinary medicines/chemicals approved and not banned*[1,2,3]	Banned antibiotics, drugs and other chemical compounds were not used.	Banned antibiotics, drugs and other chemical compounds were not used.	Banned antibiotics, drugs and other chemical compounds were not used.
2.	Post larvae sources: *Not allowance for use of wild-caught seed for grow out*[1,3]	100% seed came from artificial hatcheries.	100% seed came from artificial hatcheries.	100% seed came from artificial hatcheries.
3.	Traceability record-keeping: *logbook shall be maintained for each of specified parameters for every production unit/every production cycle*[1,2,3]	Record keeping was applied, but it was not detail and not regularly	Record keeping was applied, but it was not detail and not regularly	Record keeping was applied in detail and regularly, but it was not well organized

Source: (a) Information/data from Information/data from [1]GlobalGAP (2011), [2]GAA (2010), [3]ASC (2010); (b) IFS survey (2011)

b). Main constraints to sustainable development

There were five important factors affecting the long-term development of catfish farming perceived by farmers (Table 4.13). Factors related to environmental sustainability aspects including fish disease, water quality and seed quality. Concerns on social responsibility includes the quality of products and prices, and the capital/credit cost is the main factor for economic viability.

Currently, 68% of catfish farms faced the disease, and 92% of them used various therapeutic methods. Fish disease has tended to be increasingly complex with new types of diseases emerging, so disease was perceived as the most important sustainability factor. The responses should be improvement of the technical skills and use certified seed.

Water quality was also addressed as a sustainability factor, the water quality fluctuated and tend to decline, because farms confirmed that the trend of chemical use was increased over the last five years. Moreover, most farms applied water exchange methods daily, large amount of water was exchanged directly per time, and the water quality cannot be fully controlled. The farmers thought that bad water quality maybe come from nutrient discharge by other industries such rice farming into the river, because rice is produced at higher intensification levels (i.e. two or three rice-crops per year), and was cultivated on 1.9 million ha representing nearly 50% of the total natural MKD land (Sebesvari et al. 2012; GSO 2013).

Seed quality was perceived as an important factor driving sustainability, and the main cause can be slow genetic improvement of the brood-stock population such as a low number of brooders being added or changed at the hatcheries. At present, fish mortality was still high in both nursing and grow-out stages, and this was related to poor seed quality.

With the trend toward increasingly stringent requirements for product quality and food safety assurance from import markets, the quality of current products needs to be improved to meet the market demands and to expand the markets when creating trust with customers. There were many catfish exporters, half of them had processing plants leading to unfair competition among catfish exporters such dumping export price occur (e.g. reducing exporting price from US$3.1 in 2007 to US$2.7 per kg of pangasius fillet in 2012) to gain the buyers, and thus it led to unstable markets and fluctuation of farm gate price over time (Fisheries Directorate 2013; VASEP 2014). Farmers suggested that the farm gate price should be managed and improved by regulation on the ceiling price to ensure premium price for catfish farms, if the fish price is not higher than the production cost in a long term many farms will leave the catfish industry.

In addition, the operation of a catfish farm requires huge capital investment, and currently a farm's capital is limited and dependent on credit, especially loans from State banks and money lenders, but regulations about loans from the State bank in terms of time and amount of the loan do not meet the minimum needs of the farms and it is also less effective. The investment required for 1ha per production cycle is around US$300,000; but the credit offered by State banks is usually a fraction of this amount because farmers typically did not have adequate collateral required by banks for such size of land, which were also typically only available on a short-term basis which does not meet the requirements of the pangasius production cycle. To cope with the financial constraints, many smaller scale farms got large amount from informal lenders with high interest rates (e.g. relatives, money-lenders), and through delay payment terms of feed and/or vertical linkage to processors (e.g. contracting farms).

Table 4.13. The major factors related to sustainable development of catfish farming

Constraints	Current farming practices?	Responses and what would it show?	How does it related to sustainability?
Fish disease	- Fish disease faced (68%) - Therapeutics applied (92%): *Antibiotics used (26%)* *Disinfectant used (27%)* - Main disease: BNP, MAS	- *Responses:* Update and improve technical skills; use of certified seed - *Expected outcomes:* Successful harvest (less mortality and high yields); lower cost from less use of chemicals and drugs	- *Why it is important:* Indicate better farm management, effective health management protocols - *How it related to SIs:* Effective environmental and health management, a higher biodiversity promote sustainability, contribute to protection of natural capital and to enhance economic performance.
Water quality	- Farms did not have sediment and reservoir ponds. - Water quality was not monitored regularly. Waste water without treatment was exchanged into public area (92%). - Daily water exchange applied, and total water use/crop was 5,438m^3/ton.	- *Responses:* Update and improve technical skills; upgrading of farm infrastructure; applied new technology for production - *Expected outcomes:* No or low incidence of challenges to the farm from government; less negative effects to public environment; lower disease incidence	- *Why it is important:* It indicates environmentally responsible and friendly farming; also a proxy indicator of better sector governance (i.e. zoning, planning). - *How it related to SIs:* Environmentally friendly farming; good sector management; less social risks (less risk from food safety issues) and environmental risk; improves market access; improves yields.
Seed quality	- High mortality rate (24%) - Unknown bloodstock sources (99%) - Stocking density (42.13pcs./m^2)	- *Responses:* Use of certified seed; update and improve technical skills - *Expected outcomes:* Less disease incidence; less mortality; higher yields.	- *Why it is important:* Indication of good risk management practice - *How it related to SIs:* Farmers' widespread use encourages seed producers to adopt seed certification standards. This improves overall productivity and sustainability of farming.
Products quality and price	- Unstable markets and unfair competition among seafood exporters leads to dumping export price, and the farm gate often was lower. - White flesh rate (85%) & Yellow/pink flesh rate (15%).	- *Responses:* Upgrading of farm infrastructure; applied new technology for production; strong linkages of operation - *Expected outcomes:* More buyers; probably higher prices for the products of the farm. Share of the margin between farm gate and retail market is fair to the farmers.	- *Why it is important:* It indicates quality and price of farm products. - *How it related to SIs:* Trust in the farmer by buyers is an important social capital that can translate to better profitability. Better market access improves competitiveness and sustainability of farms. An efficient market mechanism that enables a fair price to farmers improves farm profitability and competitiveness. Also indicates that trust and prevails along the value chain which enhances social capital.
Capital & credit costs	- Total cost for a production cycle was around US$302,920/ha, of which 60% derived from loan sources. - Input cost has increased yearly at 10%, while farm gate price has not increased and often lower than production cost.	- *Responses:* Improve policy on financial supports and farm management to save cost of inputs; and strong linkages of operation - *Expected outcomes:* High repayment rates, low default rates; low incidence of indebtedness; better economic viability	- *Why it is important:* It indicates profitability of the farm and the farmers' management ability. - *How it related to SIs:* Credit sources don't impose onerous terms; production loans are invested wisely; or enterprise is profitable to enable farmers to avoid heavy indebtedness. It gives resilience to the farm against economic shocks, which improves human capital.

4.4. Current shrimp farming practices

4.4.1. General information

a). Shrimp farms characteristics

✧ ***Farm characteristics*[4]*:*** Most farms were established and owned by families, at a low level of investment (LoLI: mixed mangrove-shrimp, improve extensive and rice-shrimp rotation system) more than 15 years before this study. High level investment systems have emerged more recently (HiLI: semi-/intensive system) following improvement in technical skills and the introduction of new techniques in farming practices. Aquaculture Ltd. companies have gradually formed and concentrated in high intensive farming areas in Soc Trang, Bac Lieu and Kien Giang provinces. There were large differences in farm size and surface water area between the farm systems *($P<0.05$)*. Intensive farms were often larger farms with large farm-size in terms of water area, amount of required labour, intensification level and high investment, followed by mixed mangrove -shrimp farms with large land area, the other types of shrimp farming systems were characterised by relatively small land holdings (around 1.5ha). Land holdings were mostly owned by families with a small proportion of shrimp farms renting land based on 3-5 year contracts. Most shrimp farms were operated by the families (LoLI) and aquaculture companies (HiLI) and they were mainly individual farms and only 15% of intensive farms were run by salaried managers.

✧ ***Pond infrastructures:*** Not all shrimp farms had sediment ponds, and more than 40% of HiLI shrimp farms had reservoir ponds. In particular, mixed mangrove-shrimp and improved-extensive farms did not have reservoirs and sediment ponds, their ponds were

[4] LoLI and HiLI were classified by the level of intensification. The LoIL system is the improved-extensive shrimp system and open system; while the HoLI is the semi-intensive/intensive shrimp system and closed system

used for grow-out shrimp culture. Many shrimp farmers have not built reservoir ponds, and water supplies are sourced typically direct from the river. Water exchange is not fully controlled leading to increased risk of disease.

Table 4.14. Shrimp farming: Farms characteristics

Items	BTS					WLS
	Intensive *(n=20)*	**Semi-intensive** *(n=60)*	**Improved -extensive** *(n=60)*	**Mangrove -shrimp** *(n=30)*	**Rice-shrimp** *(n=30)*	**Semi-intensive** *(n=30)*
Trading name (%)	15.00	0	0	0	0	3.33
Total land (ha)*	18.27	2.31	1.96	3.94	2.46	2.61
	±22.36	±1.93	±2.13	±2.04	±3.86	±9.38
Water area (ha) *	11.80	1.53	1.51	2.67	1.29	1.54
	±14.56	±1.14	±1.67	±1.56	±0.79	±4.85
No.of ponds*	20.00	4.65	1.27	1.10	3.20	3.87
	±23.21	±3.07	±0.73	±0.55	±1.13	±9.51
Duration of operation (years)*	12.05	11.95	15.05	16.67	17.53	9.77
	±3.43	±3.34	±3.38	±8.3	±3.61	±3.63
Farm established by owner (%)	90.00	100.00	100.00	96.67	100.00	100.00
Land ownership (%)						
*- Owned by family/company**	*90.00*	*95.00*	*100.00*	*86.67*	*100.00*	*100.00*
*- Leased from State/private owner **	*10.00*	*5.00*	*0*	*13.33*	*0*	*0*
Contract length (years)	5.00	3.00	-	-	-	-
Management type (%)						
- By owner & salaried labour	*5.00*	*1.67*	*0*	*0*	*0*	*3.33*
*- By owner family/company**	*85.00*	*98.33*	*100.00*	*100.00*	*100.00*	*96.67*
*- By salaried labour/absentee owner**	*10.00*	*0*	*0*	*0*	*0*	*0*
Pond conditions:						
- Reservoir water pond (%)	*40.00*	*45.00*	*0*	*0*	*53.33*	*63.33*
- Effluent storage pond (%)	*0*	*0*	*0*	*0*	*0*	*0*
Grow-out pond size (ha)*	0.55	0.33	1.32	2.45	0.48	0.44
	±0.14	±0.14	±1.49	±1.30	±0.24	±0.46
*- Water depth (m)**	1.72	1.41	1.23	1.24	1.12	1.71
	±0.3	±0.21	±0.44	±0.27	±0.35	±0.18
Pond lining material (%)						
- None or earth pond	*80.00*	*66.67*	*83.33*	*83.33*	*80.00*	*100.00*
- Clay	*5.00*	*11.67*	*15.00*	*16.67*	*20.00*	*0*
- Polyethylene sheet	*15.00*	*21.66*	*1.67*	*0*	*0*	*0*

** significant differences (p<0.05); %: percent of survey farms; value: mean ±std. dev. Source: IFS survey (2011)*

The diversity of shrimp farm category gave raise to variability in investment and management characteristics. Culture pond size varied greatly with shrimp farm category *($P<0.05$)*. There was no significant difference in the pond characteristics between BTS and WLS semi-intensive system, because WLS system was switched from the former BTS system in 2008. The HiLI system that had high stocking density and used feed for shrimp ponds was a contrast to the LoLI system characterized by low stocking density and no feeding and dependence on natural feeding large ponds. The pond size of the mangrove-shrimp and improved-extensive systems was larger than others; however the actual water areas inhabited by the shrimp was not bigger than the others, accounting for 40-60% of water area in the mangrove-shrimp system and around 30-40% in the improved-extensive system. Generally, water depth was over 1.12m, but most ponds were earthen without polyethylene sheet covering. However, where soil conditions produce structurally weak ponds, conditions may not be good for shrimp culture because pond dikes are unstable and give rise to water leakages. Moreover, predators (i.e. crabs, snails, wild-fish) in this type of pond, may not be removed and act as vectors for pathogens from one pond to another.

b). Status of labour in farms

Table 4.15 presents information on respondents and status of labourers working in farms. Most respondents were shrimp farm owners, however 25% of respondents in the intensive farm system were salaried managers or technicians *($P<0.05$)*. The average age of respondents ranged between 40-45 with more than 10 years experience, so they have relatively good technical husbandry skills to manage their shrimp ponds. Currently farm management is based on family labours, however intensive farms had to hire full-time labourers to work on their farms. The main tasks of full-time labourers on intensive shrimp farms were feeding, autofeeders such as are common place in Thailand are rare. Nietes-

Satapornvanit (2014) noted that use of autofeeders had led to reduced the labour requirements and decreased FCR in Thailand since their widespread introduction, since 2010.

Additionally, all shrimp farms also hired part-time workers for sludge removal and pond preparation during the production cycle. The average working time of employees did not exceed 8hours/day and most shrimp farms had not signed legal contracts with employees, with workers employed under verbal agreements. These data suggest the significant employment impacts on local communities that shrimp farming has encouraged bases on both permanent and seasonal jobs for local people.

Table 4.15. Shrimp farming: Information on workers

Items	BTS					WLS
	Intensive *(n=20)*	**Semi-intensive** *(n=60)*	**Improved-extensive** *(n=60)*	**Mangrove-shrimp** *(n=30)*	**Rice-shrimp** *(n=30)*	**Semi-intensive** *(n=30)*
Farm role (%)						
*- Manager**	*20.00*	*3.33*	*1.67*	*0*	*0*	*0*
*- Owner**	*75.00*	*96.67*	*85.00*	*93.33*	*100.00*	*100.00*
*- Technician**	*5.00*	*0*	*13.33*	*6.67*	*0*	*0*
Gender (%)						
- Female	*0*	*6.67*	*23.33*	*6.67*	*6.67*	*6.67*
- Male	*100.00*	*93.33*	*76.67*	*93.33*	*93.33*	*93.33*
Average age	42.55	45.2	46.43	41.17	49.3	44.1
	±13.36	±11.94	±14.56	±10.85	±10.59	±9.48
Experience-years*	12.80	12.17	15.10	17.30	17.53	10.57
	±3.29	±3.27	±3.18	±8.27	±3.61	±2.96
Full-time hired staff (%)	100.00	55.00	30.00	36.67	33.33	6.67
*- No.of workers (pers.)**	*17.45*	*1.38*	*0.37*	*0.53*	*0.60*	*1.23*
	±26.48	*±1.69*	*±0.61*	*±0.82*	*±0.93*	*±6.57*
- Working hours per day	*7.34*	*7.38*	*8.00*	*8.00*	*7.00*	*8.00*
	±1.33	*±1.75*	*±0.00*	*±0.00*	*±1.15*	*±0.00*
Part-time hired workers						
*- No.of workers (pers.)**	*15.00*	*4.14*	*2.33*	*2.00*	*2.67*	*4.24*
	±7.07	*±2.91*	*±0.82*	*±0.00*	*±1.51*	*±2.81*
- Working hours per day	*8.00*	*7.29*	*8.00*	*8.00*	*7.33*	*7.09*
	±0.00	*±1.25*	*±0.00*	*±0.00*	*±1.03*	*±1.35*

** significant differences (p<0.05); %: percent of survey farms; value: mean ±std. dev. Source: IFS survey (2011)*

4.4.2. Technical aspects

a). Pond preparation and stocking

The HiLI shrimp farms paid more attention to pond preparation tasks with more than 80% of farms carrying out water preparation such water storage and treatment before stocking; while the proportion of the LoLI farms implementing such preparation was around 30%. All shrimp post-larvae use were purchased from private hatcheries, but most farms were not aware of the brood-stock source. The HiLI farms have implemented a PCR test for post-larvae before buying and stocking, while the LoLI farms did not care about this. Shrimp mortality rates were higher in the LoLI due to inconsistent seed quality, and seed quality selection can be an important factor affecting production efficiency. Stocking density varied significantly with system is high or low; the highest stocking density was recorded in the semi-intensive system of white-legged shrimp while the improved-extensive system showed the lowest stocking density.

The HiLI farms usually produced a single crop per year and the method of "simple batch production" was applied mainly for stocking and harvesting. A production cycle of the intensive system for black tiger shrimp ranged from 6 to 8 months in total, including two months for pond preparation and the following months for shrimp growth. Moreover, each local provincial government had a regulation on the single crop and stocking time for the intensive and semi-intensive systems, because the fallow days between two crops could help to reduce the risk in the offseason (i.e. rainy season), and to decrease the high pressures on the pond exploitation. However, some larger farms used multiple batch production with staggered stocking and harvesting. In contrast, LoLI farms typically stocked at lower densities with intermittent restocking and harvest.

Table 4.16. Shrimp farming: Pond preparation and stocking management

Items	BTS Intensive (n=20)	BTS Semi-intensive (n=60)	BTS Improved -extensive (n=60)	BTS Mangrove -shrimp (n=30)	BTS Rice-shrimp (n=30)	WLS Semi-intensive (n=30)
Pond preparation (%)						
- Water storage	*80.00*	*88.33*	*33.33*	*30.00*	*76.67*	*100.00*
- Water treatment	*95.00*	*96.67*	*28.33*	*26.67*	*100.00*	*76.67*
Artificial seed sources (%)						
- Hatchery - broodstock known	*55.00*	*55.00*	*61.67*	*46.67*	*36.67*	*0*
- Hatchery - broodstock unknown	*40.00*	*43.33*	*38.33*	*53.33*	*60.00*	*100.00*
- Traders/Nursery	*5.00*	*1.67*	*0*	*0*	*3.33*	*0*
Seed stocking (pcs/m^2)*	33.30 ±10.75	23.06 ±7.51	2.49 ±2.26	3.12 ±3.59	7.08 ±3.20	83.67 ±19.78
Seed size (PL stage)*	13.85 ±1.50	13.58 ±1.76	12.98 ±3.40	12.54 ±4.11	13.33 ±4.25	11.67 ±0.88
Days between stocking	84.80 ±81.67	78.7 ±60.98	31.11 ±20.34	31.00 ±14.72	51.27 ±53.36	80.7 ±50.18
Production scheduling (%)						
- Simple batch production	*70.00*	*93.33*	*0*	*0*	*100.00*	*100.00*
- Multiple "back stocking"	*0*	*0*	*100.00*	*100.00*	*0*	*0*
- Multiple batchproduction	*30.00*	*6.67*	*0*	*0*	*0*	*0*

** significant differences (p<0.05); %: percent of survey farms; value: mean ±std. dev. Source: IFS survey (2011)*

b). Feed management

Mixed mangrove-shrimp and improved-extensive shrimp systems did not use feed. The other types of shrimp farming systems used commercial feed for shrimp culture with protein contents ranging between 38-42%, and during the 1st stage of the production cycle most farms also used premix adding it into formulated pellet diets by mixing with water before feeding time 1-2 hours. eFCR varied among shrimp systems, but this figure was higher than that in the experiments (i.e. eFCR was around 1.5 for BTS intensive system, and less than 1.3 for semi-intensive system) due to weak estimation or limitations in the feeding methods. To estimate the daily feed amount supplied, shrimp farms mainly used the feed tray method, and followed the instructions on the feed packs. Feed was mainly purchased through local feed manufacturer agent and traders, accounting 86% and 4% of shrimp farms, respectively. Only 10% of intensive farms were able to purchase feed directly from aqua-feed companies as they met the requirement of feed amount. Of course, feed price from the traders will often be higher than buying directly from the feed plants, the feed price at manufacturers gate was 1-3% lower than the retail price at local area, depending on the feed quantity purchased.

Table 4.17. Shrimp farming: Feed management

Items	BTS					WLS
	Intensive *(n=20)*	**Semi-intensive** *(n=60)*	**Improved -extensive** *(n=60)*	**Mangrove -shrimp** *(n=30)*	**Rice-shrimp** *(n=30)*	**Semi-intensive** *(n=30)*
Commercial feed use (%)*	100.00	100.00	0	0	100.00	100.00
Protein content (%)	40.43 ±3.35	40.23 ±2.01	-	-	40.06 ±2.24	38.55 ±1.88
eFCR estimation*	1.55 ±0.16	1.68 ±0.17	-	-	1.63 ±0.44	1.25 ±0.13
Meal calculate method (%)						
- Regular meals to appetite	*25.00*	*20.00*	-	-	*20.00*	*0*
- % body weight by sample weights	*10.00*	*0*	-	-	*0*	*0*
- Biomass by volume estimation	*65.00*	*80.00*	-	-	*80.00*	*10.00*
Feed sources (%)						
*- Direct from manufacturer**	*10.00*	*0*	-	-	*0*	*3.33*
*- Local manufacturer agent**	*85.00*	*88.33*	-	-	*86.67*	*96.67*
*- Local trader**	*5.00*	*11.67*	-	-	*13.33*	*0*
Payment terms (%)						
- Full cash on delivery	*30.00*	*6.67*	-	-	*10.00*	*20.00*
- Delay payment until the end of crop	*70.00*	*86.66*	-	-	*73.33*	*80.00*
- Others	*0*	*6.67*	-	-	*16.67*	*0*

** significant differences (p<0.05); %: percent of survey farms; value: mean ±std. dev. Source: IFS survey (2011)*

Generally, feed is paid for immediately when purchased from both feed manufacturers and feed traders, however, with long term relationships between farmers and feed sellers there was a popular trading practice "delay payment term" where farmers can buy feed from the 2^{nd} or 3^{rd} month of the shrimp crop with a delay in payment until the end of the shrimp crop. The delay payment time ranged from two to three months, and the feed sellers normally charged higher feed prices for sales on credit compared to cash sales, such as total cost for 20kg per feed pack was 420,000VND (≈US$20.19) for delay payment terms compared to 400,000VND (≈US$19.23) by cash on delivery (i.e. 5% higher than normal price). It reflects that feed sellers want to avoid trading risk, because shrimp farms can profit from this stage of the production cycle. Tran et al. (2013) pointed out that making delayed payment term from the third culture month reduced the risk of losing money for feed sellers as the crop could be harvested early if shrimp disease occurs; however, larger and successful farmers were more able to access such terms of purchase than small-scale farmers.

c). Water management

Shrimp farms are often located in coastal areas and estuaries, so the water source used for shrimp ponds comes mainly from the river-mouth, coastal canals, and a few farms get water from primary and secondary canals. Around 50% of shrimp farms conducted water preparation in reservoir ponds and/or in grow-out ponds before stocking, and the time taken for water preparation ranged from 7-17 days. In a particular case, the mixed mangrove-shrimp and improved-extensive system put water directly into shrimp ponds with PLs stocked 2-3 days later. Most farms did not have sediment ponds, and only 35% of intensive farms had drainage canals.

Currently shrimp farms have applied limited water exchange methods for shrimp ponds. LoLI farms mainly applied the "partial drainage & water replacement" method; while the "top-up water losses only" method was mostly applied by the HiLI farms *($P<0.05$)*. The main reason was due to fluctuation of environmental conditions and risks from disease outbreaks, so most farms did not want to use water directly from rivers to avoid disease risk. There was a significant difference in the frequency of water exchange between shrimp farming systems *($P<0.05$)*, the water exchange of the mixed mangrove-shrimp and the improved-extensive system was mainly based on the tidal regime, so it is usually carried out fortnightly or monthly, and this was also an additional source of wild-seed and natural food for shrimp ponds. Whereas, in the HiLI farms, water exchange was not regularly and it was based on the manager's experience on water colour, and new water sources came mainly from the settling ponds or farm's water supply canals. The HiLI farms aimed to control water quality and the water exchange was around 20% of the total volume from reservoir pond/basins on each occasion; while the LoLI farms with large pond-size could only carry out partial water exchange at around 38% of the total volume from the direct river/canals.

Table 4.18. Shrimp farming: Water management

Items	BTS					WLS
	Intensive *(n=20)*	**Semi-intensive** *(n=60)*	**Improved-extensive** *(n=60)*	**Mangrove-shrimp** *(n=30)*	**Rice-shrimp** *(n=30)*	**Semi-intensive** *(n=30)*
Main water source (%)						
- Estuary/river	*95.00*	*70.00*	*100.00*	*80.00*	*60.00*	*100.00*
- Primary canal	*0*	*11.67*	*0*	*20.00*	*6.67*	*0*
- Secondary canal	*0*	*16.67*	*0*	*0*	*33.33*	*0*
Water storage method (%)						
- None	*40.00*	*45.00*	*98.33*	*100.00*	*60.00*	*100.00*
- Reservoir pond use	*25.00*	*36.67*	*0*	*0*	*40.00*	*0*
- Sediment pond use	*35.00*	*18.33*	*1.67*	*0*	*0*	*0*
No.of days of settling water *	9.85 ±9.28	16.44 ±9.35	2.63 ±3.84	2.07 ±3.34	6.50 ±5.39	11.70 ±2.73
Water exchange (%)						
*- Top-up water losses only**	*70.00*	*60.00*	*28.33*	*16.67*	*56.67*	*100.00*
*- Partial water replacement**	*30.00*	*40.00*	*71.67*	*83.33*	*43.33*	*0*
Water replacement (%/volume)	18.75 ±8.35	13.64 ±4.92	38.82 ±12.6	49.71 ±15.26	17.00 ±8.78	8.00 ±2.49
Water exchange freq. (%)						
*- Fortnightly**	*5.00*	*5.00*	*40.00*	*50.00*	*3.33*	*0*
*- Monthly**	*0*	*0*	*21.67*	*40.00*	*23.33*	*0*
*- Based on their experience**	*95.00*	*95.00*	*38.33*	*10.00*	*73.34*	*100.00*

** significant differences (p<0.05); %: percent of survey farms; value: mean ±std. dev. Source: IFS survey (2011)*

d). Effluent management

The water release using the gravity drainage method was mainly applied in the mixed mangrove-shrimp and improved-extensive shrimp system. Other shrimp systems used a method of pumping or both methods were applied. Most farms designed their own supplying/drainage system to facilitate water exchange. Most farms reported that waste-water is not treated and is drained directly into rivers or canals that are the same as the supply source. A small number of shrimp farms reused effluent from shrimp ponds to culture other species in the same pond after the shrimp have been harvested, or waste water was partially reused for the next crop because the water could not be fully drained in the large pond-size in mixed mangrove-shrimp and improved-extensive systems. Currently, there is no agreement concerning water effluent management from the local community. Sludge from shrimp ponds was mostly removed to pond dykes after each harvest. Although the un-fed mangrove-shrimp and improved-extensive systems resulted in much lower volumes, sludge that accumulated from water exchange was removed annually. A few shrimp farms had sediment ponds or basins, or several farms had small drainage canals and empty land for sludge storage. There was no difference found in terms of the sludge management between BTS intensive and semi-intensive systems. The key differences in practice between BTS and WLS semi-intensive should be type of sludge disposal, whereas BTL farms removed sludge to the pond dyke, sediment basins were commonly used in WLS farms. However, the storage capacity of the areas was limited and sludge still indirectly went to the rivers. Discharge of untreated waste water and sludge, especially during shrimp disease outbreaks, may be a cause of the spread of diseases that affect farm production efficiency. Shrimp diseases were often caused by polluted water in the pond itself, and the bad water quality such as high Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) concentrations is a favorable condition for pathogenic microorganisms (Anh et al. 2010a; Oanh & Phuong 2012). Anh et al. (2010a) indicated that most of the waste water and contaminated sediment from shrimp ponds were discharged into receiving waters, and this is the source of water for other shrimp ponds due to not separately canals between water supplying and draining at the current situation in the MKD. Hence, the pathogens from infected ponds are likely to spread to other ponds if an effluence source was not proper treatment (Anh et al. 2010; Oanh & Phuong 2012). For example, the study of Hoa et al. (2011) found white spot syndrome virus (WSSV) can be transmitted horizontally through water, via carrier organisms and/or by cannibalism of infected shrimp. The transmission from neighbouring ponds (at current crop or from previous crop) was the main route for WSSV transmission in the semi-intensive shrimp farming system.

Table 4.19. Shrimp farming: Effluent management

Items	**BTS**					**WLS**
	Intensive *(n=20)*	**Semi-intensive** *(n=60)*	**Improved-extensive** *(n=60)*	**Mangrove-shrimp** *(n=30)*	**Rice-shrimp** *(n=30)*	**Semi-intensive** *(n=30)*
Water discharge method (%)						
- Pumped	*45.00*	*28.33*	*11.67*	*10.00*	*63.33*	*100.00*
- Based on tidal cycle	*30.00*	*43.33*	*73.33*	*86.67*	*30.00*	*0*
- Both	*25.00*	*28.33*	*15.00*	*3.33*	*6.67*	*0*
Main water discharge to (%)						
*- Same as source**	*100.00*	*98.33*	*95.00*	*90.00*	*70.00*	*100.00*
- Drainage canal	*0*	*1.67*	*5.00*	*10.00*	*30.00*	*0*
Water effluent treatment (%)	*0*	*3.33*	*0*	*0*	*0*	*0*
Sediment removal freq. (%)						
*- Once during crop**	*30.00*	*6.67*	*15.00*	*13.33*	*3.33*	*0*
*- After each crop**	*70.00*	*93.33*	*85.00*	*86.67*	*96.67*	*100.00*
Sediment fate (%)						
- Add to the pond dyke	*90.00*	*100.00*	*93.33*	*93.34*	*100.00*	*0*
- Pump into own fields	*10.00*	*0*	*0*	*3.33*	*0*	*0*
- Sediment basins	*0*	*0*	*6.67*	*3.33*	*0*	*100.00*

** significant differences (p<0.05); %: percent of survey farms. Source: IFS survey (2011)*

e). Shrimp health management

✧ ***Type of shrimp disease:*** Most farms faced the problem of shrimp mortality during the production cycle, thus better management skills can help to reduce the rate of shrimp mortality. Around 55% of farms in the semi-/intensive system confirmed that their shrimp pond faced losses over the production cycle, while the rate for white-legged shrimp system was only 37% of farms. The rice-shrimp rotation system shows better production efficiency, a small number of farms suffered shrimp mortality (i.e. partial loss) throughout the production cycle. There were several causes of shrimp loss, with the main cause coming from shrimp disease problems (>75%), followed by extreme weather and seed quality. Most shrimp farms faced shrimp disease problems affecting shrimp production; however, around 65% of intensive farms faced shrimp disease and this ratio was the lower than other types of farm due to better farm management. At the time of the survey, three main shrimp diseases were common *White Spot Syndrome Virus (WSSV)*, followed by the *Yellow Head Virus (YHV)* and *Vibrosis*. Although the HiLI farms screened for pathogens of seed source, they still faced shrimp disease. The reason for this could be poor water quality.

✧ ***Shrimp disease management:*** The HiLI farms used more disease diagnostic services (≥75% of the HiLI fams) compared to the LoLI farms (≤30%). The high stocking density and investment often required more effort and technical skill, therefore the HiLI farms were more interested in shrimp health care compared to the LoLI farms with low stocking density and no feeding. There is also a clear difference on the type of diagnostic service used among the shrimp systems. The LoLI farms had to learn prevention and treatment of shrimp diseases from technical training courses while the HiLI farms focused on the use of professional diagnostic services, followed by support for disease diagnosis from chemical/drug suppliers and providers. More than 75% of the HiLI farms used chemicals for water treatment and improvement of pond bottom conditions during the production cycle. In contrast, less than 28% of the LoLI farms (excluding rice-shrimp) used chemicals for water treatment and pond preparation at the first stage of shrimp crop. Many shrimp farms in the BTS semi-/intensive and rice-shrimp systems used disinfectant for the pond preparation and sediment treatment.

Table 4.20. Shrimp farming: Shrimp health management

Items	BTS					WLS
	Intensive *(n=20)*	**Semi-intensive** *(n=60)*	**Improved -extensive** *(n=60)*	**Mangrove -shrimp** *(n=30)*	**Rice-shrimp** *(n=30)*	**Semi-intensive** *(n=30)*
Shrimp loss cause (%)	55.00	56.67	35.00	36.67	13.33	36.67
- Disease	*81.82*	*85.29*	*100.00*	*90.91*	*75.00*	*81.82*
- Extreme weather	*14.00*	*52.00*	*32.00*	*14.00*	*56.00*	*13.00*
- Water quality	*0*	*0*	*0*	*9.09*	*0*	*0*
- Poor quality PL	*0*	*2.94*	*23.81*	*9.09*	*0*	*0*
Shrimp disease occurrence (%)	65.00	96.67	80.00	90.00	86.67	90.00
- White Spot Syndrome Virus (WSSV)	*53.85*	*37.93*	*64.58*	*44.44*	*46.15*	*14.81*
- Yellow Head Virus (YHV)	*30.77*	*37.93*	*33.33*	*25.93*	*38.46*	*3.70*
- Vibrosis	*15.38*	*34.48*	*6.25*	*22.22*	*19.23*	*66.67*
Disease diagnostic service use (%)	75.00	75.00	30.00	10.00	63.33	83.33
- Diagnosis service by chemical supplier	*26.67*	*33.33*	*5.56*	*0*	*57.89*	*4.00*
- Professional diagnostic service	*46.67*	*68.89*	*0*	*33.33*	*42.11*	*96.00*
- Farm employ trained health specialist	*26.67*	*4.44*	*94.44*	*66.67*	*0*	*0*
Chemical used (%)	95.00	96.67	28.33	26.67	100.00	76.67
- Water/sediment treatment	*84.21*	*91.38*	*100.00*	*75.00*	*93.33*	*100.00*
- Disinfectant	*26.32*	*20.69*	*0*	*0*	*16.67*	*0*
Therapeutics (%)	75.00	86.67	0	0	70.00	20.00
- Antibiotics	*0*	*13.46*	-	-	*9.52*	*33.33*
- Feed supplements	*60.00*	*53.85*	-	-	*66.67*	*50.00*
- Probiotics	*33.33*	*30.77*	-	-	*14.29*	*0*

%: percent of survey farms. Source: IFS survey (2011)

Shrimp disease prevention and treatment were conducted by the HiLI system and rice-shrimp system, which had higher stocking density and feeding. Shrimp farms mainly used feed supplements such as premix and minerals adding to feed diet to enhance shrimp health, reflecting interest by shrimp farms in prevention rather than disease treatment. This study also found that 33% of WLS farms used antibiotics for shrimp disease prevention and treatment, followed by the rice-shrimp (10%) and the BTS semi-intensive system (13%). There was no case of BTS intensive system using antibiotics. This reflected a trend towards reduced use of antibiotics by the sector and increasing use of feed supplements and probiotics. Rico et al. (2013) found that semi-intensive and intensive shrimp farms in China, Thailand and Vietnam showed a decreased use of antibiotic treatments. It also shows a relatively high prevalence of probiotics used on the Vietnamese and Thailand shrimp farms.

4.4.3. Economic aspects

a). Harvesting management

The HiLI farms harvested shrimp after 4-5 months of a production cycle for black tiger shrimp culture and 3-4 months for white-legged shrimp farming; while the LoLI farms could harvest shrimp after three months and then carry out monthly stocking and harvesting for the remaining months. Due to better technical skills and management, the HiLI farms get high shrimp survival rate at harvest time compared to that in the LoLI farms *($P<0.05$)*. There were also differences in the harvested shrimp sizes; with 20-30 pieces/kg in the LoLI system and 30-40 pieces/kg in the HiLI system of black tiger shrimp and 70-100 pieces/kg in the white-legged shrimp system. Different intensification levels lead to different shrimp yields *($P<0.05$)* and the shrimp yield tended to increase from the LoLI to the HiLI system. Improved-extensive and mixed mangrove-shrimp produced less than 300kg/ha, rice-shrimp rotation reached around 1tonnes/ha, while the HiLI farms achieved yields of more than 3tonnes/ha.

Shrimp was often harvested and sold to the collectors or wholesalers, and 55% of intensive farms sold their shrimp production directly to the processors. Mixed mangrove-shrimp and improved-extensive farms were located in the remote areas, so a high proportion of shrimp harvested were sold to collectors who came directly to the farm. Thus, conducting traceability of shrimp production is not an easy task for current shrimp value chains.

Table 4.21. Shrimp farming: Harvesting and marketing

Items	BTS					WLS
	Intensive (n=20)	Semi-intensive (n=60)	Improved-extensive (n=60)	Mangrove-shrimp (n=30)	Rice-shrimp (n=30)	Semi-intensive (n=30)
Mean crop days*	140.25 ±16.34	158.77 ±21.96	175.33 ±82.27	186.67 ±88.14	153.5 ±27.99	97.67 ±29.53
Survival rate (%/SD)*	69.58 ±19.40	65.81 ±19.32	29.74 ±21.63	23.24 ±16.03	59.79 ±15.00	79.47 ±18.61
Harvest size (pcs./kg)*	41.70 ±26.25	37.2 ±25.66	30.87 ±5.17	20.57 ±4.97	36.3 ±11.77	70.60 ±17.94
Yield (tonnes/ha)*	5.52 ±4.00	3.62 ±2.48	0.25 ±0.29	0.14 ±0.12	0.99 ±0.71	7.18 ±4.71
Shrimp sold to (%)						
- *Collectors*	0	0	20.00	13.79	0	0
- *Wholesalers*	45.00	93.22	80.00	86.21	100.00	100.00
- *Processors*	55.00	6.78	0	0	0	0

** significant differences (p<0.05); %: percent of survey farms; value: mean ±std. dev. Source: IFS survey (2011)*

b). Economic efficiency

There was a large difference in economic efficiency of a production cycle among the shrimp farming system *(P<0.05)*, as presented in Table 4.22. The LoLI system had lower shrimp yield and economic performance than that in the HiLI system. The LoLI farms often harvested shrimp at a larger size with high farm gate price, and they had also an addition of income from wild shrimp/fish and crabs harvested from their ponds. The LoLI system with low stocking density, no feeding and less chemical use could be a less risky and more sustainable model, with potential for conversion to organic production certifiable by organisations such as Naturland. With a high intensity level, economic efficiency was the highest in the intensive system, followed by semi-intensive and rice-shrimp rotation system. The production cost for black tiger shrimp ranged from US$2.78-3.90/kg, and less than

US$2.72/kg for white-legged shrimp, while the farm gate price is a large ranging and dependent on the shrimp size and harvesting time.

Table 4.22. Shrimp farming: Economic efficiency

Items	BTS					WLS
	Intensive (n=20)	Semi-intensive (n=60)	Improved-extensive (n=60)	Mangrove-shrimp (n=30)	Rice-shrimp (n=30)	Semi-intensive (n=30)
Gross revenue ('000 US$/ha)*	29.09	22.47	1.63	1.07	6.29	36.51
	±20.44	±14.76	±2.19	±1.04	±6.75	±26.08
Total cost ('000 US$/ha)*	16.27	11.16	0.71	0.51	2.72	19.47
	±12.58	7.52	0.41	±0.49	±1.99	±13.74
Net return ('000 US$/ha)*	12.82	11.31	0.92	0.57	3.56	17.03
	±10.52	±8.22	±2.19	±1.12	±5.04	±13.43
*- Production cost (US$/kg)**	2.92	3.13	2.86	3.90	2.78	2.72
	±0.44	±0.44	±7.54	±9.31	±0.81	±0.32
*- Shrimp price (US$/kg)**	5.52	6.21	6.43	8.34	5.79	4.98
	±1.27	±1.43	±1.33	±1.87	±1.90	±0.91

** significant differences (p<0.05); value: mean ±std.dev., exchange rate 20800 VND/1US$. Source: IFS survey (2011)*

4.4.4. Shrimp farm certification and sustainability issues

a). Main certification issues of shrimp farms[5]

As trends in shrimp consumption increase, the requirements for product quality and food safety also become more stringent. To make an assessment of what current farming practices meet with the popular certifications, a number of standard criteria were selected for comparison these were GAA-BAP, GlobalGAP and ShAD and Naturland and are presented in Table 4.23. Comparisons between selection criteria and practices by shrimp system shows that many farms were likely to reach several standard criteria such eFCR (≤1.8 in BTS culture, and ≤1.5 in WLS culture), stocking density (≤15PL/m^2 in the LoLI system), survival rate (>25% in the LoLI system, and >60% in the HiLI system), no banned chemical/drug and wild-seed source use, community relationships, property rights,

[5]The information on the bracket presents indicators of the current farming practices

and biodiversity protection. However, there are still many standard criteria that farms could not meet such as criteria for effluent management (most farms release their waste water without any treatment and had no sediment basins), registration of farms (many farms were not legally registered), shrimp mortality management (lack of proper methods), labour arrangements (verbal contracts), farm hygiene, and recordkeeping requirements. Although to a certain extent most the standards were implemented by farms as they also have come across them through technical training courses. Current farming practices, however, still have a large distance to cover to reach the standard criteria.

To meet standard criteria, the current farms need to improve their practices and also support from local officers in terms of technical support (i.e. training courses) and management issues such as trade name registration, certify land ownership or property right. LoLI farms practicing, rice-shrimp rotation and small-scale semi-intensive farms have, limited infrastructure and operational capital reveals the larger gap deficits in meeting standard criteria than that of larger farms, mainly intensive farms greater financial and physical resources. There were several difficult standard criteria for the individual small shrimp farms such as labour conditions, business registration, farming infrastructure, storage and disposal of supplies, effluent management, microbial sanitation, shrimp disease control, and traceability requirements. Additionally, they still face financial constraints for adjustment of farm construction and certification fee. Thus, the ability of the LoLI and semi-intensive shrimp farms to get the certification difficult compared to the intensive farms. However, the LoLI farms with low stocking density and no feeding could be potential models for organic certification. The major constraints to compliance related to requirements for farm re-structuring (e.g. remove the on-farm toilet, no animal and livestock on-farms), certification fee, recordkeeping, and market demand and the premium price.

Table 4.23. Comparison of selected standard criteria and current shrimp farming practices

	Standards category and criteria[a]	Current farming practices[b]					
		Intensive *(n=20)*	**Semi-intensive** *(n=60)*	**Improved-extensive** *(n=60)*	**Mixed mangrove-shrimp** *(n=30)*	**Rice-shrimp rotation** *(n=30)*	**White-legged shrimp** *(n=30)*
I	**Aquaculture production guidelines**						
1.	Selection of site: *Farms registered as required by national legislations*[1]	85% of farms not yet registered	All farms not yet registered	All farms not yet registered	All farms not yet registered	All farms not yet registered	All farms not yet registered
2.	Feeding practices: *eFCR*[2,3] *is <=1.5 for L.vannamei and <=1.8 for P.monodon*	Commercial feed use with eFCR 1.55	Commercial feed use with eFCR 1.68	No feeding	No feeding	Commercial feed use with eFCR 1.63	Commercial feed use with eFCR 1.25
3.	Shrimp health and welfare:						
	- Employees shall be trained to provide appropriate levels of husbandry[1,2,3] *- Survival rate*[3] *(SR):unfed pond>25%; fed/non-permanently aerated pond >45%;fed/permanently aerated pond >60%.* *- Stocking density*[4] *(SD) <=15 PL/m^2/year and yield <=1.6tons/ha*	- Staffs were trained on technical skills. - SR: 70% at harvest - SD: 33.30PL/m^2 Yield: 5.52tons/ha	- Staffs were trained on technical skills. - SR: 66% at harvest - SD: 23.06PL/m^2 Yield: 3.62tons/ha	- Staffs were trained on technical skills. - SR: 30% at harvest - SD: 2.49PL/m^2 Yield: 0.25tons/ha	- Staffs were trained on technical skills. - SR: 23% at harvest . - SD: 3.12PL/m^2 Yield: 0.14tons/ha	- Staffs were trained on technical skills. - SR: 60% at harvest - SD: 7.08PL/m^2 Yield: 0.99tons/ha	- Staffs were trained on technical skills. - SR: 80% at harvest - SD: 83.67PL/m^2 Yield: 7.18tons/ha
II	**Social and legal issues**						
1.	Property right and regulatory compliance: *Farms shall comply with national laws and environmental regulations*[1,2,3]	Land owned by farms (90%) Farm managed by owner (85%)	Land owned by farms (95%) Farm managed by owner (98%)	Land owned by farms (100%) Farm managed by owner (100%)	Land owned by farms (87%) Farm managed by owner (100%)	Land owned by farms (100%) Farm managed by owner (100%)	Land owned by farms (100%) Farm managed by owner (97%)
2.	Community relations: *Farms shall not block access to natural resources used by local communities*[2,3]	Open access to use the same water sources.	Open access to use the same water sources.	Open access to use the same water sources.	Open access to use the same water sources.	Open access to use the same water sources.	Open access to use the same water sources.
3.	Forced labour: *Compliance with labour laws in the country where shrimp is produced.* *- Child labour: age of workers >=18*[1,2,3]	All farms hired labours, 15% signed contract with labours. - Non child labour	55% of farms hired labours, with verbal agreements only. - Non child labour	30% of farms hired labours, with verbal agreements only. - Non child labour use	36% of farms hired labours, with verbal agreements only. - Non child labour	33% of farms hired labours, with verbal agreements only. - Non child labour	7% of farms hired labours, with verbal agreements only. - Non child labour

4.	Employment conditions: *Farms shall comply with national labour laws to assure adequate worker safety, compensation and, where applicable, on-site living conditions. (8 hours/day; salary paid at a premium rate to the normal salary)*[2,3]	Labours with mean working hours per day was 7.34. Labour fee salary around S$96.15/pers/month	Labours with mean working hours per day was 7.38. Labour fee salary around US$96.15/pers/month	Labours with mean working hours per day was 8.00. Labour fee salary around US$96.15/pers/month	Labours with mean working hours per day was 8.00. Labour fee salary around US$96.15/pers/month	Labours with mean working hours per day was 7.00. Labour fee salary around US$96.15/pers/month	Labours with mean working hours per day was 8.00. Labour fee salary around US$96.15/pers/month
III	**Environmental management system**						
1.	Storage and disposal of supplies: *Fuel, lubricants/chemicals shall be stored, disposed safety/responsible manner*[1,2,3]	100% of farms had storage, this was large storage	100% of farms had storage, this was small area in house	Farms did not have storage	Farms did not have storage	Farms did not have storage	100% of farms had storage, this was small area in house
2.	Soil and water management: *Farm located in approved aquaculture development areas*[1,2,3]	Farm located in approved shrimp development areas	Farm located in approved shrimp development areas	Farm located in approved shrimp development areas	Farm located in approved shrimp development areas	Farm located in approved shrimp development areas	Farm located in approved shrimp development areas
3.	Effluent management:						
	- Farms shall contain sediment from ponds, canals and settling basins. *- Farms shall monitor effluents to confirm compliance with effluent quality criteria*[2]	- 90% farms moved sludge to dyke. - Waste water without treatment.	- 97% farms moved sludge to dyke. - Waste water without treatment	- 92% farms moved sludge to dyke. - Waste water without treatment	- 90% farms moved sludge to dyke. - Waste water without treatment	- 97% farms moved sludge to dyke. - Waste water without treatment	All farms moved sludge to basins - Waste water without treatment
4.	Microbial Sanitation: *Waste/animal manure shall be prevented from contaminating pond waters*[2,3]	Farms separated to house, local communities	Farms collocated with house, local communities	Farms collocated with house, local communities	Farms collocated with house, local communities	Farms collocated with house, local communities	Farms collocated with house, local communities
IV	**Food safety and chain-related issues**						
1.	Drug and chemical use: *Use veterinary medicines/chemicals approved, and not banned*[1,2,3]	Not use banned antibiotics, drugs, chemicals	Not use banned antibiotics, drugs, chemicals	Not use banned antibiotics, drugs, chemicals	Not use banned antibiotics, drugs, chemicals	Not use banned antibiotics, drugs, chemicals	Not use banned antibiotics, drugs, chemicals
2.	Post larvae sources: *Not allowance for use of wild-caught seed for grow out*[1,3]	100% seed come from hatcheries	100% seed come from hatcheries	100% seed come from hatcheries	100% seed come from hatcheries	100% seed come from hatcheries	100% seed come from hatcheries
3.	Traceability record-keeping: *logbook shall be maintained for each of specified parameters for every production unit/every production cycle*[1,2,3]	Record keeping was applied in detail and regularly, but not well organized.	Record keeping was applied, but it was not detail and not regularly	Record keeping was applied, but it was not detail and not regularly	Record keeping was applied, but it was not detail and not regularly	Record keeping was applied, but it was not detail and not regularly	Record keeping was applied, but it was not detail and not regularly

Source: (a) Information/data from [1]GlobalGAP (2011),[2]GAA (2009),[3]WWF (2011), [4]Naturland (2012); (b) IFS survey (2011)

b). Main constraints to sustainable development

There are four important factors affecting the long term development of shrimp farming perceived by the shrimp farmers (Table 4.24). Factors relating to environmental sustainability aspects include shrimp diseases, water quality and seed quality; while concerns on the economic viability relate mainly to capital/credit costs.

There was more than 65% of shrimp farms faced the shrimp disease problems, and most of them were forced to use therapeutic methods during the production cycle. Shrimp health management has tended to become increasingly complex with new diseases such as AHPNS disease in recent years as an example on the higher severity affecting the production performance. Therefore, shrimp disease is still the most important factor for sustainability and strongly affects production efficiency at the different level due to different impacts with farming systems and type of shrimp disease that occur.

Both shrimp and catfish farms have a common issue in the importance of water quality to sustainability. Water quality fluctuated and had tended to decline, many farms pointed out that the trend of chemical use was increased over the last five years. The shrimp farmers also thought that bad water quality maybe come from nutrient discharge by other industries such rice farming.

Seed quality was also perceived as an important factor driving for sustainability. At the present, shrimp mortality was still high proportion in the grow-out stage, reached 35% in the HoLI and 70% in the LoLI system, and the main cause was perceived coming from the seed quality. Moreover, due to biological characteristics, shrimp are sensitive to environmental changes, therefore water quality and extreme weather variability should be viewed as major factors affecting production efficiency.

In addition, the capital/credit cost was also addressed as a sustainability factor. Although the shrimp farms did not require high investment compared to that in the catfish farming sector (i.e. less than US$19,000 vs. US$300,000/ha/crop, respectively), many shrimp farms still faced the financial constraints, because currently farmers own saving was limited and farmers borrowed from money lenders, the state banks, and the feed traders through various types of delay payment terms. However, the shrimp farmers faced difficulties to access loan from the state bank due to outstanding debts. Meanwhile, it is also not easily access the type of delay payment term; because feed traders only accept the delay payment term if they can find evidence that the farmers will be able to pay back. Hence, financial policy should be created and improved to effectively support the shrimp industry.

Table 4.24. The major factors related to sustainable development of shrimp farming

Constraints	**Current farming practices?**	**Responses and what would it show?**	**How does it related to sustainability?**
Shrimp disease	- Shrimp disease faced (65-97%) - Therapeutics applied (0-87%): *Antibiotics used (0-33%)* *Disinfectant used (75-100%)* - Main disease: WSSV, YHV	- *Responses:* Update and improve technical skills; use of certified seed; and applied new technology for production - *Expected outcomes:* Successful harvest (less mortality and high yields); lower cost from less use of chemicals and drugs.	- *Why it is important:* Indicate better farm management, effective health management protocols - *How it related to SIs:* Effective environmental and health management, a higher biodiversity promote sustainability, and contribute to the protection of natural capital and to enhance economic performance.
Water quality	- Farms did not have sediment ponds, and 40-53% farms with feeding applied have designed settling ponds. - Water quality wasmonitored regularly. Waste water without treatment wasexchanged into public area (88-100%).	- *Responses:* Update and improve technical skills; Upgrading of farm infrastructure; applied new technology for production - *Expected outcomes:* No or low incidence of challenges to the farm from government; less negative effects to public environment; lower disease incidence and lower seed mortalities	- *Why it is important:* It indicates environmentally responsible and friendly farming; also a proxy indicator of better sector governance (i.e. zoning, planning) - *How it related to SIs:* Environmentally friendly farming; good sector management (zoning, planning); less social risks (less risk from food safety issues) and environmental risk (from pollution or contamination of the environment); improves yields.
Seed quality	- High shrimp mortality rate in the extensive farms (70-77%), SD is <7 PL/m^2; while mortality rate in intensive farms was 20-40%, SD is 23-83PL/m^2.	- *Responses:* Use of certified seed; update and improve technical skills - *Expected outcomes:* Less disease incidence; less mortality; and higher yields.	- *Why it is important:* Indication of good risk management practice. - *How it related to SIs:* Farmers' widespread use encourages seed producers to adopt seed certification standards. This improves overall productivity and sustainability of farming.
Capital & credit costs	- Total cost for a production cycle in the intensive farms was US$11,000-19,000/ha, of which 50% came from loan sources. The LoLI farms used their own budget with < US$3,000/ha. - Input cost has increased yearly at 10%, while shrimp faced disease so many farm lost their production and profit.	- *Responses:* Improve the policy on the financial supports and farm management to save cost of inputs; and strong linkages of operation. - *Expected outcomes:* High repayment rates, low default rates, low incidence of indebtedness, and better economic viability	- *Why it is important:* It indicates profitability of the farm and the farmers' management ability. - *How it related to SIs:* Credit sources don't impose onerous terms; production loans are invested wisely; or enterprise is profitable to enable farmers to avoid heavy indebtedness that could force them to abandon or sell the farm. It gives resilience to the farm household against economic shocks, which improves human capital.

Source: IFSsurvey (2011)

4.5. Discussion and conclusions

4.5.1. Factors driving the farm category

Striped catfish farming can be classified under three farm scales (small, medium and large). Previous studies used farm-size exclusively to classify farm category, i.e. small-farm ≤0.5ha and large-scale farms ≥1.5ha/farms (Khiem et al. 2010; Belton et al. 2011; Bush & Belton 2012; Trifković 2013; Hansen & Trifković 2014). Farm-size alone did not provide fully an actual picture of existing catfish farming that is more complex in term of business ownership and management regime. Belton et al. (2011) used five criteria to classify catfish farm category, including market orientation, production intensity, farm size, ownership and labour, and organization of production. However, the criteria of market orientation and intensity level are not necessary as, all striped catfish are farmed under a high intensive system and almost all are produced principally for export. The criteria of farm-size, business ownership and organization of production showed clear differences among three types of farms. Small-farms were typically owned and operated by the family, while large-farms were owned and operated by the corporate enterprises and medium-farms were in the middle (Belton et al. 2011; Belton & Little 2011; Bush & Belton 2012). Labour source was also an important factor for farm category, large-farms were highly dependent on hired, full-time labour and managed by salaried managers, while small-farms were mainly managed by family members (Belton et al. 2011; Belton & Little 2011). However, we found that 65% of small-farms also used full-time salaried permanent labours, with an average 1-2 labourers/farm (Table 4.4). Other reports also showed that Asian aquaculture in general is by and large a small-scale farming activity, where most practices are family-owned, managed and operated, and use a large percentage of family labours (Siar & Sajise 2009; Bueno 2009; Melba G. Bondad-Reantaso et al. 2009; De Silva & Davy 2009a; Belton & Little 2011).

By way of contrast, shrimp is farmed in the MKD under very different systems (i.e. from more extensive to more intensive systems), with significant distinct investment levels compared to the catfish farming sector (i.e. only farmed in the intensive system). Hence, a simple 'scale definition' like catfish farm category is not appropriate because of heterogeneity of farming systems. Previous studies classified shrimp farms into the farming system based on pond-size, seed source and stocking density, feed use, water exchange level, and shrimp yield (Primavera 1998; Nhuong et al. 2003; Nguyen et al. 2009; Anh et al. 2010a; Ha et al. 2012; Tran et al. 2013). Bush et al. (2010b; 2010a) contend that shrimp industry can be classified under two competing scenarios for sustainable development, including the small-scale landscape integrated farmers and industrial-scale closed system. The reality in the MKD is a more complex, with a range of heterogeneous farming systems that defy such as simple dichotomy in the MKD. Because of the highly diverse system, based on the results of previous studies (Nguyen et al. 2009; VIFEP 2009b), we modified and classified shrimp farms under six types of shrimp system (Table 4.2), and main factors used for classification based on technical characteristics. Shrimp farming methods categorized as improved-extensive, semi-intensive and intensive systems. The essential features differentiating production systems along the extensive to intensive are additional seed stocking, feeding and water management. This study also used the same criteria as previous studies, and added three more important factors that are method of water management, seed quality control and management regime. Shrimp farming systems classified in this study do not fit neatly into Bush et al. (2010a; 2010b) dichotomy and most shrimp is raised in neither typical landscape (mangrove) nor biosecure (intensive) but rather systems that have features of neither/both.

Intensive farms mainly industrial-scale producers owned and operated by aquaculture Ltd. companies; their farms often managed by salaried managers and heavily depended on full-time labours (Nguyen et al. 2009; Bush et al. 2010b; Bush et al. 2010a; Belton & Little 2011). Intensive farms applied a closed system approach and the biosecure models that used only ‘top-up water’ method for water exchange; PCR test for post-larvae source, aeration system and this system could fit in the biosecure category described by Bush et al. (2010b). Similar to intensive farm, semi-intensive farms and rice-shrimp farms also applied closed system for shrimp ponds; however, rice-shrimp farms did not use aerators or purchase PCR tested PLs. Semi-intensive and rice-shrimp systems were mainly operated by households and mostly managed by family labour. In contrast, the mixed mangrove-shrimp and improved-extensive were open systems relying on ‘tidal water exchange’; used non-screened PLs in addition to naturally recruited seed and no feeding. They are operated by households and mostly depended on family labour (Nguyen et al. 2009; Bush et al. 2010b; Bush et al. 2010a; Belton & Little 2011). Generally, most shrimp farms, excluding intensive systems in the MKD were small-scale producers farming, small water area per farm (less than 1,5ha). Other studies in Asia found that shrimp farming sector essentially consists of small-scale owner-managed and operated practices in several Asian countries with average farm-size ≤1.6ha (Kongkeo 1997; Primavera 1998; Umesh 2007; Umesh et al. 2009; Kongkeo & Davy 2009).

4.5.2. Factors driving different farming practices

- **Factors driving different catfish farming practices by farm scale**

Analysis of the current practices of catfish farming in the MKD shows that small catfish farms had relatively poor farm infrastructure characterised by small and shallow ponds, incomplete water supply system and lack of feed storage facilities compared to that in the large-farms. Normally, small-farms had 1-2 ponds mainly used for grow-out, while larger farms reserved area for sediment basins and other facilities such as feed storage. Khoi (2011) found that most small-farmers lack land for waste water treatment ponds because the majority of their land has been converted into grow-out ponds. With a limited number of ponds, small-farms also have to apply “simple batch production” stocking method, thus the small-farms often faced problems with low fish price during the oversupply period. In contrast, larger farms could be more flexible and use “multiple batch production” where both stocking and harvest times can be staggered to reduce being impacted by temporal declines in farm gate price. Belton et al. (2009) came to the same conclusion in their study, noting the importance in capacity for flexible fish harvesting being important to maintaining viability over time.

Different feed practices were also key aspects differentiating pangasius farms by scale. Use of farm-made feeds was much more common among small and medium farms than large-farms. Sustainability perceptions suggest that small and medium farmers are more motivated by economic sustainability than environmental so this is no surprise. Generally, catfish farms of all scales tended to use commercial feed for better performance and convenience. Although, use of farm-made feeds remains more cost effective than commercial feed (Phan et al. 2009; Bush & Belton 2012; Ali et al. 2012), many small-/medium farms shifted to use commercial feed compared to the previous surveys in 2008 of Phan et al. (2009) and in 2009 of Da et al. (2013). The main reason for this trend were linked to pressure from processors who prefer to buy fish produced using commercial feed

(Khoi 2011). When using farm-made feed, culture period are also up to 4-6 weeks longer than when commercial feed are used (Phan et al. 2009), while the farms paid more attention to the turnover of investment and cost efficiency due to high interest rates and short time of loans. In addition, the lack of raw materials, especially fishmeal or trash fish for feed ingredients was also a driving force for changing trends (Nguyen et al. 2009; Tuan et al. 2013). The master plan of catfish sector development up to 2020 also motivated the catfish farms using the commercial feed instead of farm-made feed to reduce the constraint of feed ingredients and environmental impact (VIFEP 2009a). The environmental impacts are reduced by using commercial feeds with a lower FCR (Boyd & Michael 1996; Cripps & Bergheim 2000; Lin & Yi 2003; Bosma et al. 2011).

High amount of feed use and dense stocking density required careful water quality management (Phuong et al. 2009; De Silva & Nguyen 2011). With high stocking density and feeding, most farms exchange water daily, and effluent water is not treated and could be a potential pollution source for surface water of the Mekong river in the long run (Khoi 2011; Cao et al. 2010; Truong et al. 2011). Comparing inlet and outlet water parameters shows that values of DO and TSS are lower and the BOD and COD are higher value in the outlet water (Phuong et al. 2008). However, these four water quality parameters in outlet water do not exceed these Vietnamese standard for surface water quality/TCNVN 5942-1995 (i.e. DO 6.8mg/L, BOD 4.8mg/L, COD 9.0mg/L and TSS 46.1mg/L in outlet water compared to >2mg/L, <25mg/L, <35mg/L and <80mg/L on maximum residue limits of TCNNVN 5942-1995, respectively), catfish farming has been characterised as 'non-polluting' (Phuong et al. 2009; Anh et al. 2010a; De Silva et al. 2010). Anh et al. (2010b) reported that pangasius production accounted for less than 1% of the total suspended solids (TSS), nitrogen and phosphorus loads in the MKD and contributed relatively little to the overall nutrient discharge into the river. Additionally, the relatively high effluent water quality associated with the design of very deep ponds that essentially 'treat' water suggests that they are acting as sedimentation ponds for waste feed and faeces; and hence requirement to remove sludge 2-3 times per cycle. This was a farmer innovation based on better growth and returns from fish raised in deeper ponds. Phan et al. (2009) noted that there was a positive relationship between the water depth and fish yield in case of the same stocking density and feed use. This reflects the farmers perception of sustainability being geared towards economics in this case being complementary to environemental sustainability.

There was no significant difference in the productivity among farm scales, which is partly explained by the similar level of intensification applied by all catfish farms. Nguyen & Dang (2009) observed that the exceptionally high productivity of striped catfish culture can be related to the biological features of this air-breathing species but the development of simple methods for maintaining water quality deep ponds, high water exchange, similar reliance on the same formulated diets and regular, manual in solids removal that have few economies of scale also explain the lack of difference between smaller and larger enterprises. However such densely stocked 'open' systems, often located in close proximity to other similar enterprises, increases vulnerability to disease (Phan et al. 2009; Khoi 2011; Truc 2013). In this respect striped catfish is not unlike cage farming, for which consequences of a lack of a zonal approach to planning have been painful lessons as demonstrated by the Atlantic salmon in Chile (Kvaløy & Tveterås 2008; Gildemeister 2012). Striped catfish relies on relatively large amounts of chemical inputs (Rico et al. 2012; Rico et al. 2013). Rico et al. (2013) noted that the use of antibiotic treatments was significantly higher in the Vietnamese pangasius farms compared to other farmed species in Thailand, China and Bangladesh. However, total quantities of antibiotics applied by the pangasius farmers were comparable or lower than those reported for other animal production commodities. The same authors suggest that the main alternative to extensive antibiotic use could be the introduction of vaccines, as already done in the European salmon industry (Gildemeister 2012; Rico et al. 2013).

- **Factors driving different shrimp farming practices by farm system**

Shrimp farming practices are highly differentiated from the perspective of stocking density, water management, shrimp health management, and feed management etc. compared to the catfish farming practices. Large areas of shrimp farm could be characterised as improved-extensive system, and shrimp farms are mostly owned and operated by families (Nguyen et al. 2009; VIFEP 2009b; Tran et al. 2013). Shrimp farming practices were very different between shrimp systems, including preparation of the culture unit, stocking density, water exchange and feeding regimes, and resultant productivity. Due to the closed system approach, pond preparation (e.g. water storage and water treatment) was carried-out by most intensive, semi-intensive and rice-shrimp farms. Whereas, with large pond size and open system application, around 30% of mangrove-shrimp and improved-extensive farms conducted the pond preparation. Indicators of the position of a given system within the landscape to biosecure continuum (Bush et al. 2010b) include the use of juveniles screened for disease. The HiLI farms (semi-intensive and intensive) tended to purchase post-larvae directly from hatcheries that screened for pathogens; whereas, LoLI farms mainly purchased post-larvae through traders without the PCR test and of unknown provenance (Tran et al. 2013). Unscreened post-larvae were recognised as a major factor in the high shrimp mortalities of LoLI farm; once introduced such pathogens would endure and their impacts exacerbated by multiple stocking, extended harvest practiced in large, extensive systems. The pathogens from infected ponds are likely to spread to other ponds if an effluence source was not proper treatment (Anh et al. 2010; Oanh & Phuong 2012). For example, the study of Hoa et al. (2011) found that white spot syndrome virus (WSSV) can be transmitted horizontally through water, via carrier organisms and/or by cannibalism of infected shrimp. The transmission from neighbouring ponds (at current crop or from previous crop) was the main route for WSSV transmission in the semi-intensive shrimp farming.

The HiLI shrimp systems paid more attention to reducing risks associated with poor water quality and shrimp disease from the environment. Semi-intensive and intensive farming, based on higher stocking densities, and fundamentally more reliant on good water and seed quality to reduce the risk of disease (Primavera 1998; Anh et al. 2010a; Bush et al. 2010a; Bush et al. 2010b; Ha et al. 2013; Tran et al. 2013). Most HiLI shrimp farms have applied limited water exchange methods for shrimp ponds. The "top-up water to make good losses only" method was mostly applied by the HiLI farms, and water exchange was not regular but based on the manager's experience of water colour, and new water sources came mainly from the settling ponds or farm's water supply canal. In contrast, LoLI farms mainly applied the "partial drainage & water replacement" method, and water exchange was mainly based on the tidal regime. Most farms reported that waste-water was not treated, but drained directly into rivers or canals that are the same as the supply source. Discharge of untreated waste water, especially during shrimp disease outbreaks, may be a cause of the spread of diseases that affect farm production efficiency. Shrimp diseases are often caused by polluted water in the pond itself, and the bad water quality such as high BOD and COD concentrations is a favorable condition for pathogenic microorganisms (Anh et al. 2010a; Oanh & Phuong 2012). Anh et al. (2010a) indicated that most of the waste water and contaminated sediment from shrimp ponds is discharged into receiving waters, and this is the source of water for other shrimp ponds due to not separately canals between water supplying and draining at the current situation in the MKD (Nguyen et al. 2009).

4.5.3. Farming practices - the risk profiles affect

The comparison of farming practices between striped catfish and shrimp sectors seems to point to two distinct outcomes. On the one hand, this study states that there is no relationship between striped catfish farm scale and fish productivity and economic efficiency. This in turn supports a social relations hypothesis for explaining why smallholders are unable to keep up – social relations that control access to credit, and material constraints to accessing land for sedimentation. On the other hand, the analysis of shrimp farming practices outlines the persistence of a widevariety of systems with very different risk profiles – and again a dependence on social relations that provide access (or not) to the credit and resources necessary for upgrading production. Additionally, a comparison on the key risk profiles between striped catfish and shrimp farms showed that there were differences on the risks between smaller and larger farms for both these species, smaller farms often faced higher level of operational risks compared to larger farms (Table 4.25). Striped catfish farms, especially small and medium-farms, faced higher risks in securing capital/credit), maintaining fish quality, and markets (i.e. fish farm gate price, unstable marketd, and lack of market information) compared to the shrimp farms; however, technical skills of catfish farmers were higher than shrimp farmers, and fish yields were more stable. Other risk factors appeared to have a similar level of influence on both species; with smaller farms being more vulnerable than the larger operations, reflecting the numerous challenges, constraints and risks that small-scale producers of both species face participating in global value chains.

Table 4.25. Risk profiles: Comparison between striped catfish and shrimp farming

Risk profiles	Catfish farms		Shrimp farms	
	Small/medium	**Large**	**LoLI**	**HiLI**
- Infrastructure: *limitation on land area for reservoir and sediment ponds*	✓✓✓	✓	✓✓✓	✓
- Seed quality: *high fish/shrimp mortality, and limited control of seed quality*	✓✓✓	✓✓	✓✓✓	✓
- Animal disease: *increasing disease severity and incidence*	✓✓	✓	✓	✓✓
- Water quality*: limited control of water supplying and effluent treatment*	✓✓✓	✓✓	✓✓✓	✓
- Capital & credit cost: *lack of operational finance, and high input cost*	✓✓✓	✓	✓	✓
- Product quality: *unstable fish/shrimp quality*	✓✓✓	✓✓	✓	✓
- Operation linkages: *limited linkages with other actors*	✓✓✓	✓	✓✓✓	✓
- Market issues: *unstable farm gate price, unstable markets; and market information*	✓✓✓	✓	✓	✓
- Technical issues: *limited technical skills, and unstable production*	✓	✓	✓✓✓	✓✓

Impact level: (✓) less influence; (✓✓) moderate influence; (✓✓✓) high influence. Source: IFS (2011)

Khoi (2011) highlighted five constraints for inclusion of smallholders in global value chains: i) stringent food quality standards in global markets: food safety and product quality (Dey & Ahmed 2005; Oosterveer 2006; Subasinghe et al. 2009; Belton 2010; Khiem et al. 2010; Belton et al. 2011; Pham et al. 2011; Haugen et al. 2013), and high costs of compliance with food quality (Siar & Sajise 2009; Washington & Ababouch 2011; Tran et al. 2013); ii) production technology knowledge: lack of access to technological innovations (Umesh et al. 2009; Kelling et al. 2010; Mohan 2013; Ponte et al. 2014; Jespersen et al. 2014), and lack of quality control at farm gate (Ruben et al. 2007; Francesconi 2009); iii) market information: asymmetric information from buyers (Segura 2006; Kambewa 2007; Umesh et al. 2009; Khoi 2011), and insufficient access to market information due to high transaction costs (Page & Slater 2003; Kariuki 2006; Bijman 2007); iv) diseconomies of scale: small-scale of production, small plots of land (Kariuki 2006; Ruben et al. 2007; Umesh et al. 2009), poorly developed rural infrastructure (Page & Slater 2003; Reardon & Timmer 2006; Sriwichailamphan 2007; Kambewa 2007; Ruben et al. 2007; Henson et al. 2008), and low investment in advanced technology (Ruben et al. 2007; Kariuki 2006); and v) access to credit: lack of access to credit for production inputs (Segura 2006; Kambewa 2007; Umesh et al. 2009), and banks and buying firms large scale transactions (Key & Runsten 1999; Dannson 2004; Henson et al. 2008). Khoi (2011) also indicated that these constraints for smallholder inclusion are related to the GVC governance forms developed by Gereffi et al. (2005), the 'captive' and the 'relational' governance types are the most relevant for understanding the relationships between importers-exporters and smallholders. Increasing quality standards and the lack of market information make 'market' governance less effective. Jespersen et al. (2014) noted that hierarchy, relational, captive and market forms of coordination are all present simultaneously in the Vietnamese pangasius value chain, though the trend is towards hierarchical forms as the industry consolidates. The 'modular' governance form will become possible in the future if Vietnam producers manages to resolve the problems related to technology and production knowledge (Khoi 2011).

4.5.4. Farming practices: challenges to reach food standards

Consumers are increasingly concerned about the environmental and social impacts of food production in developing countries (Oosterveer 2006; Corsin et al. 2007; Bush & Oosterveer 2007; Bush 2008; Brunori et al. 2011; Belton & Bush 2014; Jespersen et al. 2014). Additionally, consumers are interested in the process through which a product travels and it's process-oriented quality (Corsin et al. 2007; Reilly 2007; Yamprayoon & Sukhumparnich 2010; Brunori et al. 2011; Young et al. 2011). Hence, food certification has been identified as an easy way of demonstrating sustainability (Bush & Oosterveer 2007; Bush et al. 2010b; Bush & Oosterveer 2012b; Young et al. 2011; Kelling 2012; Mohan 2013). Catfish and shrimp are target-farmed species for Vietnamese seafood export, have begun to move towards meeting various food standards to maintain access to these markets as such private governance becomes the norm. Bush et al. (2010) noted that farmers have to respond to food quality and safety standards to gain or maintain their position in export markets. Many catfish and shrimp farms have been able to meet several of the standard criteria such eFCR, stocking density, no use of banned chemical/drug and wild-seed source uses, positive community relations, valid property rights, and biodiversity protection. However, there remain many standard criteria that could not be easily met by farms such as those for effluent management, registration of farms, limiting fishmeal use in diets, mortality management, labour arrangements, farm hygiene, and recordkeeping requirements. To cope with the increasing requirements on food safety, quality and sustainability of seafood production, current farms both species have to improve. Additionally, they also needed support from local officers who can give technical supports (i.e. training courses) and management issues such as trade name registration, certify land ownership or property rights. Reilly (2007) noted that the focus of new regulations from the markets is from farm-to-fork and places the responsibility for marketing safe food with the producers. General principles of food hygiene legislation now extend to all operations involved in the primary production of food (Reilly 2007; Washington & Ababouch 2011; Tran et al. 2013), so these could be viewed as a trade barrier (Reilly 2007; De Silva & Nguyen 2011; Tran et al. 2013). However, Dalsgaard et al. (2013) found that the bacterial microflora on pangasius in frozen fillets reaching Europe was not related to any contamination in the fish pond, but rather at the processor level. Seafood producing countries should overcome challenges by continuously improving the whole production chain and to achieve sustainability of the seafood industry food standards must be promoted and practiced by farmers (Reilly 2007; Bush et al. 2010; Bush & Belton 2012). Although food standards paid more concern to the primary production at the farm level, fraud in the value chain is often not associated with farmers but rather intermediaries such as secondary processors where illegal/poor practices such as lack of knowledge of food hygiene and safety, use of polyphosphates and over-glazing are common place (Fisheries Directorate 2012; Vu et al. 2013; VASEP 2014a). Generally, farmers often face the compliance constraints when they try to apply the food standard; because farmers had lack of proper knowledge and awareness, poor access to information on requirements, lack of expertise and trained people to examine compliance requirements, lack of technological capacity and weak implementation and monitoring capacity (Kelling et al. 2010; Mohan 2013; Ponte et al. 2014; Jespersen et al. 2014). Washington & Ababouch (2011) suggested that farms follow the national standards as the foundation to achieve sustainable production, making it easier to meet the additional criteria from private standards and certification (Nietes-Satapornvanit 2014). Moreover, the certification schemes should be integrated with other governance mechanisms and public rulings, including local standards that are already in place, making use of the existing local expertise (Bush et al. 2013). Although farm-level certification contributes to sustainable seafood trading, is still beset with significant limits such as measuring the impacts of the external environment on the farms (Allsopp et al. 2008; Bush & Belton 2012; Bush et al. 2013; Han & Immink 2013).

4.5.5. Farm upgrading - the key barriers to upgrading

Striped catfish and shrimp are the target farmed seafood species for exporting, and thus the increasing pressure from the international seafood markets such as the EU, US and Japan markets related to food safety and sustainability of farmed seafood has prompted value chain upgrading that can contribute to reducing environmental, social and economic risks. (Khiem et al. 2010; Pham et al. 2011; Jespersen et al. 2014; Ponte et al. 2014). However, this study showed that both catfish and shrimp producers have faced several major barriers that influence to their capacity for upgrading (Table 4.26). Smaller farms have to cope with higher level of these barriers for upgrading compared to the larger farms on both these species. The shrimp farms, especially the LoLI systems, faced higher influence level of barriers on the process upgrading (i.e. limited improvement of seed quality, disease management); the functional upgrading (i.e. limited improvement of increasing yield through management practices or use of new technology, and limited horizontal contractualisation to group formation leading to changed provisioning production and trade practices); and the inter-chain upgrading (i.e. limited expansion with existing product categories, and limited certification skills acquired in monitoring and evaluating national regulation on food safety are transferable to forthcoming international food standards). In contrast, the striped catfish farms have to cope seriously with the product upgrading (i.e. limited improvement of product quality and product size) and the process upgrading (i.e. limited improvement of input management). Both these species sectors, especially small farms faced the same influence level of barriers to the process upgrading (i.e. limited improvement of water quality), the product upgrading (i.e. guarantee on the absence of chemical residues) and the functional upgrading (i.e. limited vertical contractualisation: contract with other actors to change in provisioning practices of feed, seed; and in selling their products). Ponte et al. (2014) presented the upgrading strategies for the seafood farm-level in Asia including improve process, improve product, improve volume and improve variety. The same authors noted that the barriers to upgrading at the farm-level include lack of explicit economic incentives (e.g. improved market access or increased price), limited access to capital to invest in improved management practices, and lack of appropriate skills for smallholders. Additionally, the other barriers may be come from the economic risks associated with market volatility and quality regulation (Bush & Belton 2012; Ponte et al. 2014).

Table 4.26. Barriers to upgrading[6]: Comparison between striped catfish and shrimp farming

Key barriers	Catfish farms		Shrimp farms	
	Small/medium	Large	LoLI	HiLI
i) *Process upgrading* - improvement of management practices:				
- Limited improvement of water quality	✓✓✓	✓	✓✓✓	✓
- Limited improvement of seed quality	✓✓	✓	✓✓✓	✓
- Limited improvement of disease management	✓✓	✓	✓✓✓	✓
- Limited improvement of input management	✓✓	✓	✓	✓
ii) *Product upgrading* - improvement of product quality and safety:				
- Limited improvement of product quality	✓✓✓	✓	✓	✓
- Limited improvement of product size	✓✓	✓	✓	✓
- Absence of chemical residues	✓✓	✓	✓✓	✓
iii) *Functional upgrading* - improvement of volume:				
- Limited improvement of increasing yield through management practices or use of new technology	✓✓	✓	✓✓✓	✓
- Limited horizontal contractualisation: group formation leads to changed provisioning production practices	✓✓	✓	✓✓✓	✓
- Limited vertical contractualisation: contract with other actors to change in provisioning practices of feed, seed; and in selling their products	✓✓✓	✓	✓✓✓	✓
iv) *Inter-chain upgrading* - improvement of variety:				
- Limited expansion with existing product categories	✓✓	✓	✓✓✓	✓✓
- Limited certification skills acquired in monitoring and evaluating national regulation on food safety are transferable to forthcoming international food standards	✓✓	✓	✓✓✓	✓

Impact level: (✓) less influence; (✓✓) moderate influence; (✓✓✓) high influence. Source: IFS (2011)

Both striped catfish and shrimp farm faced currently the financial constraints (lack of operational finance) and constraints on access to credit (limited access to credit, or lack of access to credit for production inputs) that have been also cited as important barriers for upgrading. To implement four upgrading strategies, both striped catfish and shrimp sectors need finance for investment. For instance, the functional and inter-chain upgrading are implemented through application of ASC standards at the farm-level. The cost associated with these upgrading types are certification fee (US$4,500-6,000), annual fee (US$1,000-

[6] A typology of upgrading based on four categories (Humphrey & Schmitz 2002; Bolwig et al. 2010; Ponte et al. 2014): *i) process* upgrading: achieving a more efficient transformation of inputs into outputs through the reorganization of productive activities; ii) *product* upgrading: moving into more sophisticated products with increased unit value; iii) *functional* upgrading: acquiring new functions (or abandoning old ones) that increase the skill content of activities; and iv) *inter-chain* upgrading: applying competences acquired in one function of a chain and using them in a different sector/chain.

2,000) (Nguyen 2012; Haugen et al. 2013), cost of consultants (US$10,000-15,000) for technical supports, cost for farm re-structuring and cost for water/effluent parameters monitoring (Fisheries Directorate 2014). Consequently, the production cost for ASC application was 8.96% higher than the uncertified production (Tuan 2013). Even though the producers bear high costs of investment in standards, application of ASC standards to striped catfish farms increased productivity by 15% (Corsin 2013) and shrimp farms certified by GAA-BAP achieved better production efficiency (Lam & Truong 2010). Additionally, the ASC certified catfish farms can receive 5% premium price (Corsin 2013), and shrimp farms certified by GAA-BAP received an 11% premium price (Lam & Truong 2010). However, application of food standards at the farm-level is inhibited by financial constraints, as the costs of farm upgrading and certification are high and tend to exclude the weak farms (e.g. small-producers) from the export supply chain (Dey & Ahmed 2005; Oosterveer 2006; Subasinghe et al. 2009; Belton 2010; Khiem et al. 2010; Belton et al. 2011; Pham et al. 2011; Haugen et al. 2013).

CHAPTER 5

Understanding transition in striped catfish and shrimp farming in the Mekong Delta

5.1. Introduction

Striped catfish and shrimp culture play an important role in producing raw materials for the processing sector and thus both of the species have been highlighted for future development (Nguyen et al. 2009; Fisheries Directorate 2013b). Sustainable development of these species was placed at the core of the master plans until 2020 (MARD 2009b; GOV 2013) aiming to create long-term secure employment and ensure an environmentally sound industry, as well as ensuring economic viability (Sheriff 2004; Focardi et al. 2005; Bueno 2009; Costa-Pierce et al. 2011). Setthasakko (2007) indicated that the lack of a long-term view of sustainability issues and a system perspective were major barriers to the creation of corporate sustainability. Assessment of a farm's sustainability could provide primary and essential factors to drive forward sustainable development, and it helps to develop strategies to support long-term development of the aquaculture sector.

Grow-out farmers play an important role in the value chain, but they are also the most vulnerable actors, especially small-scale farmers (Bush et al. 2010; Le et al. 2011; Khoi 2011; Tran et al. 2013). Rapid changes in the catfish sector have been characterized by a decline in the number of small-scale farmers (De Silva & Nguyen 2011; Trifković 2013) and changes in farm design and management (Phan et al. 2009; De Silva & Nguyen 2011; Trifković 2013). Understanding of such changes and those affecting shrimp farms due to disease have often been compromised by studies being limited to single observations or 'snapshots' rather than any multiple sampling over time (VIFEP 2009b; DoAH 2012; Fisheries Directorate 2013b). Studies that chronical change in practice over time and interpret the drivers of change, remain limited. Hence, this chapter assesses general development trends of the two main farmed species and the main changes in farming practices over the three years between the integrated farm survey in 2010 and a telephone survey of the same respondents in 2013. The study also aims to describe and explain underlying reasons for the transitions in striped catfish and shrimp value chain focussed primarily on the farming sector. It also provides an assessment of major driving forces of these changes and which are related to sustainability issues.

5.2. General information on the telephone farm surveys

Of the 212 catfish farms included in the telephone survey (TLS), 131 responded, accounting for 62% of the integrated catfish farm survey (IFS) respondent base. Small-farms contributed the highest response-rate accounting for 77 % of the IFS small-farms, followed by the medium farms and large farms at 56% and 41%, respectively. There were many explanations for non-response from catfish farms, however, no significant difference between farm scale was observed. With the small-farm group, the main reason was an inactive mobile phones due to the high promotion of cheap mobile SIM-card programmes in Vietnam. This was followed by incorrect phone numbers and no phone number *($P<0.05$)*. For the medium-farms a change in telephone number was the main reason for non-response (32%), followed by no phone number collected and job changes of the last respondents; while respondents no longer employed by the IFS farm was the main reason for non-response of the large-farms group *($P<0.05$)*, followed by no contact phone number and mobile phone no longer active (Figure 5.1). Therefore, the analysis in the following sections is based on data from 131 catfish farms all of whom responded to the TLS, and 22 responses from catfish farms using the in-depth survey (IDS: face to face interviews) and data from the key informant interviews of other actors along value chains.

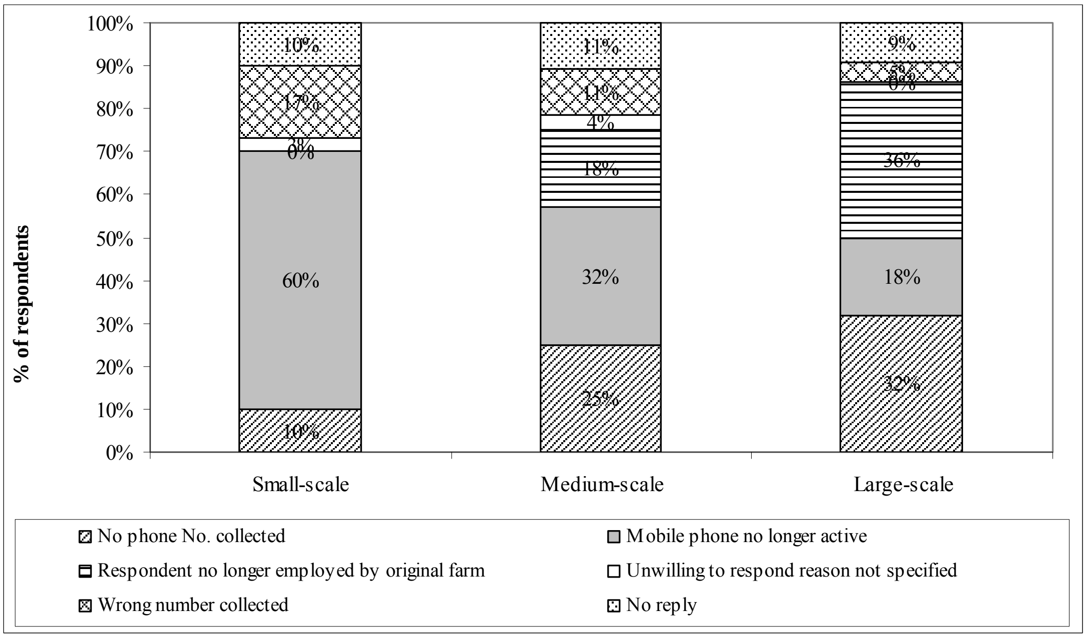


Figure 5.1. Reasons for non-response to TLS by striped catfish enterprise scale
Source: TLS of catfish farms (2012)

Telephone interviews collected information from 189 of 230 integrated shrimp farm surveys in 2010, equating to 82% of the IFS shrimp farms. The response-rate of rice-shrimp rotation farms was the highest (around 90% of IFS rice-shrimp farms) and the lowest rate was from the intensive shrimp farms (70%). There were three main reasons for non-response: no phone number collected, the mobile phone number was no longer active and no reply. There was a difference between the shrimp farm groups related to the cause of non-response *(P<0.05)*, and no phone number collected was the main reason from the low level investment shrimp farmers (LoLI); while for the high level investment shrimp system (HiLI) the main reason was no reply was such farmers tended not to answer calls on their mobile phones from unfamiliar numbers (Figure 5.2). Thus, the analysis in the following sections is based on data from 189 shrimp farms that took part in the TLS, 30 shrimp farms from the in-depth survey (IDS: face to face interviews) and data from key informant interviews of other actors along value chains.

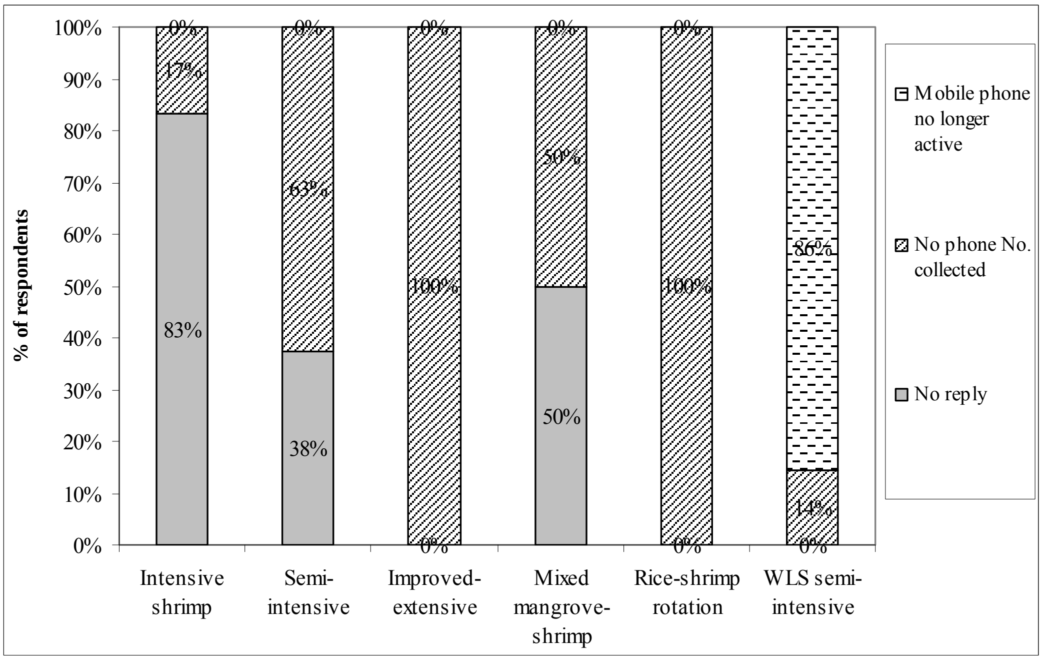


Figure 5.2. Reasons for non-response to telephone interview by shrimp farmers by system

Source: TLS of shrimp farms (2012)

Overall, shrimp farmers had a more stable career than the catfish farmers and fewer job changes because they lived in the coastal and remote areas with very few options for other economic activities, and most of their land area was mainly used for shrimp farming.

5.3. Transitions in striped catfish farming practices

5.3.1. General development trends of striped catfish farming

a). Farm type movements

Striped catfish culture began with the small-farms in terms of pond area and number of farms, and most farms were owned and operated by families (Phan et al. 2009). In 2009, there were 5,393 *tra* catfish grow-out farms, of which 82% had holdings ranging in size ≤1.0ha, and followed by a much smaller group with holdings between 1.0-5.0ha (15%) and a very small group of farm-size ≥5.0ha (3%) (Murray et al. 2011; Phan et al. 2011). However, there has been an increase in large-scale farms (Phan et al. 2009; De Silva & Nguyen 2011; Bosma & Verdegem 2011; Trifković

2013), which were mostly owned and operated by seafood processors; a trend was encouraged by the MARD (GOV 2009; De Silva & Nguyen 2011). The Decision No.2033/QD-TTg (GOV 2009) approved the master plan for the striped catfish development until 2020; it encourages the investment from the private sector to produce striped catfish on a large scale, vertically integrated basis in order to ensure stable raw materials in terms of quantity and quality. In contrast, the number of small-scale farms has decreased due to many factors, including a drop in farm gate price leading to economic losses and an inability to increase investment (De Silva & Nguyen 2011; Trifković 2013). Statistics on catfish production in the two representative provinces of An Giang the centre of traditional catfish farming located in an upstream location and Vinh Long located in the middle-area. New emergent catfish farming development showed rapid growth in area up to 2007 in An Giang and up to 2009 in Vinh Long. In contrast, the production continued to increase slowly in Vinh Long after this time, in An Giang production levels were erratic in recent years (Figure 5.3).

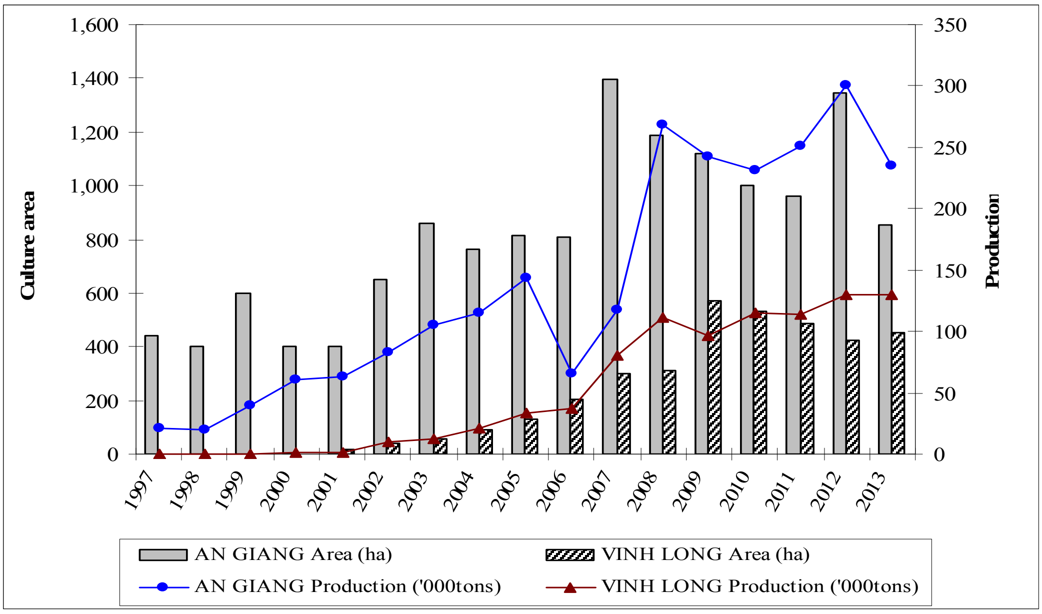


Figure 5.3. Trendlines of striped catfish farming growth in An Giang and Vinh Long

Source: An Giang DoF (2012) & Vinh Long DoF (2012)

This generalized picture obscures the consolidation that has been ongoing indicated by a significant change in the structure and distribution of catfish farms. Both provinces showed a rapid decline in small farm numbers (holdings <1ha of farm-size); whereas, larger catfish farms showed little change or increased (Figure 5.4). The reasons for the increasing trend of small-farms leaving the catfish sector has become clear in recent years and was due to fluctuating fish prices and generally lower farm gate price compared to the production costs leading to high risk for small-farms. The tight regulation of lending during the economic crisis also contributed to the decline through difficulties to access loans. Catfish farms with limited financial resource were gradually excluded from the catfish value chain, the situation in An Giang and Vinh Long shows a clear example where small-farms have to leave the catfish industry recently.

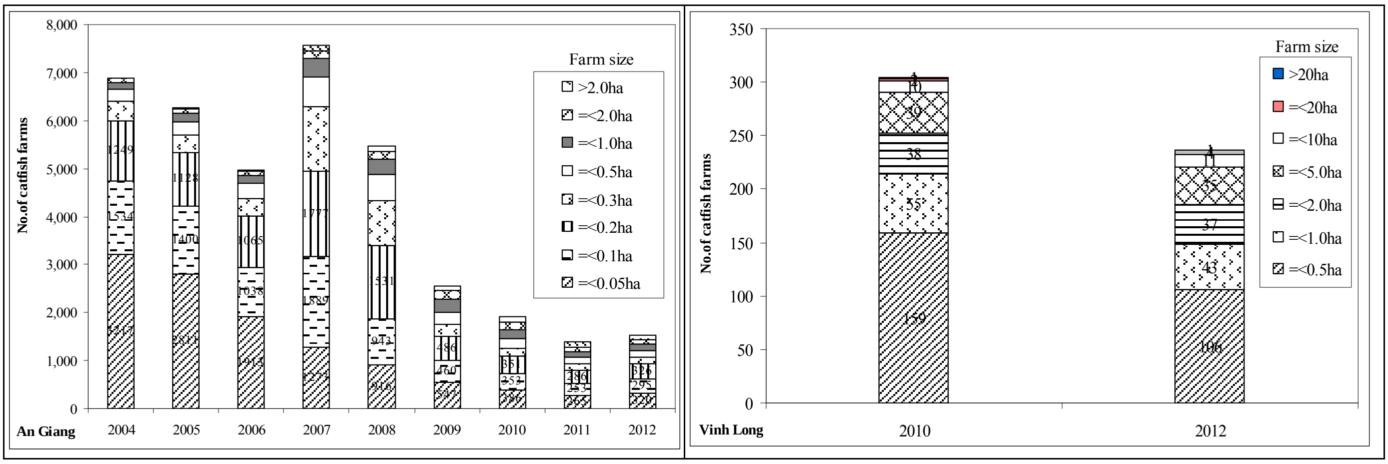


Figure 5.4. Distribution of catfish farms in An Giang and Vinh Long province by farm size class and farm numbers. *Source: An Giang DoF (2012) & Vinh Long DoF (2012)*

b). Trends in vertical integration and certification issues

Increased investment costs, capital resource constraints, and critically inconsistent and low farm gate prices have destabilised the catfish industry over time and, particularly, led to decline for small-scale farms. Independent, stand-alone farms, especially small-scale farms, tended to leave the catfish value chain or become contracted farms linked to seafood processors. The trend for large-farms operated by the seafood processors has increased and to independently ensure the quality and availability of raw materials for processing (Trifković 2013; Fisheries Directorate 2013; Ponte et al. 2014; Jespersen et al. 2014). Many processors now produced 50-70% of the total raw material on their own farms (VASEP 2011; Khoi 2011; Trifković 2013). The balance is sourced from the aquaculture Ltd. companies and independent farms; but there is a strong tendency for them to develop vertical linkages with such farms through contract farming arrangements to ensure stable raw material sources and also to control the fish quality and food safety issues. Large-farms operated by the processors have grown through purchase and conversion of agricultural, often orchard land. Most large-farms are located on the inland islands that were previously orchards (VIFEP 2009; Khoi 2011). Large-farms have also developed through the purchase or lease of ponds from catfish farms that were not able to continue farming. In 2009, statistics showed that around 15% of total catfish farmed areas came from farms with farm-size ≥10ha and this group made up approximately 909ha (Phan et al. 2011). However, by 2012 the catfish farmed areas from the eleven largest pangasius processors totalled 2,080ha, with farm-sizes ranging between 50-700ha and accounting for 35% of the total catfish farmed area (Fisheries Directorate 2013a). This reflects the rapid expansion of large-farms and ongoing attrition of small-farms from the sector.

Another important driver of this trend has been the need to respond to the demands of international certification, the remit of which extend far beyond product quality and food safety, and requiring compliance with environmental and societal standards. Most certified farms are large-scale and mainly associated with the processors in the aquaculture zone (Belton et al. 2011; Trifković 2013). There were 103 catfish farms with 2,800 ha (around 40% of the total area of catfish farming) achieving various sustainability certificates; and more than 50% of pangasius processors attained certificates from GlobalGAP and ASC

(Fisheries Directorate 2013). By 2012, around 10% of catfish products had already achieved the ASC certification accounting for 9% of the total catfish farmed area and it is envisioned that by 2015, ASC certified products will reach 50% of the total catfish export-volume contributing to 30% of the total catfish farmed area (Fisheries Directorate 2013a). Currently, there were no small-/medium farms with certification, who have faced difficulties in application for certification due to limitated capital resources and farm conditions. VietGAP (Vietnamese Good Aquaculture Practices) is being applied to major farmed species at present. The fisheries sector has a target of 80% of semi-/intensive farms getting the VietGAP certification before 2020 (MARD 2009b; MARD 2009c; GOV 2009; GOV 2013).

c). Catfish price trends and its effects to farm changes

The farm gate price was unstable during the production cycle and there has been a further downward trend recently (Figure 5.5). The fish farm gate price decrease over time can be caused by unfair competition between the seafood exporters discounting prices to gain the buyers; and the farm gate price could be driven by foreign importers or supermarkets demanding lower prices to secure contracts. There were 136 pangasius exporters of which only 64 exporters had their own processing plants; and thus the high competition in the market led to a dumping situation (i.e. export price race to bottom) and reduced the purchase price at the farm gate (Fisheries Directorate 2013a; Tuan et al. 2013). The processors do not want to reduce their net return during the low exporting price as a result of dumping exporting price occurs; and reducing farm gate price is a way to cope with this issue from processors side. While farm gate prices declined, the cost of farming inputs such as feed, chemicals and labour cost have increased by more than 10% per year. Fish prices have generally been lower than production costs recently; hence many catfish farms have become insolvent.

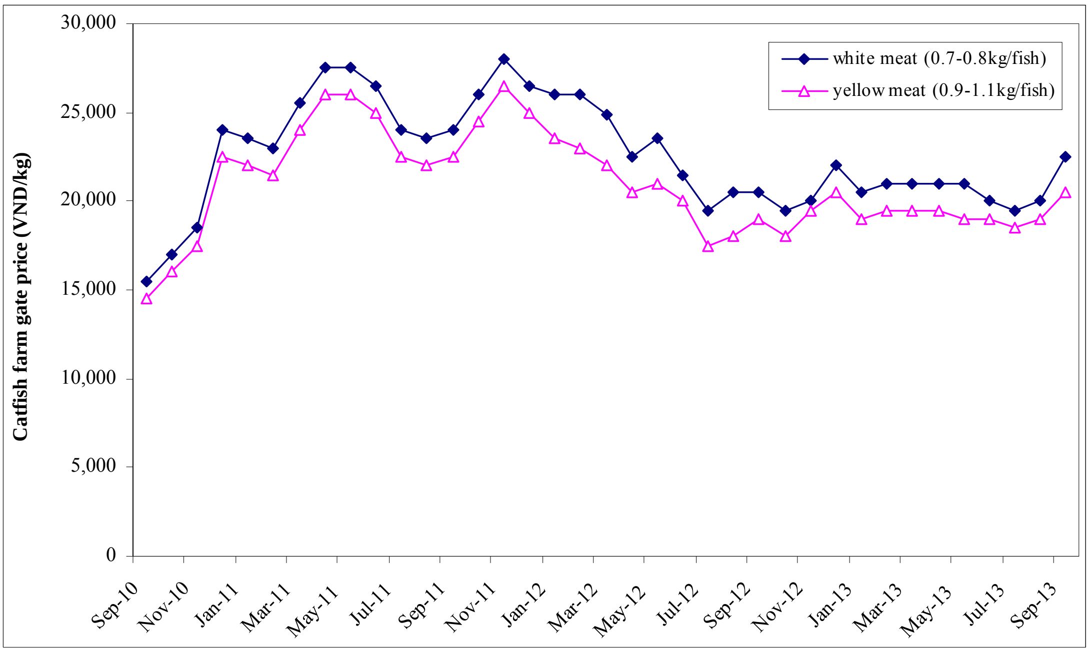


Figure 5.5. Average farm gate price for different catfish sizes in the MKD
Source: VASEP (2012, 2013)

5.3.2. Farm status and reason for changes

Around 55% of IFS catfish farms reported that their farming activities had undergone some significant changes (Figure 5.6). However, 19% of small-farms and 30% of medium-farms temporarily stopped farming and/or permanently stopped farming, while only 7% of large-farms temporarily stopped farming *(P>0.05)*. The farm change status shows that small-/medium farms were more likely to have temporarily or permanently stopped farming than large-farms. Large farms were less affected by low fish price than small/medium farms, thus their changes were mainly on improving practices such as stocking density and feeding improvement. Many small-/medium farms with more than two grow-out ponds faced problems with low fish price, forcing them out of catfish farming activity over the last two years, since 2011.

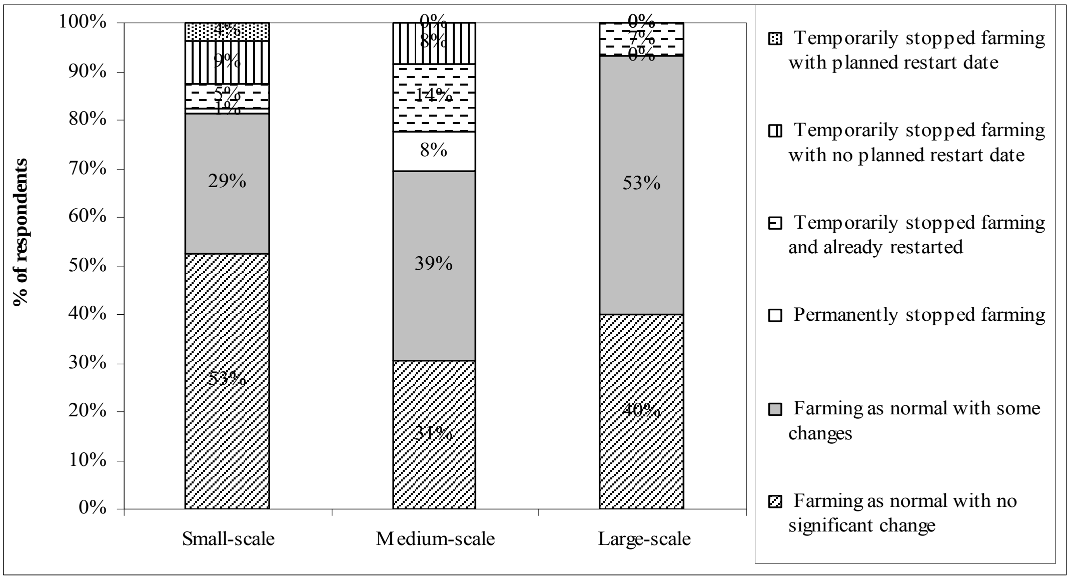


Figure 5.6. Farm change status in striped catfish farming practice
Source: TLS of catfish farms (2012)

Many changes in activities were reported by fish farms, and the nature of these changes was affected by farm scale. Increased fish production was reported by 24% of small-farms, the main reasons were the change of feed type (i.e. move to use commercial feed instead of farm-made feed) and the improvement of technical skills. Small-scale farms also diversified into pangasius seed production and reduced financial investment (Table 5.1). For medium-farms diversification into pangasius seed production (28%), increased production (16%) and cessation of farming or creating a contract farm with processors were the most cited changes. Large-farms mainly focused on reducing financial investment (22%) and developing contracts with other feed/chemical processors (22%), followed by increased production and diversification into other species (11%, respectively). The improvement of culture techniques had led to increased fish yields and production; while the lack of working capital following economic losses linked to low fish prices was the main reason leading to cessation of farming or more livelihood diversification, such as switching to other species culture and diversifying into pangasius seed production which helped to reduce fingerling cost. Moreover, contracts with processors, through vertical integrated linkages, was also perceived as a better way to maintain farming operation during low fish price periods. Due to financial constraints after economic loss, many farms reduced their investment in catfish farming including culture area and financial investment during 2010 and 2012. However, many farms still earned money from the catfish farms and they tended to increase culture area. There was no significant effect of farm scale on the dichotomy, suggesting that production efficiency was not directly related to farm-scale but that management was a key factor. As most small/medium farms were owned by individual farmers rather than processors and therefore likely to suffer relatively poorer prices it suggests that the management of small and medium farms was actually better than large in some cases. The stoppage rate in medium-scale farms was higher than in small-scale farms, and the explanation could be that many the medium-scale farms faced the high economic loss and could not re-invest their operation during the low fish price between 2010 and 2012.

Table 5.1. Changing activities implemented over time by striped catfish farms

Items	Small *(n=80)*	Medium *(n=36)*	Large *(n=15)*
Farm operation as normal (%)	52.50	30.56	40.00
Farm operation as some changes (%)	47.50	69.44	60.00
Of which, type of farm change (%)			
Stop farming	*2.63*	*12.00*	*0*
Reduce culture area	*0*	*4.00*	*0*
Reduce stocking density	*2.63*	*0*	*0*
Reduce financial investment	*10.53*	*8.00*	*22.22*
Increase culture area	*10.53*	*0*	*11.11*
Increase stocking density	*0*	*4.00*	*0*
Increase production	*23.68*	*16.00*	*11.11*
Applying for a certification	*0*	*8.00*	*0*
Diversify into pangasius seed production	*18.42*	*28.00*	*11.11*
Diversify into other species culture	*2.63*	*0*	*0*
Diversify into other agricultural activities	*0*	*8.00*	*0*
Cooperate with others to enlarge farm-size	*5.26*	*0*	*0*
Contract with processing company	*5.26*	*12.00*	*22.22*
Leasing of ponds	*2.63*	*4.00*	*0*

** significant differences (p<0.05); %: percent of survey farms. Source: TLS of catfish farms (2012)*

Around 85% of small-/medium catfish farms ceasing production indicated that the main reason was low fish price, followed by lack of operational finance, poor seed quality and/or a switch or diversification into other business (Figure 5.7). Following a period of rapid increase in fish prices, from US$0.82/kg in December 2010 to US$1.35/kg in December 2011, fish prices then declined to US$0.92/kg at the time of the telephone survey time (June 2012). However, at the same time, increases in input costs lead to increased production costs above breakeven. This was an important cause of many small-/medium farms being temporarily inactive or leaving the catfish farming sector. Selling fish at a low price, unstable markets during the time of oversupply and delayed payments from the seafood processors were also major reasons for cessation in farming in the small-/medium farms. Large-farms were less affected by the above reasons because of their closer relationships with the processors, usually enjoying smoother acceptance of fish and payment. Moreover, unit production costs of large-farms tended to be lower as they benefited from cheaper input costs through direct purchase from input suppliers (i.e. feed and chemical/drug companies) at preferential rates compared to the small-/medium farms at the same time of a crop.

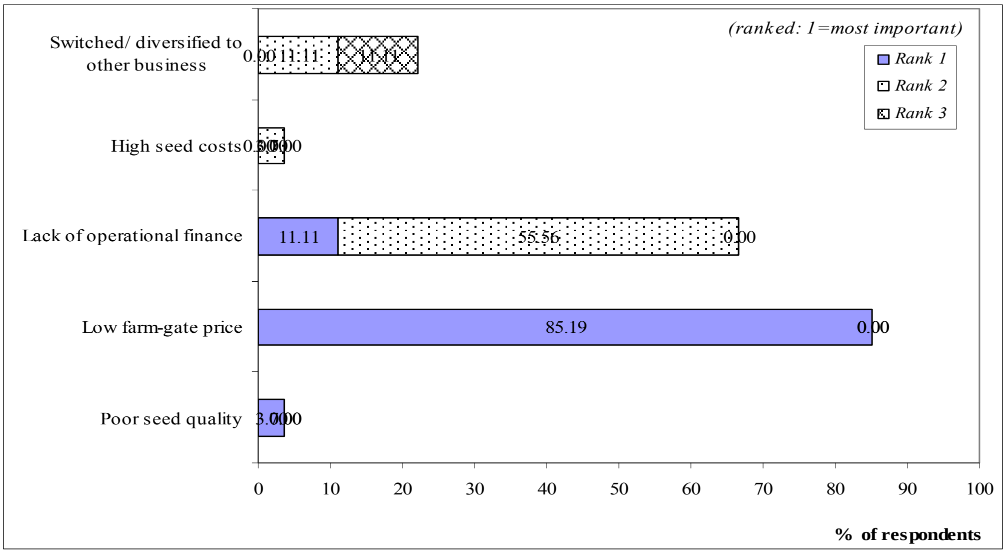


Figure 5.7. Reasons for stopping striped catfish farming
Source: TLS of catfish farms (2012)

The adaptations used by farmers to maintain catfish farming during periods of low farm-gate prices and credit access were mainly i) suspending pond production until the farm gate prices attained an economically viable level, ii) changes to feed management (i.e. temporarily stopped feeding or abnormal feeding conditions), iii) reduced investment levels (i.e. reduced in culture area, stocking density), iv) shifts to other species (i.e. snakehead fish, African catfish, walking fish, and catfish nursing farming), and v) contracting the farm to processors. There were differences among farm scale on how to cope with the problem of low fish price, small-/medium farms temporarily stopped farming and waited until the fish price increased, shifting to culture other species and leasing or suspending ponds. In contrast, large-farms mainly reduced their investment level (i.e. reduced culture area, stocking density and restricted feeding) or temporarily stopped farming with a planned restart date. For farms that permanently stopped production, most of the ponds were empty or suspended due to difficulty in leasing or selling the ponds during the low fish price periods.

5.3.3. Changes in technical aspects

Comparing the indicators of technical aspects between the two-survey periods (i.e. IFS vs. TLS) shows there was no significant difference suggesting few changes occurred in this period in the technology of highly intensive catfish system among the farm categories. The grow-out pond size and water depth did not change between 2010 and 2012; however, significant differences emerged in pond size between farm scales, the small farms had smaller and shallower ponds compared to medium and large farms *($P<0.05$)*. Technical changes also occurred on feed management. The eFCR was reduced around 2-7% compared to the data on the IFS survey in 2010 (Table 5.2, Table 4.6). Larger farms showed better improvement in the feed management compared to smaller farms.

Table 5.2. Major indicators on technical aspects of the existing catfish farming

Items	Small *(n=80)*	Medium *(n=36)*	Large *(n=15)*
Pond size (ha/pond)*	0.28±0.16	0.51±0.27	0.74±0.21
Pond water depth (m)	3.63±0.48	4.31±0.70	4.20±0.27
Stocking density (pcs./m^2)	45.00±12.43	51.25±21.75	50.00±18.03
eFCR	1.61±0.09	1.58±0.04	1.52±0.03

** significant differences ($p<0.05$); value: mean ±std. dev. Source: TLS of catfish farms (2012)*

5.3.4. Changes in economic aspects

Results from the IDS interviews showed that stocking density and seed size tended to decrease in the medium-farms and the same trend of reduced stocking density was recorded in large-farms; these changes indicate reduced investments. In contrast common adaptations in small-farms were increased stocking density (as a result of reducing seed size) and self-production of fingerlings. Some small-farms allocated a small culture area to nurse their own fingerlings both own for their grow-out ponds and also sale to others. Most farms significantly improved feed management through better estimation on the daily amount of feed used, indicated by a decrease in eFCR compared to the IFS. Data on fish mortality rates suggested little change, but production cycles were longer partly because of the smaller size of stocked seed but also linked to feed restriction. Productivity increased in the large-farms because of bigger seed size and longer production cycles; whereas, fish production decreased in the small-/medium farms as a result of reduced seed size and harvested fish size; average harvested size had declined by 20% since the IFS survey from 1kg/fish to 0.8kg/fish. This trend may relate to European buyers selling smaller sized fillets during the economic downturn in Europe (CBI 2012a; CBI 2012b; Beukers et al. 2012).

Feed cost still accounts for around 80% of the total cost, followed by seed costs, interest rate, cost of fuel and chemical/drugs use. Analysis of production efficiency shows that the

IDS farms lost any profit from the last crop because the fish price was lower than the production cost US$0.0144-0.0336/kg. The production cost ranged between US$1.05-1.09/kg; therefore the fish price at which farms would make a profit was US$1.15-1.16/kg and was expected to be higher than the production costs of between US$0.0625-0.1153/kg (Table 5.3). Results show that large-farms had a higher breakeven point than small-/medium farms, and that this was related to different harvest times with large-farms completing in January 2013 and small/medium farms in June 2012. This and the higher cost of inputs for catfish culture at the end of 2012 compared to the first six months was the main factor driving this result. The different time of production cycle resulted in different operation costs. For example, transportation cost increased greatly over time, diesel price was increased around 300-500 VND/litre from January to December 2012; it led directly to increase the transportation cost of inputs (feed) to farms and also increasing feed price. Additionally, labour cost was also a reason leading to the different on the production cost among farm scales. Labour cost was higher in the large-scale farms, because they had to hire labour while small farms were mainly based on family labour.

Table 5.3. Major indicators of economic aspects of the existing catfish farming

Items	**Small[a]**	**Medium[b]**	**Large[c]**
Stocking density (pcs./m^2)	42.55	38.75	35.00
Fingerling size (cm in body depth)	1.46	1.57	1.93
eFCR	1.54	1.55	1.53
Fish mortality (%/SD)	22.50	22.50	23.33
Number days of a crop (days)	231.00	225.00	232.50
Average production yield (tonnes/ha)	236.31	254.36	307.50
Breakeven price/Production cost (US$/kg)	1.05	1.05	1.09
Actual selling price (US$/kg)	1.02	1.04	1.07
Expected price for 'adequate' return (US$/kg)	1.16	1.15	1.15

[a]referred data of the last crop in May 2012, [b] in June 2012; [c]in Jan 2013. Source: IDS of catfish farms (2013)

✧ ***Financial sources:*** Catfish farms often sourced credit from multiple sources simultaneously for farm operation (Table 5.4); however, the main sources were their own savings and loans from commercial banks. There were differences in the source of finance among farm scale, all large-farms had loans from commercial banks; while only around 66% of small-farms used bank loans and 64% in the medium-farms *($P<0.05$)*. Large farms accessed loans from the banks more easily than small-/medium farms, because they could meet collateral requirements or use loans from their parent company for catfish farming. Additionally, many farms have also used other sources of finance such as borrowing from money-lenders or credit savings through vertical linkages such as contracted farms with feed companies or pangasius processors.

Table 5.4. Finance source for striped catfish farming investment

Items	Small *(n=80)*	Medium *(n=36)*	Large *(n=15)*
Use own savings (%)	70.00	72.22	80.00
Sell assets (%)*	0	0	6.67
Borrow – moneylender (%)	13.75	11.11	20.00
Borrow – relatives (%)	7.50	8.33	0
Borrow - non-relatives (%)	20.00	16.67	26.67
Borrow - commercial bank (%)*	66.25	63.89	100.00
Supported by feed company (%)	13.75	25.00	6.67

** significant differences ($p<0.05$); %: percent of survey farms. Source: TLS of catfish farms (2012)*

The use of farmers' own savings was still the most important source of finance among both groups i.e. "farm operations indicating significant changes" and those continuing without significant change (Figure 5.8), with 83% and 60% of farms ranking this source at the most important, respectively *($P<0.05$)*. Loans from commercial banks were the second most important finance source for both groups, accounting for 18% and 10% of farms, respectively; however, there were many farm operations with changes that depended on loans from commercial banks and money-lenders compared to that of the farm operating as normal. Thus suggests that, catfish farm operations were more stable if they had access to multiple sources of finance instead of any single reliance on bank loans that are very hard to access. In addition, farmers linked in with aqua-feed companies through contract farming were less likely to have changed operations than those independent of such relationships. Thus vertically integrated linkages were associated with stable development of the aquaculture sector in the long-term. Moreover, as input costs had increased by more than 10% per year, strong vertical linkages appeared to reduce vulnerability, mitigation such input cost inflations and improving access to working capital.

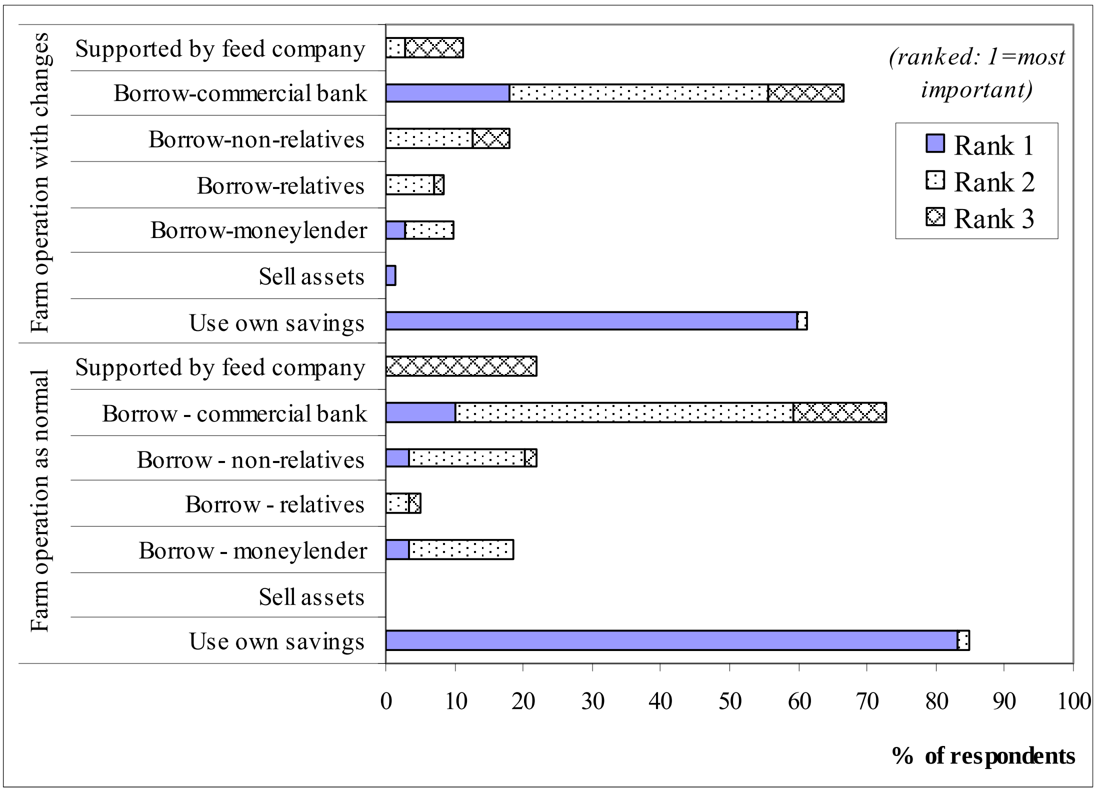


Figure 5.8. Rank of financial source by change status of striped catfish farms
Source: TLS of catfish farms (2012)

The previous survey on catfish farming in the MKD showed that loans from state banks contributed 30-45% of total investment per a production cycle and that the payment of loan interest was about US$8,990/ha/crop accounting for 3.50% of the total cost in 2010 (Pham & Truong 2011). Tuan (2013) noted that loans accounted for 50-60% of total finances required by catfish farm operation and farmers must pay US$24,230/ha/crop (6.23% of the total cost) in loan interest in 2013. Combining these results with our findings shows that lack of financial sources and high dependency on loans can be key factors leading to farm change over time. Comparative dependence on catfish as a source of income compared to other activities is now considered as a factor in explaining changes on farms.

✧ ***Income sources:*** Catfish producing households or companies were often pluriactive, having several income sources in addition to catfish farming including other agricultural activities, casual wage labour and service provision (Table 5.5).

Table 5.5. Income source of the striped catfish farms

Items	Small *(n=80)*	Medium *(n=36)*	Large *(n=15)*
Grow-out pangasius farming (%)	92.50	86.11	93.33
- Income in 2012 (%/total income)[a]	*35.71*	*40.00*	*80.00*
- Income in 2010 (%/total income)[b]	*60.99*	*73.88*	*86.79*
Agriculture; farming, livestock, processing (%)*	67.50	50.00	26.67
Casual wage labour (farm and non-farm) (%)	22.50	27.78	0
Long-term agricultural employee (%)	1.25	2.78	0
Salaried employment (%)	0	0	6.67
Business, trade, manufacturing (%)	0	2.78	0
Service provision[7] (%)*	0	8.33	26.67
Small business owner (%)	3.75	2.78	0
Leasing of ponds (%)	8.75	8.33	0
Rice farming (%)	20.00	11.11	0

** significant differences (p<0.05); %: percent of survey farms; [a]IDS; [b]IFS. Source: TLS of catfish farms (2012)*

Large-farms still focused on grow-out catfish farming as their main activity and income source and had lower livelihood diversification, while many small-/medium farms had more diversified income sources coming from other agricultural activities *(P<0.05)*. Results from the IDS survey in 2013 found that the contribution of catfish farming to household incomes was estimated to have reduced by 50% in small-/medium farms compared to that in IFS survey in 2010.

[7] Service provision: this is come from other service such transportation (truck, boat, excavator, etc.)

Grow-out striped catfish farming was still an important income source in both groups of farm operation with significant changes and farm operation as normal (Figure 5.9), with 78% and 93% of farms ranking this as the most important, respectively *($P<0.05$)*, followed by agricultural activities and casual wage labour. However, the farm operation with significant changes was more likely to have diversified their livelihoods to farm operations continuing as normal. For large-farms that had made significant changes, the main adaption appears to have been adjustment of investment level of their farm operations (reductions in culture area and stocking density); while the small-/medium farms were more interested in diversifying production such as switching to other species culture, livestock, rice farming and casual wage labour. The contribution of catfish farming to total income of the small-/medium farms had tended to decrease over last three years (since 2011) and they have tended also to switch to other activities or have continued to maintain farm operation at a low investment level. The low fish price and lower economic efficiency of catfish farming may be main causes of many small-/medium farms gradually leaving the catfish farming sector. Moreover, the individual nature of operating small/medium farms makes means it can be difficult to sell their fish and access loans from banks.

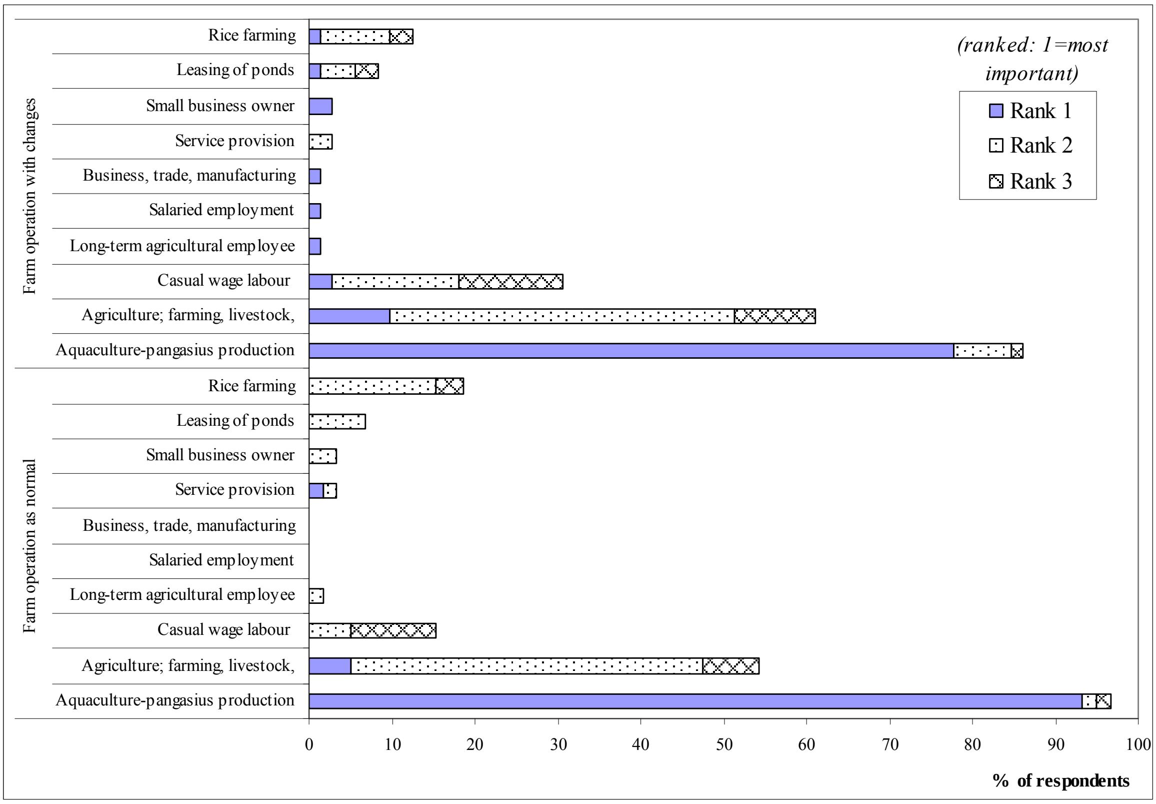


Figure 5.9. Rank of income source by change status of the striped catfish farms

Source: TLS of catfish farms (2012)

5.3.5. The responses of farms for sustainable development

✧ ***Main factors related to sustainable development:*** based on the above analysis of farm change status, the factors affecting long-term development could be identified as variation of fish farm gate price and capital/credit costs. Farm gate price has tended to fluctuate and decrease in recent years and it has often been lower than the production cost. Many catfish farms are still operating separately and very few models of horizontal and vertical integrated linkages exist; therefore, they have faced difficulties in selling fish during the time of oversupply leading to lower fish price and less power in price negotiation with traders or processors. At the time of this study, the farms' own financial resources were not sufficient to invest in and maintain catfish farming, especially for small-/medium farms, while the loans from the commercial banks were not easily accessed due to a stringent regulation on loans during the economic crisis. In addition, input costs increased 10-15%

annually, leading to increased production cost; many farms lost profit from catfish farming and so were forced to change their farming practice such as reducing investment, switching to other activities, and temporarily or permanently ceasing farming. These two main factors strongly affected the status of farm changes between IFS (in 2010) and TLS surveys (in 2012), and were mentioned in Table 4.13. To solve the constraints of low farm gate price, rising input cost, lack of financial resources, technical barriers and increasing the competitive price, the catfish farmers need to make i) a reasonable return on investment, and ii) institute the main 'costs' associated with the main certification schemes.

Pangasius products have highly competitive prices compared to whitefish in the international food markets, for example, the retail price of frozen plain pangasius fillets was €4.65-4.79/kg in the Netherlands, €7.65/kg in the UK compared to €3.98-6.83/kg and €4.53/kg of frozen plain Alaska pollock fillets in 2011, respectively (Beukers et al. 2012). The Netherlands and UK markets have higher requirements with respect to production quality and sustainability and therefore pay high import prices (€2.13-2.48/kg). Whereas, Spanish and Polish markets have lower requirements which is reflected by significantly lower import prices (€1.64-1.90/kg) (Beukers et al. 2012). There is a big difference within European markets; the pangasius product is very competitive in the Netherlands market while less in the UK market. This suggests that the fish can be 'marketed' in different segments that could have much more impact on profitability. This reflects there is the high potential for future development of the catfish farming sector, but the requirement for food quality and safety will be stringent. Although pangasius is highly competitive prices and its quality (e.g. white flesh colour, mild taste and texture) compared to whitefish (Little et al. 2012), the catfish sector should be made to complement the investment being made to meet international standards with greater emphasis on marketing that fact and the positive credence qualities of panagaisus compared to its competitors to maintain and gain markets. Moreover, whitefish traditionally has a strong focus on Alaska pollock, which is sometimes sold at a lower price than pangasius, with rather stable stocks and MSC certification. This constrains opportunities for positioning pangasius as a higher value product (CBI 2012a; CBI 2012b; Beukers et al. 2012). In addition, with the increasing requirement on the environmental sustainability from the NGOs and customers, sustainable production will be paid more attention on the global environmental impact of seafood products. In this point of view, an analysis on life cycle assessment of Vietnamese catfish production shows the greenhouse gas (GHG) emissions, acidification and eutrophication value were in a similar range as tilapia production in China while lower than in Thailand, that were 8,000kg CO_2-eq, 60kg SO_2-eq, 65kg PO_4-eq per tonne product in Vietnam compared to 10,000kg CO_2-eq, 80kg SO_2-eq, 100kg PO_4-eq in Thailand (Henriksson et al. 2014). This suggests the pangasius products have competitive qualities in terms of their low global environmental impacts even compared to tilapias, often extolled for their 'green' credentials (e.g. Little et al. 2012).

✧ ***Farms responses:*** Of the farms questioned, 33% had no plans or proposals, while many farmers were still confused and made passive suggestions (Figure 5.10). Around 31% of farms planned to discuss proposals with local authorities regarding the situation of fish production/consumption in order to looking for the way to solve their difficulties or constraints. For example, through the VINAFIS and local authorities the discussion and suggestions on the financial support during the low fish price and economic crisis were taken by the government to support catfish farms during 2011 and 2012 (as mentioned in Chapter 3). Although the financial support did not reach all request from farms, it also helped many farms solving their financial constraint. The active responses and plans were to improve technical skills (21% of farms), followed by improvement of farm management

(16%), and use of more environmentally friendly and cost-effective techniques (15%). Thus, sustainable development of catfish farming should have the participation and support of local government agencies to develop appropriate policies, technical assistance for capacity building, and interference or adjustment in the management of production and consumption. An integrated solution for managing the development of the value chain should be revised and planned. Building operational linkages among stakeholders in the value chain is necessary, each chain actor and supportive institutions should focus investment on improving and upgrading their current practices rather than investing in expanding the farm size.

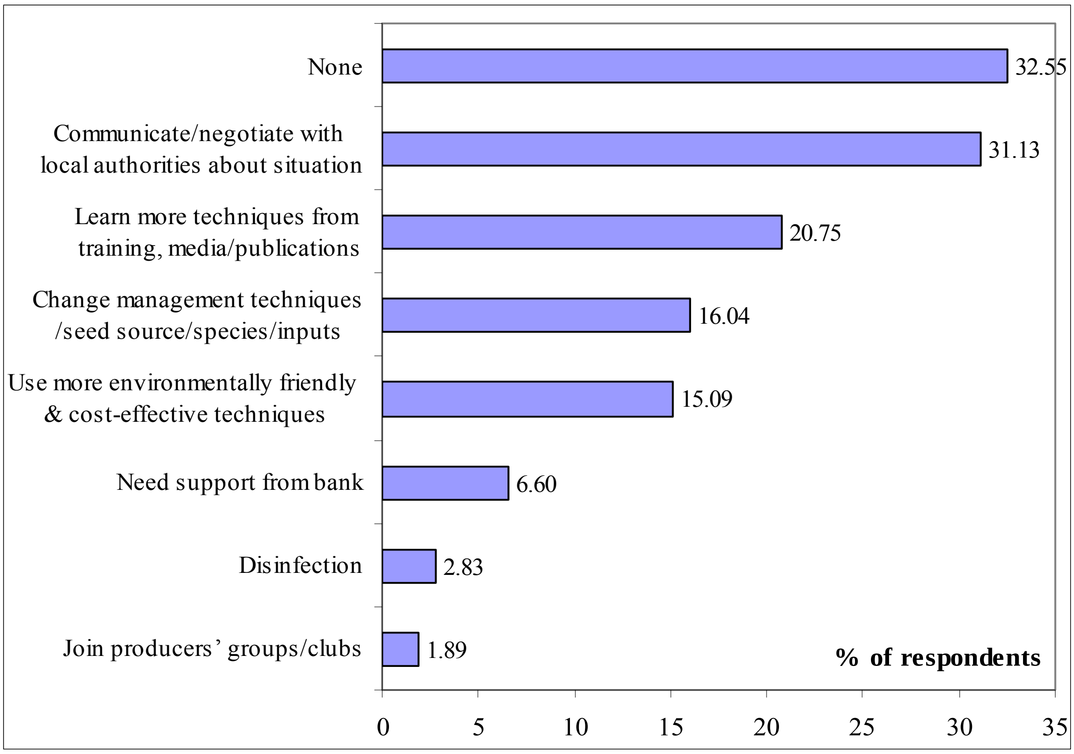


Figure 5.10. Striped catfish farm's responses for sustainable development
Source: TLS of catfish farms (2012)

5.4. Transitions in shrimp farming practices

5.4.1. General development trends of shrimp farming

a). Farm type movements

Before the 1990s, shrimp were mainly cultured under the extensive system in mangrove-forests and this sector began to develop quickly when artificial breeding was successful and transferred to mass production in the early 1990's. However, at this stage shrimp farms were mainly in mixed mangrove-shrimp systems. Shrimp farming grew rapidly since the end of the 1990s, when the Government implemented the Decree 09/2000/NQ-CP and seafood markets became more accessible to the shrimp industry. Since 2000 many saline rice fields and salt pans were converted to shrimp farming; and improved-extensive and rice-shrimp rotation systems were started. Since 2002, when farming techniques improved, many culture areas of the improved-extensive and rice-shrimp systems developed into mainly semi- and intensive shrimp farming systems. The semi-/intensive shrimp system required high investment in feed/chemicals and relatively high technical skills; however, the farms could be highly productive, while risking negative impacts on the environment. Therefore, semi-/intensive shrimp systems are not widespread, remain limited in range to less than 15% of the total shrimp farming area and are geographically limited to specific sites with good infrastructure conditions (e.g. road and irrigation canal system, electricity networks, transportation services) and capacity for monitoring and controlling the impact on the environment. Semi-/intensive shrimp systems have grown quickly. In 2002 together these shrimp systems accounted for around 15,310ha (3.28% of shrimp farmed area) and 28,000tonnes (23.16% of shrimp farmed production), which then increased to 88,200ha (14.65%) and 260,320tonnes (61.91%) in 2013 (Table 5.6). Improvements of culture techniques and increased culture area as well as a switch to white-legged shrimp were the main factors driving this change.

Table 5.6. Variation of shrimp farming system in the MKD

	2002				2013			
	Culture area		Production		Culture area		Production	
	('000ha)	*(%)*	*('000tonnes)*	*(%)*	*('000ha)*	*(%)*	*('000tonnes)*	*(%)*
Black tiger shrimp:								
Intensive	*10.72*	*2.29*	*24.11*	*19.94*	*27.73*	*4.61*	*97.05*	*23.08*
Semi-intensive	*4.59*	*0.98*	*3.90*	*3.23*	*19.35*	*3.22*	*19.35*	*4.60*
Improved-extensive	*329.88*	*70.57*	*65.98*	*54.55*	*292.45*	*48.59*	*78.96*	*18.78*
Rice-shrimp	*86.23*	*18.45*	*21.56*	*17.82*	*172.72*	*28.70*	*69.09*	*16.43*
Mangrove-shrimp	*36.00*	*7.70*	*5.40*	*4.46*	*48.49*	*8.06*	*12.12*	*2.88*
White-leg shrimp:								
Semi-/intensive	*0*	*0*	*0*	*0*	*41.12*	*6.83*	*143.92*	*34.23*

Source: Nguyen et al. (2009), Tran et al. (2003), VIFEP (2009), Fisheries Directorate (2011, 2012, 2013)

Since 2008 culture of white-legged shrimp was tested in several places in the MKD due to the high risk of disease outbreak in black tiger shrimp and the increasing popularity of white-legged shrimp in the markets. After that white-legged shrimp farming grew rapidly especially among semi-/intensive farms. In 2008, white-legged shrimp farming began with only 1,399ha (accounting for 0.24% of shrimp farmed area) and provided 3.69% of shrimp farmed production in the MKD. The culture area then increased, reaching 41,120ha (6.83%), and contributing more than one third of the total farmed shrimp production in 2013 (Figure 5.12). In the master plan up to 2020 (MARD 2009b; GOV 2013), white-legged shrimp farming has been marked for further expansion into several areas of the MKD because of its advantages in comparison with the black tiger shrimp; however, white-legged shrimp farming is only allowed to develop in aquaculture zones of semi-/intensive farming. Due to the highly vulnerable nature of black tiger shrimp to disease and the long turnover of capital investment, many large farms have moved 50% of their production area to white-legged shrimp farming in recent years (Fisheries Directorate 2013b; Fisheries Directorate 2014).

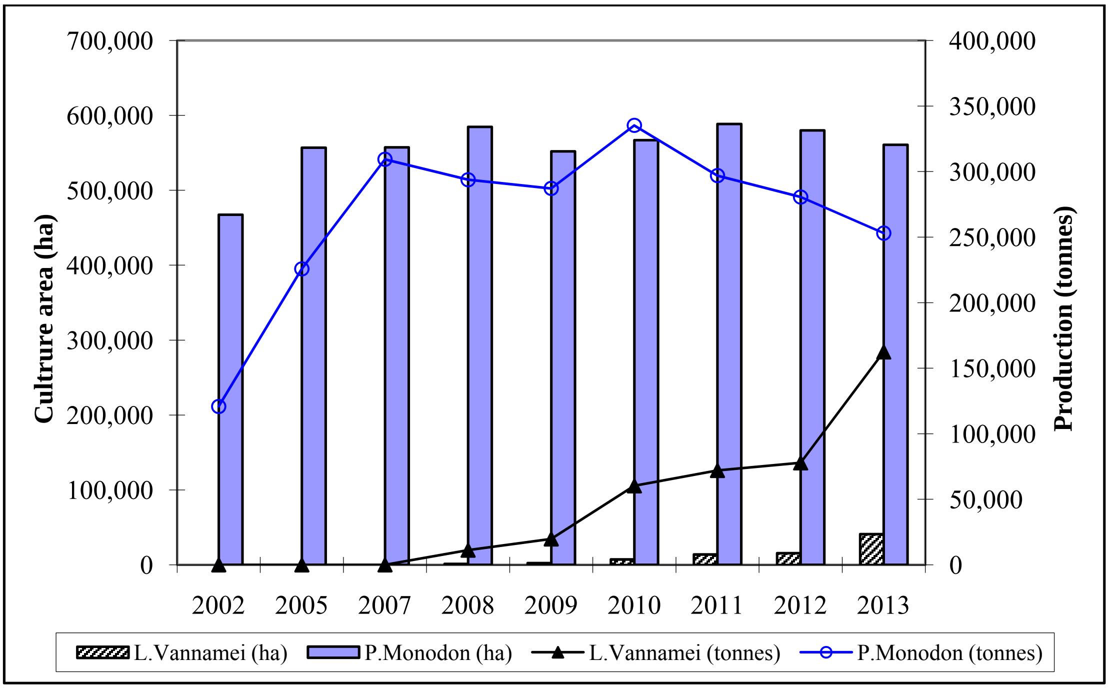


Figure 5.11. Movement trend of white legged shrimp farming in the MKD
Source: Data from Nguyen et al. (2009) and Fisheries Directorate (2013)

b). Trends of AHPNS disease

Before 2010, shrimp disease mainly caused by WSSV and YHV occurring every year in the MKD due to poor quality seed, bad water quality and disease spreading from the surrounding environment (Nguyen et al. 2009; Oanh & Phuong 2012); however, shrimp farming still contributed around 300,000tonnes per year. Since late 2010, Acute Hepatopancreatic Necrosis Syndrome (AHPNS) diseases began to increase in 2011 and 2012 as practitioners became better at identifying symptoms and effects (DoAH 2012; DoAH 2013a). Statistics on shrimp disease show the most severe damage caused by AHPNS was in 2011 with 65,593ha affected (accounting for almost 10% of shrimp farmed area) leading to a reduction in total shrimp production (DoAH 2012). Shrimp farming in 2012 continued to be affected by AHPNS, with the farmed area affected by AHPNS accounting for 7.28% of total shrimp farmed area and shrimp production declined by 9.38% compared to 2010. The AHPNS epidemic seriously affected both black tiger shrimp and white-legged shrimp in the semi-/intensive farming systems, but were not reported for more extensive systems (DoAH 2012; DoAH 2013a). In 2012, 14.6% of black tiger shrimp farmed area and 6.8% of the white-legged shrimp farmed area were affected by AHPNS disease. By 2013, AHPNS in shrimp appeared to have abated (Figure 5.12) with reported incidence with the peak showing in the shrimp season of 2012 where shrimp farms affected by AHPNS disease was accounted for 35,254ha (5.84% of total shrimp farmed area), but at the same time in 2013 it had decreased and accounted for 5,460ha (0.91%) (Table 5.7). Fisheries Directorate (2014) indicated that successful factors in AHPNS disease control included better farm management with adequate investment leading to control of water quality and effluent treatment. Moreover, many shrimp farmers had also increased their awareness of shrimp disease prevention, such the use of seed with screened pathogens, veterinary medicines and the use of high quality feed and application of advance techniques in aquaculture. Local authorities and professional bodies have been directed and guided effectively for shrimp farming and disease prevention. In conclusion, the better control of seasonal culture times (i.e. regulation on the stocking time), seed quality (i.e. PCR test to eliminate bad seed sources) and improved farm management including lower stocking density, full pond preparation and improvement of feeding process could help to reduce and control AHPNS disease.

Table 5.7. Information on the AHPNS disease outbreak in Vietnam shrimp farming

Items		**2011**	**2012**	**2013**
Shrimp farmed area (ha)		656,426	657,000	666,000
Farmed area affected by AHPNS	- (ha)	65,593	47,856	5,800
	- (%/total)	*9.99*	*7.28*	*0.87*
Shrimp farmed area, from Jan to Jul (ha)		-	603,947	598,436
Farmed area affected by AHPNS	- (ha)	-	35,254	5,460
	- (%/total)	-	*5.84*	*0.91*

Source: DoAH (2012), DoAH (2013)

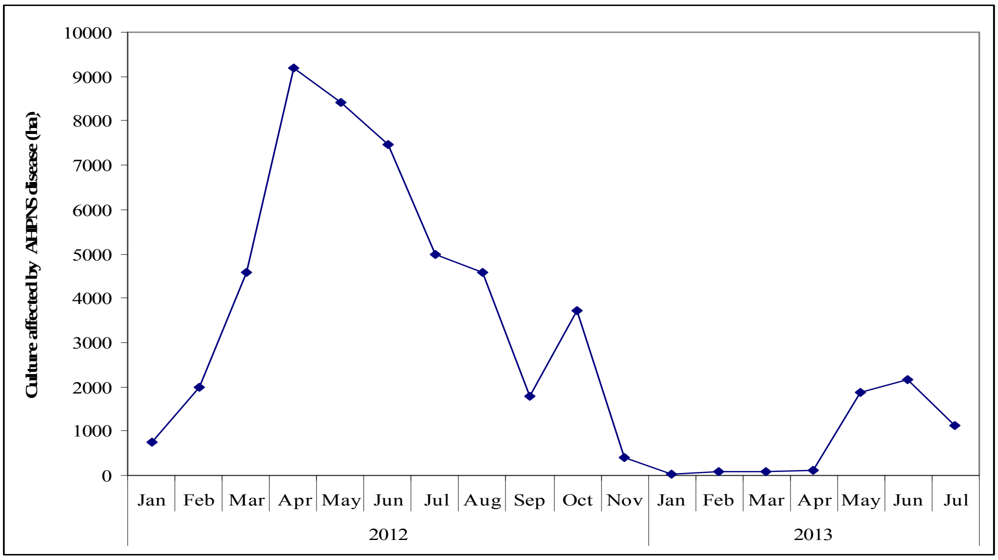


Figure 5.12. Shrimp farmed area affected by AHPNS disease since 2012

Source: DoAH (2012), DoAH (2013)

c). Shrimp price trends and its effects to farm changes

Shrimp prices fluctuate seasonally throughout the year, and depend mainly on the harvested shrimp-size. Shrimp price at the farm gate is usually higher at the end of the year when there is high demand for several festivals in importing countries (Figure 5.13) and the price is often lower at peak harvesting time from July to September (Figure 4.14).

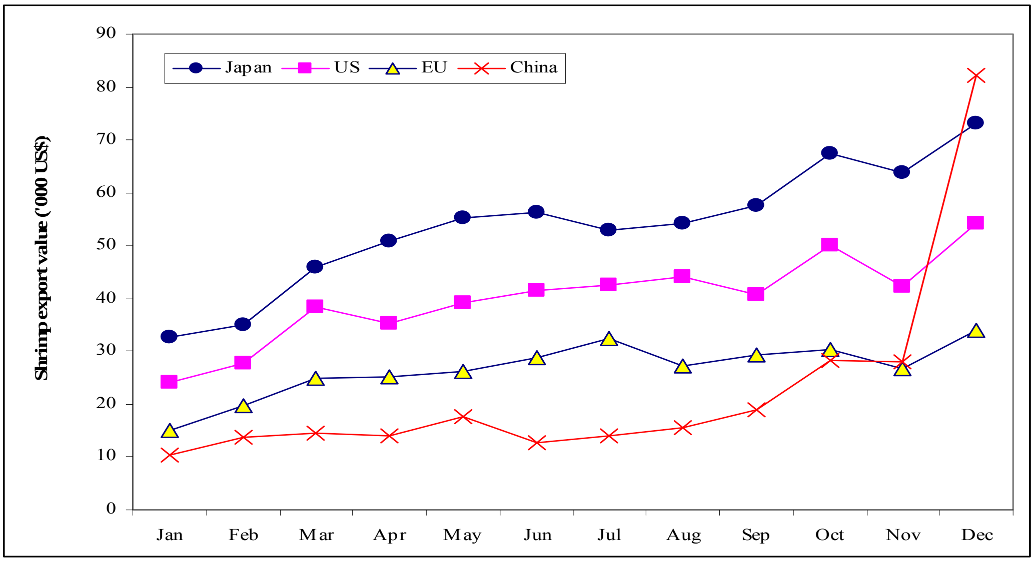


Figure 5.13. Monthly Vietnam shrimp export to major markets in 2012

Source: VASEP (2011), VASEP (2012)

Trends in shrimp prices showed no significant change between 2010 and 2011. Shrimp prices then reduced until the first half of 2012, and then increased again but were still far lower than the shrimp price in 2010. Although shrimp production declined due to the AHPNS epidemic, shrimp prices remained low as a result of competitive raw shrimp production in Thailand, Philippines and Indonesia. However, shrimp processors reported that importing raw shrimp was also a risk to the shrimp quality assurance and shrimp production delivery. Overall, although shrimp prices were not stable, shrimp price was not an important factor stimulating change at the farm level. Shrimp price did affect the shift from black tiger shrimp to white-legged shrimp in semi-/intensive systems as the price of white-legged shrimp was more stable than that of black tiger shrimp.

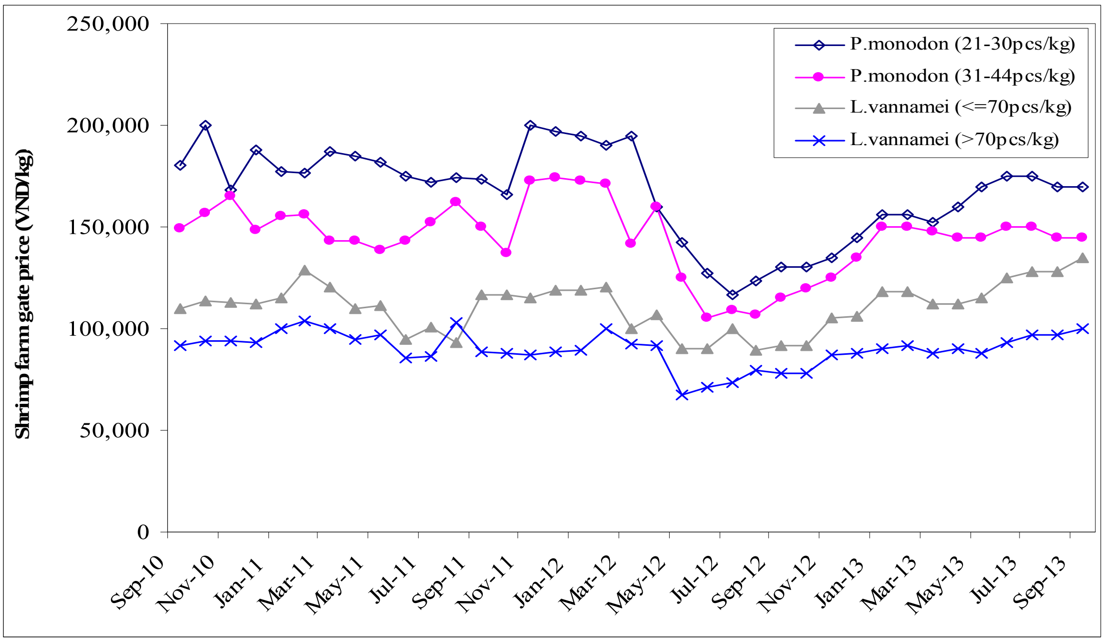


Figure 5.14. Average farm gate price of different shrimp sizes in the MKD
Source: NACA(2011), VASEP (2011), VASEP (2012), VASEP (2014)

5.4.2. Farm status and reason for changes

The LoLI farms showed fewer changes in farming practices compared to the HiLI farms *(P<0.05)* (Figure 5.15). In particular, all intensive shrimp farms changed over time, but the main cause was shrimp disease, especially the AHPNS epidemic. Shrimp farms have changed mainly in investment level (i.e. culture area) and farming techniques. There were some intensive shrimp farms (29%) and semi-intensive farms (15%) that temporarily stopped farming, and 4% of mixed-mangrove-shrimp farms shifted to other activities.

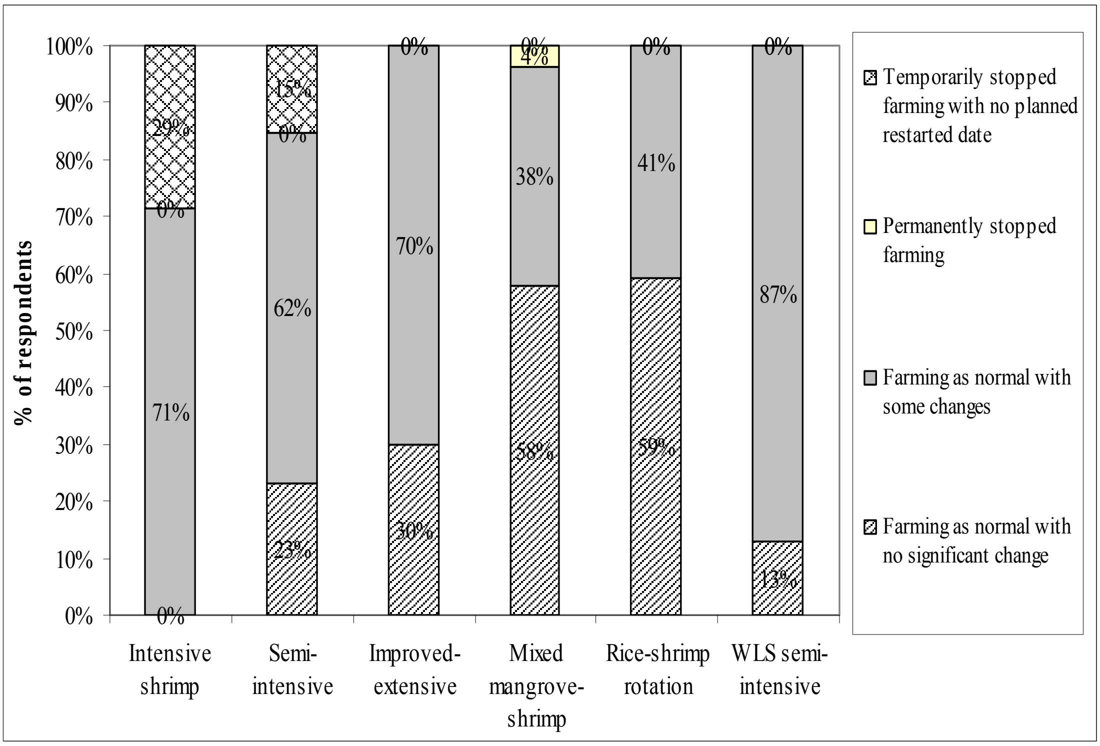


Figure 5.15. Farm change status in shrimp farming practice

Source: TLS of shrimp farms (2013)

Adaptation measures varied with types of shrimp farming systems; a shrimp farm may implement synchronous changes overtime. Producers of white-legged shrimp farming mainly focused on the adjustment of farming area, stocking density and improved farm management (Table 5.8). Semi-/intensive shrimp farms implemented changes including reducing farming area and stocking density, shifting to white-legged shrimp or other culture species (i.e. marine fish), and leasing of ponds. Many rice-shrimp farms that had a semi-intensive pond switched into white-legged shrimp culture at low stocking density (≤40 PL/m^2), and adjusted farmed area and stocking density. Comparison to shrimp sector in Thailand, white-legged shrimp farming started in the freshwater area and now this species were commonly farmed in the freshwater polyculture at low stocking density (Nietes-

Satapornvanit 2014). Meanwhile, an increasing stocking density was a significant change of the LoLI farms as a result of natural seed recruitment being less reliable over time, and some improved-extensive adjusted their farmed area.

Table 5.8. Changing activities implemented over time by shrimp farms

Items	BTS/WLS	BTS/WLS	BTS	BTS	BTS/WLS	WLS
	Intensive *(n=14)*	**Semi-intensive** *(n=52)*	**Improved -extensive** *(n=47)*	**Mangrove -shrimp** *(n=26)*	**Rice-shrimp** *(n=27)*	**Semi-intensive** *(n=23)*
Farm operation as normal (%)*	0	23.08	29.79	57.69	59.26	4.35
Farm operation as changes (%)*	100.00	76.92	70.21	42.31	40.74	95.65
Of which, type of farm change (%)						
Diversify into marine fish	*7.14*	*0*	*0*	*0*	*0*	*0*
Improved management	*14.29*	*0*	*0*	*0*	*0*	*13.64*
Increased culture area	*0*	*42.50*	*0*	*45.45*	*36.36*	*31.82*
*Reduce culture area**	*28.57*	*17.50*	*0*	*36.36*	*0*	*59.09*
Increased stocking density	*0*	*2.50*	*90.91*	*45.45*	*36.36*	*40.91*
*Reduced stocking density**	*14.29*	*55.00*	*6.06*	*0*	*9.09*	*36.36*
Leasing of ponds	*21.43*	*20*	*0*	*0*	*0*	*0*
*Move to L.vanamei**	*28.57*	*20*	*6.06*	*0*	*54.55*	*0*
Diversification strategy	*14.29*	*5.00*	*0*	*9.09*	*0*	*0*

** significant differences (p<0.05); %: percent of surveyed farms. Source: TLS of shrimp farms (2013)*

The results show that many semi-/intensive shrimp farms have suspended their farming operations; the main reason was the AHPNS disease, leading to several consecutive shrimp crop losses since 2011, and so some farms did not have enough capital resources to maintain the farm operation (Figure 5.16). The second important reason was the shift to culture other species such sea-bass, grouper and goby in order to reduce risks of AHPNS disease; however, they have still faced market related problems. In addition, environmental pollution was recognized and related to shrimp disease outbreak and affected by farming practice changes. Under conditions of environmental pollution, if diseased shrimp were harvested and cleaning was insufficient and/or culture water exchanged without treatment during the disease outbreak period; transfer within the same system and between systems was likely. Thus, shrimp disease was the main reason leading to the suspension of production in many semi-/intensive ponds. AHPNS disease related losses led to a lack of operational financial resources to reinvest and increasingly became an obstacle for the maintenance and operation of semi-/intensive farms.

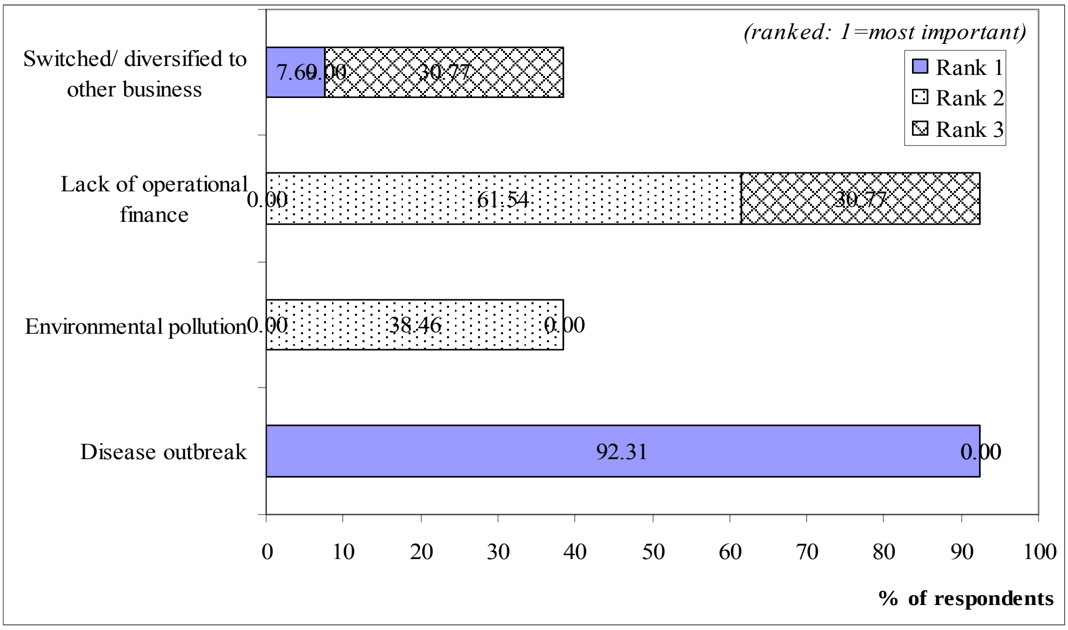


Figure 5.16. Reason for temporarily stopped farming in semi-/intensive system
Source: TLS of shrimp farms (2013)

A number of solutions to deal with the problems of shrimp disease in general and AHPNS disease in particular, were proposed by shrimp farms. The main solutions were i) reduce investment levels (i.e. reduced culture area, stocking density ≤25PL/m^2 for black tiger shrimp and ≤60PL/m^2 for white-legged shrimp with larger seed size in semi-/intensive systems; ii) improved farming techniques and farm management (i.e. pond preparation, water preparation and management, seed selection and environmental monitoring); iii) compliance regulation on stocking time to avoid the months with high temperature and the use of high quality probiotics for water control and treatment; iv) improvement of feed management: it is important to feed appropriately to avoid surplus feed in shrimp ponds and use high quality feed with lower eFCR; and v) encourage tilapia co-culture in shrimp ponds to keep waste to a minimum. AHPNS syndrome often affected shrimp in semi-

/intensive systems of both black tiger and white-legged shrimps 15-40 days after stocking (DoAH 2012; Oanh & Phuong 2012). AHPNS is caused by a unique strain of a relatively common bacterium, *Vibrio parahaemolyticus,* that is infected by a virus known as a phage (Loc et al. 2013). Therefore, shrimp farmers need to control water quality factors to reduce the potential for the development of this bacterial species including, high temperature, reduced depth of pond water, suitable pH around 7.0 and regular sludge removal (DoAH 2012; Fisheries Directorate 2012).

5.4.3. Changes in technical aspects

The major technical changes occurring between 2010 and 2013 in the HiLI farming systems were related to feeding improvement and water management, while in the LoLI systems of improved-extensive and mixed-mangrove shrimp systems, improvements were essentially increased pond preparation time, increased stocking density due to depletion of natural seed sources and a longer culture period. Over 86% of the HiLI farms faced AHPNS disease, followed by rice-shrimp system (59%). The LoLI farms did not report the occurrence of AHPNS disease in their farms, possibly related to better water quality, low stocking density (≤4 PL/m^2), large pond area with no feeding all of which result in less polluted pond sediments. Additionally, there were wild-fish in the pond helping to 'clean' the water, low pH (≤7) and S%o (≤10), and a low rate of chemical use for pond treatment, all of which do not favour *V.parahaemolyticus* development.

The HiLI farms had solutions to cope with AHPNS disease over time such as increasing reservoir pond use, reducing stocking density, improving feed management, careful pond preparation and stocking time selection. Most semi-/intensive farms created reservoir/settling ponds, while only 22% of rice-shrimp farms had them. Seed source was carefully selected and was tested using the PCR method to eliminate bad quality seed; the shrimp stocking density tended to be lower than 25PL/m^2 in semi-/intensive black tiger shrimp system, while it ranged between 66-90PL/m^2 for white-legged shrimp in the same system (Table 5.9). The improved-extensive and the rice-shrimp systems slightly increased their stocking density as farmers thought overstocking could help to compensate for the high shrimp mortality rate. Most farms did not change their grow-out pond design, but the ponds were prepared carefully and allowed a longer fallow time between successive shrimp crops. Additionally, feed management also improved including the use of high quality feed and better monitoring of feeding. The eFCR decreased significantly as a result of improvements to feeding practices and reduced stocking density, with 2-7% decreasing compared to the IFS survey. As a result of reduced stocking density and higher occurrence of shrimp disease, shrimp yield were lower compared to IFS period in the HiLI farming system. In contrast, the increased stocking density still resulted in a slightly reduced shrimp yield in the LoLI system, which may have been due to higher shrimp mortality.

Table 5.9. Major indicators on technical aspects of the existing shrimp farming

Items	**BTS/WLS**	**BTS/WLS**	**BTS**	**BTS**	**BTS/WLS**	**WLS**
	Intensive *(n=14)*	**Semi-intensive** *(n=52)*	**Improved-extensive** *(n=47)*	**Mangrove-shrimp** *(n=26)*	**Rice-shrimp** *(n=27)*	**Semi-intensive** *(n=23)*
Reservoir ponds (%)*	100%	93%	2%	0%	22%	100%
Pond size (ha/pond)*	0.55 ±0.14	0.37 ±0.12	1.00 ±0.7	1.07 ±0.48	0.47 ±0.12	0.27 ±0.09
Pond water depth (m)*	1.74 ±0.32	1.41 ±0.21	1.24 ±0.48	1.23 ±0.29	1.23 ±0.35	1.78 ±0.16
Stocking density (pcs./m^2)*	66.00 ±40.61	18.84 ±10.48	3.21 ±0.88	2.54 ±0.51	7.77 ±4.01	89.13 ±16.28
eFCR*	1.45 ±0.05	1.63 ±0.13	0	0	1.21 ±0.08	1.22 ±0.11
Yield (tonnes/ha)*	2.48 ±2.91	1.49 ±2.15	0.26 ±0.28	0.21 ±0.02	0.72 ±0.85	3.73 ±3.41
Mean crop (days)*	121.67 ±25.7	155.6 ±26.76	197.34 ±58.14	191.6 ±89.9	154.74 ±29.14	87.39 ±17.57
Pond fallow period (days)*	159.00 ±36.04	133.36 ±34.55	57.45 ±5.09	45.40 ±1.38	120.00± 0	51.09 ±10.11
AHPNS efected (%)*	86%	88%	0%	0%	59%	87%

** significant differences ($p<0.05$); %: percent of survey farms; value: mean ±std. dev. Source: TLS of shrimp farms (2013)*

5.4.4. Changes in economic aspects

Results from the IDS interviews showed that stocking densities had increased in the LoLI farming system and vice versa in the HiLI farming system. Semi-/intensive shrimp farms did not harvest shrimp when their shrimp ponds faced problems with the AHPNS epidemic. The shrimp yield did not vary much in the LoLI shrimp farming system, and decreased in the white-legged shrimp farming due to reduction in the stocking density. The production efficiency of shrimp farms who could harvest their shrimp ponds showed that such shrimp farms profited because the shrimp price was higher than the production cost of US$0.66-5.00/kg. Production cost varied around US$3.19-4.21/kg at the time of this study; therefore, the shrimp price required to ensure profit was US$4.69-9.86/kg that was US$1.50-5.65/kg higher than production cost (Table 5.10).

Table 5.10. Major indicators of economic aspects of the existing shrimp farming

Items	**BTS/WLS**	**BTS/WLS**	**BTS**	**BTS**	**BTS/WLS**	**WLS**
	Intensive *(n=14)*	**Semi-intensive** *(n=52)*	**Improved -extensive** *(n=47)*	**Mangrove -shrimp** *(n=26)*	**Rice-shrimp** *(n=27)*	**Semi-intensive** *(n=23)*
Stocking density (PL/m^2)	87.50	15.00	3.33	2.88	12.50	85.00
eFCR	1.33	1.45	0	0	1.30	1.33
Production yield (tonnes/ha)	0	0	0.21	0.20	1.03	5.75
Harvested shrimp size (pcs./kg)	82.50	28.75	21.25	20.00	55.00	75.00
Breakeven price /Production cost (US$/kg)	3.45	4.21	4.18	4.05	3.61	3.19
Selling price (US$/kg)		9.25	5.18	7.64	5.38	3.85
Expected price getting profit (US$/kg)	6.97	7.17	9.86	9.86	4.69	5.29

Source: IDS of shrimp farms (2013)

✧ ***Financial sources:*** Most shrimp farms relied on their own saving and in particular, intensive farms were able to source additional credit from commercial banks (Table 5.11). Many large shrimp farms (i.e. intensive system) did not have enough capital to invest and were dependent on loans from commercial banks, while the LoLI farms used only their own saving resources *($P<0.05$)*. The LoLI farms faced difficulties in accessing bank loans because they had not paid their previous debt, while the large farms could access loans more easily because they could meet the bank's requirements such as collateral. About 67% of total capital investment came from the owner's own savings in the semi-/intensive farms and rice-shrimp farms. This increased to over 85% in the LoLI farming systems. Thus, the shrimp farms were a more stable operation if they had available finance resources rather than bank loans.

Table 5.11. Finance source for shrimp farming investment

Items	BTS/WLS Intensive (n=14)	BTS/WLS Semi-intensive (n=52)	BTS Improved -extensive (n=47)	BTS Mangrove -shrimp (n=26)	BTS/WLS Rice-shrimp (n=27)	WLS Semi-intensive (n=23)
Use own savings (%)	100.00	100.00	100.00	100.00	100.00	100.00
- Family budget (%/total capital)[a]	*67.50*	*69.50*	*85.00*	*100.00*	*67.50*	*67.50*
Borrow-relatives (%)*	0	0	0	0	7.41	0
Borrow-commercial bank (%)*	57.14	1.92	0.00	0.00	11.11	13.04

** significant differences (p<0.05); %: percent of survey farms; [a]IDS. Source: TLS of shrimp farms (2013)*

There were no significant differences in the source of finance use between farms that identified significant change and those that did not (Figure 5.17). The use of their own saving resources for farming was still the most important financial source for both groups; however, many farms with changes had to borrow additional money for investment compared to the farms without changes. Additionally, some shrimp farms used credit savings through delayed payment terms (i.e. delay payment until the end of the crop), essentially a type of tied credit provided by Aquafeed companies and their local dealers, but famers have to pay 5% higher than normal price (as mentioned in Chapter 4). However, this was not easy to access, especially for small farms, because it was based on the trust-based trade and a long-term relationships between farmers and the feed sellers; and allowed shrimp farms to buy feed and delay payment from 2nd month for white-legged shrimp farming and 3rd month for black tiger shrimp farming. Tung (2011) reports that intensive shrimp farms got loans from state banks that accounted for 20-30% of total capital investment per production cycle and the loan interest was about US$617.79/ha/crop accounting for 2.16% of the total cost in 2011. About 20-50% of intensive farms purchased feed with delayed payment term for their shrimp ponds (Lam & Truong 2010; Le et al. 2011; Tung 2011). Most LoLI shrimp farms, semi-intensive and rice-shrimp farms operated individually and at a small-scale in terms of farm-size and annual production, so they had to buy inputs through intermediate networks at a higher price compared to the price when directly buying from input supplying companies in case of large-farms (intensive farms). Moreover, input costs increased more than 10% per year with a result an increase in production cost. Large shrimp farms had AHPNS disease and faced financial constraints for reinvestment in their operation, while the LoLI farms faced difficulty in accessing state banks loans to upgrade their farms. Thus, financial resources could be a factor driving farm changes over the last three years.

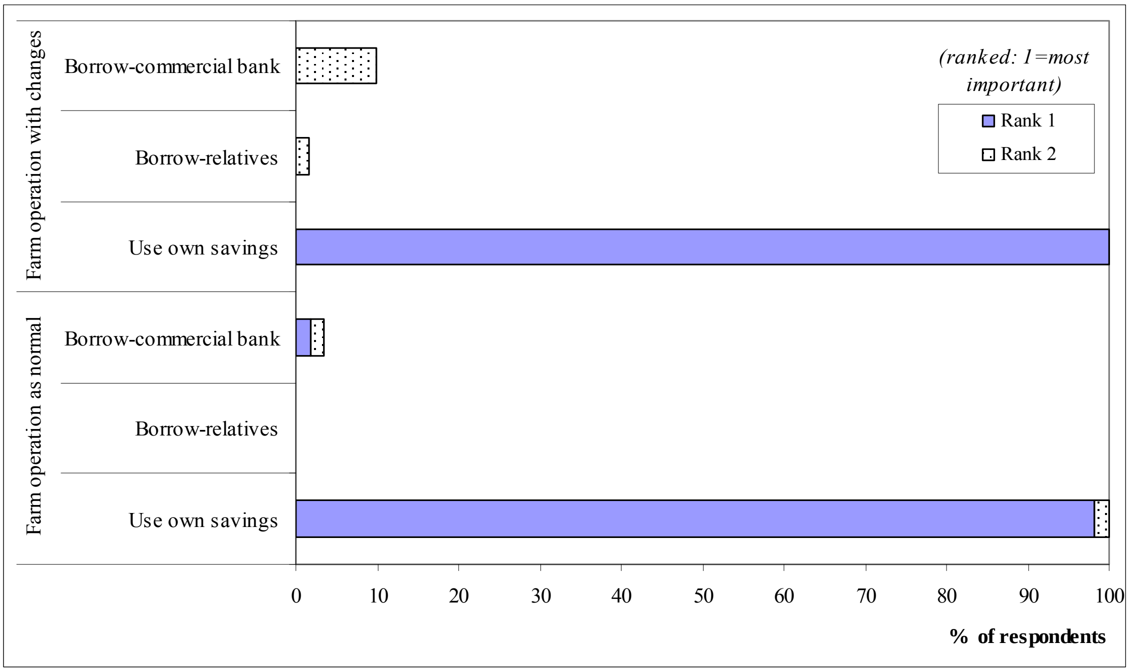


Figure 5.17. Rank of financial source by change status of the shrimp farms
Source: TLS of shrimp farms (2013)

✧ ***Income sources:*** There were several income sources that came mainly from shrimp farming, other agricultural activities, casual wage labour and service provision. Intensive shrimp farms are often aquaculture Ltd. companies so shrimp was the main income source, while the remaining shrimp farms operated individually and at a small-scale with secondary income sources coming from agricultural activities such as rice farming and livestock (Table 5.12). Particularly, mixed mangrove-shrimp farms located in remote areas and along the coast, their income came mostly from shrimp farming, wild-fish capture and mud crab culture in the same shrimp ponds with a bimonthly harvesting based on tidal cycles, and a small number of farms grew livestock on-farms (i.e. duck, chicken, pigs).

Table 5.12. Income source of the shrimp farms

Items	**BTS/WLS**	**BTS/WLS**	**BTS**	**BTS**	**BTS/WLS**	**WLS**
	Intensive *(n=14)*	**Semi-intensive** *(n=52)*	**Improved-extensive** *(n=47)*	**Mangrove-shrimp** *(n=26)*	**Rice-shrimp** *(n=27)*	**Semi-intensive** *(n=23)*
Shrimp farming (%)	100.00	100.00	100.00	96.15	100.00	100.00
- Income in 2012 (%/total income)[a]	*65.00*	*51.67*	*63.33*	*70.00*	*57.50*	*82.50*
- Income in 2010 (%/total income)[a]	*98.63*	*90.47*	*82.98*	*81.63*	*66.87*	*98.83*
Agriculture- farming, livestock (%)*	0	48.08	97.87	3.85	100.00	56.52
Casual wage labour (%)*	0	11.54	2.13	0	0	17.39
Salaried employment (%)	7.14	0	2.13	0	7.41	8.70
Business, trade, manufacturing (%)*	71.43	1.92	0	0	0	8.70
Small business owner (%)	0	5.77	2.13	0	0	0
Leasing of ponds (%)*	14.29	11.54	0.00	0	0	0

** significant differences (p<0.05); %: percent of survey farms; [a]IDS; [b]IFS. Source: TLS of shrimp farms (2013)*

Shrimp farming is still the most important income source in both groups of farm operation with significant changes and group of farm operation as normal, followed by agricultural activities (Figure 5.18). Shrimp farming located in coastal and saline intrusion areas offered few chances for other activities, and thus shrimp farming was the main occupation and income source. The farm operation with changes tended toward increased livelihood diversification and a reduced role of shrimp farming compared to the group of farm operation as normal. The results show that shrimp farming was still the main contributor to income at 51-83% of total income, but this ratio had decreased over the three years of this study in all shrimp systems. Income from shrimp farming activity reduced in the semi-/intensive farms due to the negative impact of the AHPNS diseases; while high shrimp mortality rates due to bad seed quality and untested seed use, and more livelihood diversification (i.e. rice farming, livestock, mud-crab culture) were identified in the LoLI farms. It reflects that shrimp farming has decreased in its contribution to income, and many shrimp farms have tended toward livelihood diversification or continued to maintain farm operation at a low investment level. Although AHPNS strongly affected shrimp farming during this study, shrimp farming was maintained despite a shift to other occupations in the coastal areas. Better control of shrimp disease and environmental monitoring helped to restore shrimp farming, and thus AHPNS was mostly controlled in 2013 resulting in a successful shrimp crop.

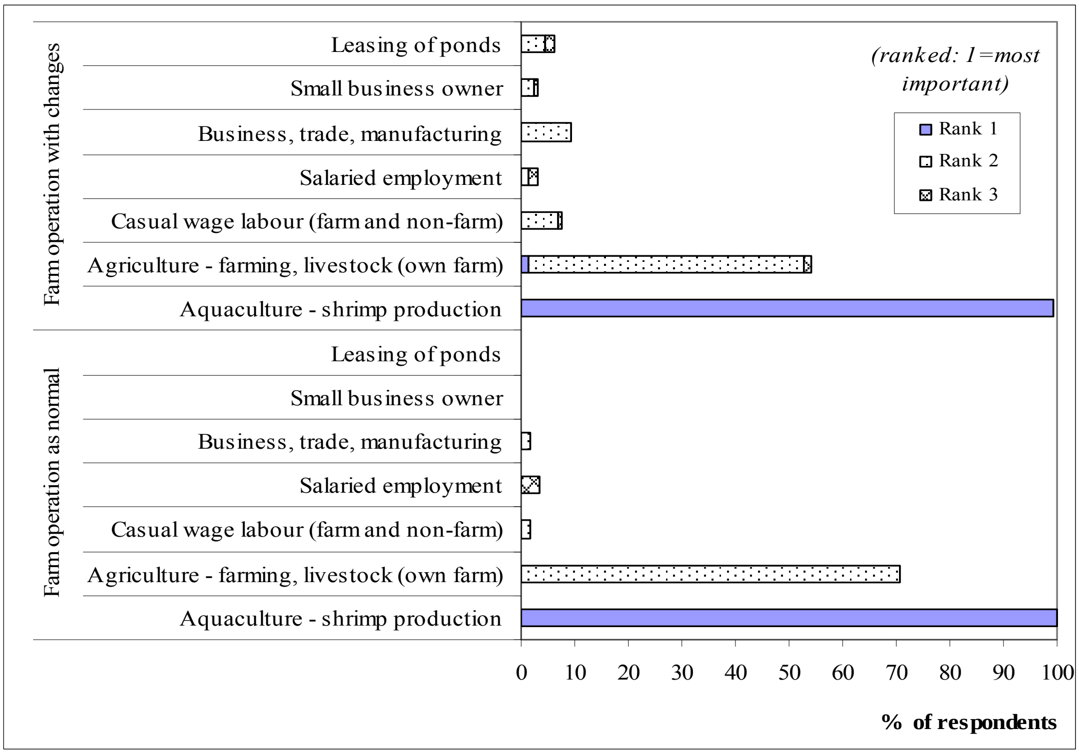


Figure 5.18. Rank of income source by change status of the shrimp farms
Source: TLS of shrimp farms (2013)

The survey showed that the LoLI farms operated with very few changes and more stability; while many farms in the HiLI farming system faced a ‘worse-off’ situation (Figure 5.19). This also correlated with negative impacts associated with AHPNS diseases, and the higher the intensification level the higher the risk level for AHPNS. The intensive shrimp systems had the highest risk of AHPNS disease, followed by semi-intensive shrimp and white-legged shrimp farms; however, some shrimp farms in the HiLI farming system still succeeded and were not affected by AHPNS disease. Therefore, sharing of information on shrimp production through farmers’ clubs and/or open fora were essential for farmers and other stakeholders to improve farm management skills.

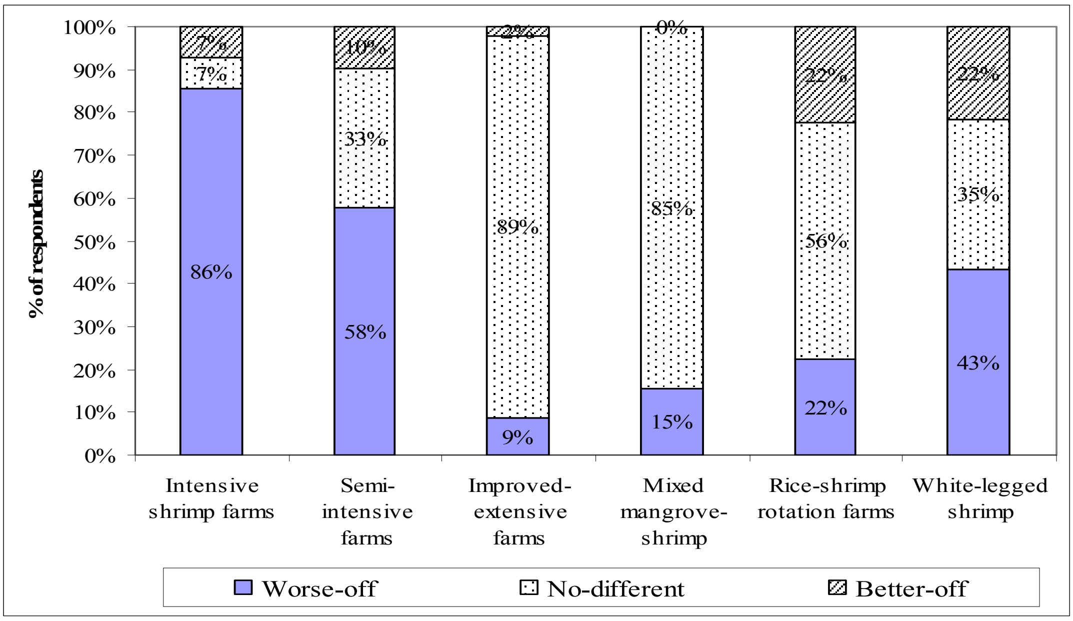


Figure 5.19. Evaluation of the shrimp farm economics status after three years
Source: TLS of shrimp farms (2013)

5.4.5. Responses of farms for sustainable development

✧ ***Main factors related to sustainable development:*** based on the above analysis of farm change status, the factors affecting long-term development were identified as shrimp disease outbreak and capital/credit costs. The AHPNS disease occurrence was a greater risk to shrimp farmers during 2011 and 2012. The main cause of AHPNS disease was identified as *V.parahaemolyticus*; however, poor seed quality, environmental degradation and weak farm management were considered as pre-conditions for disease occurrence and spread. Shrimp diseases pose latent risks in every crop and were increasingly unpredictable, so shrimp disease will still be considered as a factor affecting future development. To overcome this issue, shrimp farmers had to change their management to cope with shrimp disease. On the other hand, financial resources mainly came from the farmers own savings; however, after several crop failures due to AHPNS most of the HiLI shrimp farms did not have enough capital resource to reinvest and continue farming. In addition, with the trends towards intensification as well as emerging demands for certification, shrimp farms need financial resources to invest in their operations. Input prices have increased 10-15% yearly, leading to increased production costs; many farms lost profit from previous shrimp crops and so were forced to change their farms and reduce investment level, switch to other activities and temporarily or permanently stop farming. Thus, these two main factors strongly affected the farm changes between IFS and TLS periods, and were also mentioned in Table 4.24.

✧ ***Farm responses:*** The main factors affecting the farm changes were AHPNS disease and capital/credit costs. Two factors led to farm changes or no changes and there were no significant differences among shrimp farming systems. Particularly, the LoLI farms not affected by the AHPNS disease still faced other shrimp diseases and natural resource depletion led to reduce income from wild-fish/shrimp capture, and so they had to adjust their activities. Shrimp farms that operated as normal, were more independent in terms of operational capital, less affected by the AHPNS disease and more successful with their shrimp crops so their farms was less affected by the described factors, and shrimp farming remained an important income source. In contrast, shrimp farms changing practice often saw negative returns from 2011 onwards because of negative impacts from AHPNS disease in 2011; they also lacked capital resources for farm operation, thus had to change their farm operations.

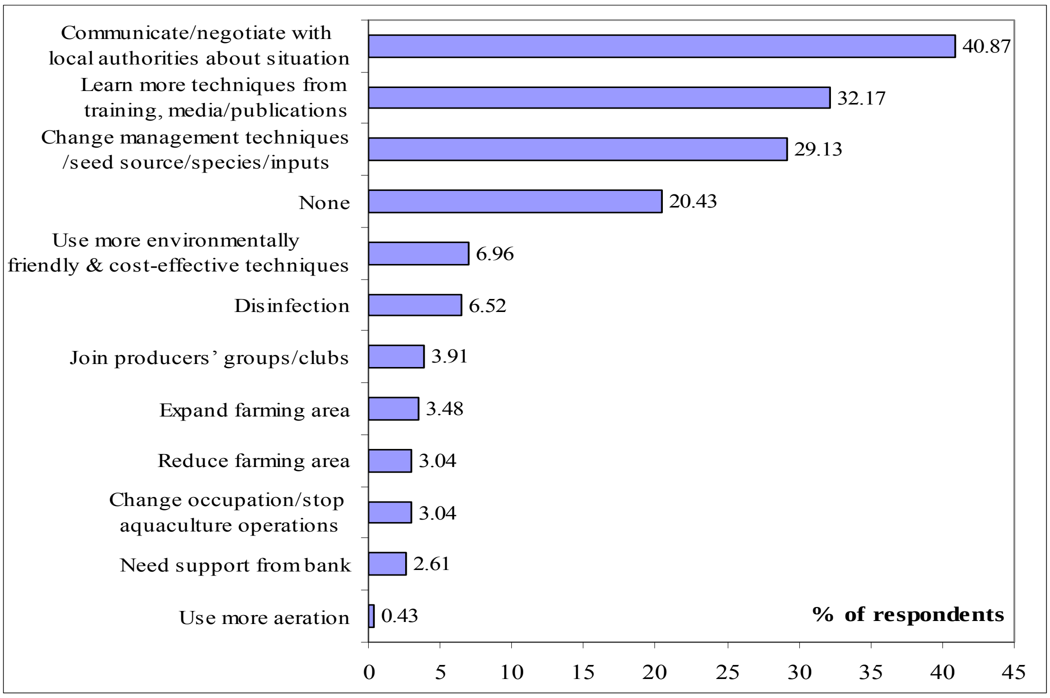


Figure 5.20. The shrimp farm's responses for sustainable development
Source: TLS of shrimp farms (2013)

Many shrimp farms gradually moved towards new business (i.e. HiLI system), or returned to the previous activities (i.e. LoLI system). However, due to the special characteristics of the coastal areas, changing from shrimp farming to other activities is very difficult. Shrimp farms were also consulted about their proposals to develop more sustainable farming practices. Of those questioned, 20% had no plans or recommendations, while many farms were still confused and put forward passive suggestions (Figure 5.20). Forty one percent of shrimp farms discussed proposals with local authorities regarding the situation of shrimp production/consumption in order to solve their difficulties (i.e. financial supports, technical training, infrastructure improvement and control of chemical/feed quality). The active responses and plans were improvement of culture techniques accounting for 32% of farms, followed by improving farm management (29%). Thus, sustainable development of shrimp farming should have the participation and support of local government agencies in creating appropriate policies, technical assistance for capacity building and interference or adjustment in the management of production and consumption.

5.5. Discussion and conclusions

5.5.1. Factors affecting the farming dynamics

- **Shrimp farming dynamic**

Shrimp farming systems are diverse however, two major shrimp systems (improved-extensive and rice-shrimp), accounted for 77% of MKD shrimp farmed area and 35% of MKD shrimp production in 2013. Farming systems have gradually shifted from traditional extensive systems to improved-extensive, and then to semi-/intensive production (Nguyen et al. 2009; Anh et al. 2010a). Semi-intensive farms tended to have been upgraded from improved-extensive and rice-shrimp rotation systems by the same operators, while intensive shrimp farms were established by newcomers. Although improved-extensive systems continue to exist in parallel, production does appear to have intensified overall (Pham et al. 2010; Ha & Bush 2010). However, intensive shrimp systems also are limited in range less than 15% of total shrimp farmed area that were planned by MARD in the master plan of shrimp sector up to 2020 (VIFEP 2009b; MARD 2009b), and such shrimp farming is concentrated at specific sites where have good infrastructure conditions (e.g. road and irrigation canal system, electricity networks, transportation services) and better in the monitoring and controlling the impact on the environment. Since 2008 many black tiger shrimp farms, including semi-intensive and intensive systems gradually shifted to white-legged shrimp culture, because the production cycle was shorter and more economic efficient but also because the former was regarded as having higher disease susceptibility (Nhuong et al. 2002; Funge-smith & Briggs 2003; Briggs et al. 2005; Yamprayoon &

Sukhumparnich 2010; Nietes-Satapornvanit et al. 2011). Although many shrimp farms shifted to raising white-legged shrimp, the black tiger shrimp still remains as the most important species in the MKD and remains preferred in most international markets (Tuan et al. 2013; MARD 2014).

- **Catfish farming dynamic**

Catfish farming began in small backyard ponds, and cage and pen-in-river systems but quickly evolved to larger, very deep ponds. Key factors driving the rapid development of pond culture practice include the availability of seed all year-round; low infrastructural investment, short culture period and high economic efficiency compared to cages and pens. Catfish farming in the MKD is an old tradition, from an era when the fish was raised in backyard ponds primarily for household consumption. This practice was also known as as overhung latrine systems because the latrines of the households were located above the ponds (VIFEP 2009; De Silva & Nguyen 2011). Commercial catfish farming began on small-farms dominated and operated by families (Phan et al. 2009; De Silva & Nguyen 2011; Cannon & Johnson 2013), but quickly evolved through a rapid increase in large-scale farms, mostly owned and operated by pangasius processors (Phan et al. 2009; De Silva & Nguyen 2011; Bosma & Verdegem 2011; Trifković 2013; Jespersen et al. 2014). The market dominance of industrial or large-scale farming has come to undermine the position of small-farms (Cuyvers & Tran 2008; Vo et al. 2009a; Bush & Belton 2012; Trifković 2013; Jespersen et al. 2014; Ponte et al. 2014), as has a lack of capital to invest in catfish culture and declining terms of trade, have been the key factors driving this trend. Farm gate price instability and a downward trend in fish price were the main reasons for smaller producers leaving catfish farming. Bush et al. (2010) noted that reasons for small-farms leaving varied, but the most cited poor economic performance and high risk due to lower farm gate price (Le & Cheong2010). Furthermore, the trend for pangasius processors to vertically coordinate production and develop their own farms has been influenced by concerns over the stable supply and control input quality (Vo et al. 2009; Bush & Belton 2012; Jespersen et al. 2014; Hansen & Trifković 2014). De Silva & Nguyen (2011) noted that there appear to be a general belief that for the long-term sustainability and economic survival of this sector it will have to make a shift towards large-scale farming practices, and small-scale farms are likely to be further marginalized in the industry (Belton & Little 2011; Bush & Belton 2012). To remain in operation, the small-/medium farms have had to develop close relationships with processors, often on a contract basis helps to ensure the selling their product and stable material sources for processors (Trifković 2013; Fisheries Directorate 2013a). Contract farming, or the process by which privately owned farm enterprises are supplied by a larger company with feed (and/or seed) with an agreement to sell back harvest at a pre-agreed price is common practice in the poultry business. Contract farming between processors and small-scale farms has been viewed as a way to increase income for farmers, and to ensure a stable supply of product in terms of quantity and quality for processors (Miyata et al. 2009; Zhang 2014). However, pre-agreed prices have been problematic for both sides in a period of unstable market, and agreed feed delivery, harvesting and payment terms were cited as major constraints to undermining such business arrangements (Miyata et al. 2009; Pham & Truong 2011; Fisheries Directorate 2013).

5.5.2. Farming transition and outcomes for sustainable livelihoods

- **Transition of shrimp farming practices**

The LoLI farms tended to more stable operation than the HiLI farms (Table 5.8). Shrimp disease was perceived as the main reason leading to the suspension operation of many semi-/intensive farming systems. Although the shrimp farms were affected by disease losses, most shrimp farms continued in production as alternative livelihood options in coastal areas only suitable for aquaculture were limited and investment costs were relatively low compared to pangasius farming sector (Nhuong et al. 2002; Le 2009). Farm changes were different among the various types of shrimp systems, and typically shrimp farms had implemented synchronous changes over time. Stocking density was main change of LoLI farms as a result of declining natural seed source and rise in importance of hatchery seed (Johnston et al. 2000; Nguyen et al. 2009). The most common change in semi-/intensive shrimp farms was to reduce farmed area and stocking density and shift to white-legged shrimp or other species. Shrimp farmers were encouraged to diversify their livelihoods by Government through switching into other farmed species (Nguyen et al. 2009; MARD 2009b; Fisheries Directorate 2013b). The increasing demands of the markets was an important reason for switching into white-legged shrimp culture (VASEP 2010; Tuan et al. 2013; CBI 2013b; MARD 2014), and Vietnam has followed many other countries who switched to white-legged shrimp culture (Kongkeo 1997; Lebel et al. 2002; Funge-smith & Briggs 2003; Kongkeo & Davy 2009; Yamprayoon & Sukhumparnich 2010; De Silva & Nguyen 2011; Bondad-reantaso et al. 2012). However, this change has only been partial perhaps because the shrimp industry in Vietnam did not face collapse as in Taiwan (1987-1988) and Thailand (1994-1997), and this is possibly linked to the enduring heterogeneity of culture systems and, in particular the persistence of more resilient, landscape systems. This affords good opportunities for the Vietnamese shrimp industry to maintain a differentiated position in seafood markets. Recently, during the outbreak of AHPNS disease, HiLI farming systems were disproportionately affected, the more intense the farming, the higher risk of AHPNS (Fisheries Directorate 2011; DoAH 2012; Fisheries Directorate 2013b; DoAH 2013a; FAO 2013). The AHPNS disease was caused by *V.parahaemolyticus* (Loc et al. 2013; FAO 2013a); however, seed quality, environmental degradation and weak farm management were believed to be contributory factors (DoAH 2013a; FAO 2013a; Saleetid et al. 2013). Shrimp disease latent risks in every crop (i.e. WSSV, AHPNS) and increasingly unpredictable, shrimp disease will be a factor affecting future development. The serious shrimp diseases during this study were WSSV and YHV, and both occurred annually and tended to increase due to poor quality seed, poor water quality and spread of disease from the surrounding environment (Nguyen et al. 2009; Oanh & Phuong 2012). Pond-to-pond transmission is more likely a contributing factor to the spread of WSSV in semi-/intensive systems, while its transmission within the pond occurs in improved-extensive shrimp systems (Hoa et al. 2011). Before 2010, serious shrimp diseases were WSSV and YHV, both types of disease occurred yearly and have tended to increase. For example, in 2011, 1,000ha of shrimp farmed area was infected by WSSV and this increased to 12,250ha by 2013.WSSV disease affected both black tiger shrimp and white-legged shrimp in all shrimp systems (Fisheries Directorate 2010; DoAH 2013a). Since late 2010, AHPNS disease has been prevalent in semi-/intensive systems, over a wide area in the MKD and it is still causing serious losses for farmers (DoAH 2013b). Statistics on shrimp disease show the most severe damage caused by AHPNS was in 2011 with 65,593ha affected (accounting for 10% of shrimp farmed area) leading to a reduction in total shrimp production (DoAH 2012). Shrimp farming in 2012 continued to be affected by AHPNS, with the farmed area affected by AHPNS accounting for 7.28% of total shrimp farmed area and shrimp production declined by 9.38% compared to 2010. Hence, shrimp farmers had to change their management to cope with shrimp disease and farmers were encouraged to use screened post-larvae, practice pond preparation and strictly follow regulations on stocking time (Hoa et al. 2011; Fisheries Directorate 2012; Oanh & Phuong 2012; DoAH 2013b). Specifically for coping with the AHPNS disease, semi-intensive and intensive shrimp farmers were encouraged to maintain water quality through control of algae growth, water exchange, increasing water depth, suitable pH and regular sludge removal to reduce the potential for *V.parahaemolyticus* growth. In Thailand, the farmed shrimp sector was seriously affected by AHPNS in 2013, and shrimp production volumes declined by 50% (GLOBEFISH 2013). The important risk factors associated with AHPNS in Thailand were the frequency of sludge removal, and improved measures were identified as having potential for prevention (Saleetid et al.2013). After several crop failures through AHPNS disease, most semi-/intensive shrimp farms, accounting for 85% of farms faced by AHPNS, exhausted their capital resources to reinvest and maintain their operation. The lack of access to credit to allow reinvestment has become an obstacle for shrimp farmers though may also have prevented them becoming too highly indebted. Some commentators have advised that, small-farms should form working groups to save operational costs and improve their position horizontal and vertical coordination with their buyers (Khoi et al. 2011; Abreu et al. 2011) but its not obvious that such action would insulate farmers from the impacts of shocks such as AHPNS. Tran et al. (2013) indicated that shrimp production is essentially controlled by shrimp processors and that integration of commodity chains would help reduce transaction costs, ensure stable food supplies and increase control quality and food safety (Grunert et al. 2005; Bush et al. 2010b; Bush et al. 2010a; Young et al. 2011; Abreu et al. 2011; Jespersen et al. 2014). Moreover, vertical strategy of contract farming is seen as the solution for small-scale shrimp farmers in improving market performance (Khiem et al. 2010; Ha et al. 2013). The authors suggest that small-farmers can organise into cooperative groups to gain production efficiencies, through sharing some management tasks and reducing disease risk and environmental impacts through cooperative action. However to date, shrimp farmers have not demonstrated much interest in farmers groups, possibly because the organization, structure and operation are still weak and have not showed clear positive benefit for farmers (RIA2 2009; Umesh et al. 2009; Nguyen et al. 2009).

- **Transition of catfish farming practices**

Lack of financial sources and high dependence on credit can be key factors leading to farm changes over time (Table 5.1), low fish price was perceived as being an important factor driving catfish farm changes, and the small-/medium farms strongly affected by than larger farms. Le & Cheong (2010) indicated that catfish price was the most significant risks for catfish farming. Price fluctuations and declines, often to levels lower than the production cost, led to poor economic performance and many small-/medium farms leaving this sector. It was the same problem for pangasius hatcheries and coffee farming sectors during periods of low farm gate price; 37% of small-hatcheries temporarily stopped their operation (Fisheries Directorate 2013a), while the small coffee farms become contract farms with wholesalers or temporarily stopped producing (Khoa 2014). The authorities have now realized that ensuring an economically viable farm gate price is key to sustaining the production side of the sector (De Silva & Nguyen 2011). Belton et al. (2009) indicated that small-scale production is risky, substantial financial losses are probable in the event of low farm-gate price; while large intensive operations are far more sustainable from an economic perspective, since production can be staggered across a number of ponds harvested on a rotation, and risk related to poor growth. The coping mechanism for dealing with the problem of low price varied by farm scale; small-/medium farms temporarily stopped farming and waited until price firmed, shifted to culture other species or leased out their ponds whereas, large farms mainly reduced their investment level. Farmers responded to lower prices by decreasing their costs or scale of operation;

offsetting their losses with other business interests; downgrading to fingerling production; or growing other fish species (Vo et al. 2009a; Bush et al. 2009; Khiem et al. 2010; Belton & Little 2011; Bush & Belton 2012). However, these strategies still have limitations, especially marketing challenges when switching to other species and/or seed production. For those operators that permanently ceased production, most of their ponds remained empty or suspended or lease or sale of ponds was forced during difficult low price periods. Small-producers may often suspend farming until the farm gate prices attain an economically viable level (Khiem et al. 2010; De Silva & Nguyen 2011). However, we argue that the small-/medium farms could not come back to the catfish farming sector if they were carrying outstanding debts from previous crops, because access to the required credit would be problematic. Moreover, small-/medium catfish farms that continue to operate independently are disadvantaged even during 'normal' price periods when most faced difficulties in selling fish during periods of oversupply. Small-farms are the most vulnerable to changes in the political economy and unstable markets, and this is likely to increase with a shift away from relational modes of governance such as vertical integration (Khiem et al. 2010; Nguyen 2010; Grunert et al. 2010; Khoi 2011). In addition, input costs have increased yearly leading to increased production cost that could not be offset through efficiency gains, forcing them to temporarily stop their operation or leave the sector.

5.5.3. Farming sustainability: vertical and horizontal coordination

This study provides insights to the changing risk profile of catfish and shrimp farming in the MKD, for which catfish relate mainly to the risks of economic change and for shrimp to the risk of disease. Vertical and horizontal dimensions of coordination in value chains are suggested to reduce the risk and vulnerability[8] of both these species. Bolwig et al. (2010) presents that the *vertical linkages* present contractual relationship and flows of products/services, information, inputs, and finance between a node and other nodes in the value chain; and the *horizontal elements* of value chains are represented by 'discs' radiating from each node that shows the chain actors in the centre of the disc and in the periphery the external actors, the excluded actors, the non-participants, and the communities surrounding these. Riisgaard et al. (2008) indicates that value chain coordination around the production node may be strengthened as part of a broader 'upgrading strategy' to improve value chain participation for farmers, especially small producers. The change in position of farmers is discussed in relation to the vertical and horizontal linkages in value chains, as follow:

a). Vertical coordination

Risk profiles were mainly influenced by unstable catfish farm gate price, shrimp disease and financial constraints that lead to farm changes over time. Small-medium catfish farms are independent farms and they faced higher level of these risks compared to larger catfish farms that are owned and operated by the pangasisus processors; while the shrimp farms faced more serious shrimp disease (AHPNS in intensive system; and WSSV, YHV in the more extensive systems). The main reasons were lack of the operation linkages between value chain actors e.g. between catfish farmers and pangasius processors; between shrimp farms and input suppliers (seed, feed, chemical/drug), and limited access to capital to invest production inputs. Enhancing vertical integrated linkages between farms and the other value chain actors is suggested as a way to reduce the risks and vulnerability for the small-/medium catfish farms as well as the shrimp farms. Vertical coordination is an

[8] risk is the likelihood of a specific shock occurring, while vulnerability is a property of systems and is a way of describing their response to shocks (Bolwig et al. 2010)

umbrella term used for describing institutional arrangements. Various forms of coordination exist, but production contracts (i.e. full ownership management) are the most relevant in the agri-food sector in developing countries (Reardon et al. 2009; Trifković 2013). Vertical contractualisation requests longer-term relationships or 'contracts' between famers and other actors (e.g. pangasius processors, shrimp input suppliers) which can provide a security of market for small producers (pangasius) as well as benefits such as improved access to market information (e.g. on quality demands), services and inputs (Bolwig et al. 2010). This vertical coordination is related to the 'captive' governance form of GVC (Jespersen et al. 2014). Strengthening value chain coordination through increased contractualisation (longer-term and more complex linkages between chain actors) is an important part of upgrading for weak actors due to widespread factor and product market failure (Gibbon 2001; Giuliani et al. 2005; Ponte & Ewert 2009; Bolwig et al. 2010).

Vertical contractualisation can also be useful for reducing price risks for small producers (pangasius), and reducing marketing costs. In the shrimp sector, the vertical linkages with the input suppliers can reduce risk associated with shrimp disease and financial constraints. Contracted catfish farms privately owned by a farm enterprise, has risk reduced the pangasius processor supplying feed and seed based on agreement to sell back harvest at pre-agreed price. Shrimp farms could also develop contracts with input suppliers in terms of high quality of farming inputs (e.g. screened shrimp seed pathogen, high quality of feed and chemical/drug) and payment terms. In the case of vertical linkages with pangasius processors, small-/medium catfish farms may solve the financial constraints because of changes in providing feed and seed from the pangasius processors. Such contracted small/medium catfish farms based on pre-agreed prices with processors, can clear 500-1,000VND/kg marketable fish of net profit. For example, members of Thoi An Pangasius cooperative in Can Tho province were contracted by Hung Vuong pangasius Joint-stock company, receiving feed and seed from them in addition to technical support. However, the farmers have to pay the labour, electricity and chemical costs. At the end of production cycle, Hung Vuong company bought fish and paid the farmers 3,000VND/kg after deducting cost of feed and seed cost (Anh 2014). Although the net profit was lower in the contract system compared to the 'normal' farming practices, the system benefits the farmers through greater stability of prices and access to finance, and for processor who is assured of a stable supply raw materials and quality control. However, pre-agreed prices have been problematic for both sides during periods of unstable market; and agreed feed delivery, harvesting and payment terms were cited as major constraints to undermining such business arrangements (Miyata et al. 2009; Pham & Truong 2011; Fisheries Directorate 2013). Zhang (2014) indicated that vertical integration through contract system between feed companies and agricultural farms had failed in China due to unstable relationships and unbalanced power between companies and farmers (Wang 2009). Contract farming does not in itself change the status of small-scale and scattered farming practices, and cannot resolve the food safety problems (Lin & Ren 2006), for instance the notorious food scandal of melamine contamination in milk product in China occurred within small-scale farms working under contract farming (Wang 2009).

In the shrimp sector, seed quality was studied as an important cause leading to shrimp disease occurs (Nguyen et al. 2009; Oanh & Phuong 2012; Hoa et al. 2011). In the LoLI system, most shrimp farms used unscreened post-larvae and high shrimp mortality was very high. Although shrimp seed were checked for pathogens (WSSV, YHV) using PCR, the HiLI shrimp farms still faced problems of AHPNS disease. AHPNS can be caused by the seed source and pond environment conditions that are controlled mainly by the chemical treatments. Shrimp farms need to control the seed quality and the farming inputs (feed and chemical/drug), and vertical linkages with prestigious input suppliers can help to reduce the risks of shrimp disease. Vertical coordination between a shrimp farm group and large-scale shrimp hatchery in India helped to reduce risk of shrimp disease for shrimp farm members (Umesh et al. 2009).

Smaller farms can benefit from participation in global trade because of positive effects of participation in export on farmers' productivity (Minten et al. 2009), employment opportunities (Maertens & Swinnen 2009), and access to technology, inputs and investment (Gow & Swinnen 1998; Dries & Swinnen 2004). However, many of these benefits are available mainly to vertically integrated farms (Dries & Swinnen 2004). The salmon value chain in Europe is a good example, where both vertical and horizontal integration has developed. Salmon supply chains are the most industrialised in aquaculture, with an increasing degree of vertical coordination from salmon farms to the supermarkets, a model that has more similarities with manufacturing and the most industrialised value chains in agriculture (Kvaløy & Tveterås 2008).

b). Horizontal coordination

Vertical coordination can bring good chances for small-/medium catfish and shrimp farms to cope with the risks and vulnerability. However, pangasius processors are not attracted to make contract with the individual small-scale farms due to the small volume and dispersed nature of fish production. In this regard, horizontal coordination is asserted as being important for reducing risks and vulnerability for small-/medium catfish farms. Meanwhile, the LoLI shrimp farms also faced the same problems as catfish sector when individual farms attempt to form contracts with the prestigious input suppliers. Horizontal contractualization is a way to implement this coordination, where producers agree among themselves to cooperate over input provision, marketing, certification, crop insurance or other forms of collective action in order to increase revenues, reduce costs, or reduce individual risks (Bolwig et al. 2010). The model of Fair trade coffee producer cooperatives in Latin American countries is a good example of this, the Fair trade chains contribute to reduce risk and improve credit access, enabling producers to make long-term investments (Lyon 2006; Valkila & Nygren 2009; Ruben et al. 2009; Bacon 2010; Ruben & Fort 2012). However, Fair trade certification is only available to cooperatives of small-scale farmers, and for a small-scale farmer to be organically certified a cooperative membership is mandatory (Gómez Tovar et al. 2005; Cruz 2006; Valkila & Nygren 2009; Valkila 2009; Bacon 2010). The change in position of small-scale farmers through forms of upgrading (technological and functional) often depend on creating stronger contractual ties among the weak actors themselves or with buyers (Gibbon 2001; Ponte & Ewert 2009; Bolwig et al. 2010). Therefore, independent small farmers should be formed into the farm groups or cooperatives, because the Government also has policy to support the operation of farm groups in terms of technical aspects (training on the management of farm groups and technical training) and financial supports (investment and tax incentive, preferential interest rates and debt rescheduling). Moreover, the pangasius processors have incentives to develop and establish the vertical contractualisation with the farm cooperatives and farm groups, because they are also motivated by the Government through policy supports (loan incentive and preferential interest rates).

Literature reviews show that agriculture cooperatives and group actions are important for development, improving farm performance significantly (Council & Cooperatives 1987; Parliament et al. 1990; Srinath et al. 2000; Garrido 2007). Small-scale farms can enhance competitiveness and achieve improved economies of scale by collaborating and through working as clusters of organisations (Berdegué Sacristán 2001; Tain & Diana 2007). Moreover, a group farming approach was an effective way for extension intervention to educate farmers on sustainability while helping them to improve their farming practices (Srinath et al. 2000; Umesh et al. 2009).

Bolwig et al. (2010) noted that the two dimensions of contractualisation are often connected, as collective action (horizontal contractualisation) among small producers is frequently necessary for increasing vertical contractualisation. Vertical contractualisation is determining factor in the success of group formation, as well as providing important explicit incentives for process, product and functional upgrading (Khiem et al. 2010). Working in the farm group, farmers can receive many benefits through the collective actions, such as: i) reducing the transactions cost: they buy input (feed/seed/chemical) directly from the input manufacturers to get high product quality, preferential price and free services, and shrimp seed source is controlled in terms of quality and pathogen; ii) reducing risks: they can become contract farms with processors (pangasius), and they can buy high input quality and get supports on disease diagnostic services from professional sector and input suppliers; and iii) improvement of management practices (technical and management skills): they can share the experience on the husbandry skills and receive frequently technical training courses from the local government. Collective action through farmers' organizations can help small-scale farmers overcome challenges related to market liberalization, globalization and increasingly stringent quality and safety requirements for aquaculture products (Kassam et al. 2011). For example, Thoi An Pangasius cooperative was established in 2003 with 10 farmers, and a successful model on the co-operation with Hung Vuong company led to increased the number of cooperatives members, by 2010 there were 20 members. To join the co-operatives, the farmers have to contribute their fish ponds and investment, the benefit sharing being based on the amount of capital investment and land area contributed in each production cycle. Working as a cooperative helps the farmers to overcome the difficulties of securing operational finance and reduce risks of farm gate price through vertical linkages with Hung Vuong company. Moreover, they can more easily obtain loans from the state bank with preferential interest rate (Anh 2014).

Although vertical and horizontal contractualisation are necessary for risks and vulnerability to be reduced, the government agencies play an important role in providing support and interventions. Agro-food value chains often are characterised by highly asymmetrical power relations, and that the terms of participation in these chains to a large extent are controlled by downstream actors (Bolwig et al. 2010), and particularly small-scale farms are very weak power relations. The role of the government is important in establishing regulatory control programmes for ensuring food quality at the primary production level. The private sector's role is to invest in supply chain infrastructure, develop service markets, and transfer technical and market information to smallholders (Humphrey 2006; Ruben et al. 2007). Horizontal coordination in terms of support and interventions from the government should be improved to make these dimensions of contractulisation becoming feasible and effective. The policy on financial and technical supports are revised to support for the vertical and horizontal contractualisation, but simultaneously the Government intervention is needed to create and enforce legal contracts between farmer groups and processors (pangasius), and ensure control on the quality of farming input products, especially seed quality and chemical products. The government institutional environment plays a decisive role in guaranteeing the legal framework and defining transparent rules for conflict settlement (Key & Runsten 1999; Ruben et al. 2007; Amanor 2009). For example, current catfish farming practices show that the payment schedule between farmers and processors was often delayed by processors, and this increased the operation cost of farmers due to their interest payment of loan for the delay period (Belton 2010; Trifković 2013; Hansen & Trifković 2014). Hence, the intervention should be ensure legal agreement in term of payment schedules and minimum price are in place and observed (Bush et al. 2010; Le & Cheong 2010). Key & Runsten (1999) indicate that contract farming provides best outcomes under conditions in which public surveillance is guaranteed. Moreover, the Government needs to improve the cooperative law and farmer group regulations, with special attention to smaller scale groups to improve economic performance (Bush et al. 2009; Ha & Bush 2010; Pham et al. 2011).

CHAPTER 6

Perceptions of sustainable development issues for farmed seafood species in the Mekong Delta

6.1. Introduction

Aquaculture plays an important role in the global fish system and contributes more fish to global food demand than capture fisheries (Subasinghe et al. 2009; Asche & Guttormsen 2009; Belton & Little 2011). The aquaculture sector has continued to grow, however, it has to guarantee sustainable development that not only meets the needs of seafood producing countries, but also the requirements of importing countries in terms of customers' requirements on food safety, animal welfare, environmental sound and social responsibilities (Corsin et al. 2007; Subasinghe et al. 2009; Bostock et al. 2010; FAO 2012). Hence, the challenge for the sustainable growth of aquaculture is to improve production performance while simultaneously minimizing impacts (Martinez-Cordero & Leung 2003; Frankic & Hershner 2003). Aquaculture can make significant contributions to development by improving incomes, providing employment opportunities and increasing the returns on resource use (Subasinghe et al. 2009; FAO 2012; Hishamunda et al. 2014; Belton & Bush 2014). However, growth of aquaculture must not only maximize benefits, but also minimize negative impacts on the natural and social environment (Kutty 1995; Frankic & Hershner 2003). Sustainable aquaculture systems can avoid most conflicts among reasonable interests, and three-dimensional sustainability principles can serve as a basis for building a more complex sustainability system (Kutty 1995; Glavič & Lukman 2007).

The use of sustainability indicators has proved to be both an objective and efficient monitoring tool to assess the rational use and management of natural resources

(Moctezuma-Malagón et al. 2008; Bell & Morse 2008). Sustainability indicators are not only useful for measuring progress but also for identifying problems, setting sustainable development goals and identifying suitable management strategies (Reed et al. 2006; Bell & Morse 2008). Development towards a sustainable trajectory for the Vietnamese aquaculture sector in the master plan until 2020 (MARD 2009b; MARD 2009c); however, there are only general guidelines for how this will be accomplished. There is a lack of specific analysis on factors driving sustainability such as the role of actors along the value chain, the nature of the specific sustainability issues to be concerned about and which factors are driving forces for sustainability through the value chain. Considering the gradual increase in seafood consumption and requirements from the customers regarding sustainability issues in recent years, for instance the Netherlands, Germany and UK markets have higher requirements for pangasius products with respect to production quality and sustainability (Beukers et al. 2012; CBI 2012a; CBI 2012b). This chapter, therefore, analyses value chain clusters of farmed striped catfish and shrimp, the main marketing channels and constraints of main stakeholders along the value-chain. This study also provides an assessment of perception of sustainability issues by different stakeholder groups along the value chains and their corresponding measurement tools and mitigation actions.

6.2. Chain actors: position and operational constraints

6.2.1. Catfish value chain: current constraints of key chain actors

Stakeholders in the striped catfish value chain are highly diversified (Figure 3.12). In chapter 3, general information on the current situation of stakeholders along the value chain in the MKD was described, and its value chain has also been described in the detail in previous studies (Vo et al. 2009a; Vo et al. 2009b; Le 2011; Khoi 2011; CBI 2012b;

Trifković 2013). Therefore, in this section, based on the scoping survey, the current constraints of major stakeholder groups affecting the process of commodity flow are presented as follows:

a). Input suppliers

Input suppliers can be classified into two main sub-groups i) feed manufacturers and traders; and ii) veterinary medicine manufacturers and traders. These actors participate indirectly in the production chain, providing inputs for production flows. This group also plays an important role in ensuring the quality of inputs for production and affects the production efficiency of the value chain. The system of feed and veterinary product distribution is quite diversified; however, diversity of distribution channels could make for difficulties of quality control and management. At the time of this study, feed costs accounted for 80-83% of production cost per kg of fish at the farm level, and can bring US$0.163-0.254/kg harvested fish of net profit for feed suppliers. While the cost of veterinary products used was 1.50-2.20% of production cost per kg of fish, and thus the chemical/drug suppliers could earn US$0.0036-0.0054/kg of harvested fish. By participating in the catfish value chain, the input suppliers profit while facing low business risk compared to the farmers. There were however, several problems faced including i) market issues/trade competition (71% of respondents) with many input suppliers leading to high trade competition among them; ii) operational linkages (36%) with a lack of horizontal and vertical integrated linkages leading to unstable markets in term of customers and the volumes of product traded; iii) capital investment (29%) as they faced financial constraints related to operation and upgrade; iv) supply materials sources (21%) with more than 60% of raw-materials for feed production imported feed manufacturers often faced problems obtaining raw-materials in term of unstable sources and quality; and v) policy and regulation issues (14%) where the lack of proper policies for financial support and high import tax on feed raw materials also increased production cost.

b). Seed suppliers

There are several stakeholders related to seed production, including brood-stock suppliers, hatcheries, nurseries and seed traders. Hatcheries play an important role in this group; however the hatcheries developed spontaneously and the production target of hatcheries depends on the demand from grow-out farmers (Khoi 2011; Rigg 2012). The seed supplier group is a key foundation node of the value chain, and it can directly affect the value chain through the quality and cost of production. Seed quality is a key measure of the successful operation of a hatchery, and directly relates to and depends on the quality of brood-stock (Khoi 2007; Le & Le 2010; Khoi 2011). Seed comprised between 5.96-7.20% of production cost per kg of marketable fish, so the seed suppliers could earn US$0.0121-0.0181/kg harvested fish. With the higher intensification level of catfish farming, this sector also provides greater opportunities for seed suppliers to gain profit and provide jobs for local people. However, they also faced several constraints i) market issues/trade competitions (91% of respondents) as many hatcheries were concentrated in a small area leading to high competition, inconsistent sales price and unpredictable supply/demand situation; ii) capital investment (59%) with a lack of operational finances for operation and upgrading; iii) water sources (43%) where poor water quality may contribute to increased seed mortality and reduced seed quality; iv) seed disease (34%) where seed disease can lead to high mortality rate from fry to fingerling, caused by poor water quality and slow replacement/improvement of brood-stock population; and v) operation linkages (28%) where a lack of horizontal/vertical integrated linkages leads to unstable markets in terms of customers and seed production.

c). Grow-out farmers

This group is an important actor of the value chain, providing the main source of raw material for processing. The quality of raw materials depends on technical skills, seed sources, type of feed, drugs/chemicals used and environmental conditions. Striped catfish farming can be classified into three main types: i) type 1: farm is fully owned and operated by a pangasius processor who takes all or most of its harvest (i.e. vertically integrated business); ii) type 2: privately owned by a farm enterprise to which a pangasius processor supplies feed (and/or seed) based on agreement to sell back harvest at pre-agreed price; and iii) type 3: privately owned by an independent farm enterprise that independently sources feed (and/or seed) inputs and sells the harvest to processors at an 'on the spot' price. Recent trends have shown that the farm type 1 and 2 are gradually increasing with the reverse trend for farm type 3. In order to become farm type 2, farms often come from co-operatives or large-scale farms, as it is not easy for independent small-/medium farms to become contracted farms as they do not meet the criteria for contract terms and also lack a historical business relationship (Pham & Truong 2011).

From the scoping study it was clear that during operation fish farmers faced some problems the most important being i) capital investment (i.e. finance for investment) identified by 80% of respondents; ii) 71% of catfish farms faced market issues (i.e. fluctuation of farm gate price and unpredictable supply/demand); iii) fish disease (67%) has increased, especially BNP and MAS diseases; iv) 67% of farms reported degradation in water quality due to increased chemical/drug use; and v) reduced seed quality (58%) leading to higher mortality and increased frequency of fish disease.

d). Pangasius processors

Processors play an important role in the value chain of catfish, by regulating the value chain in terms of raw material and fish price. Processors share a lower proportion of net added value per 1kg of fish (Table 3.5), but with large production capacities the processors always play important role in the value chain (Le et al. 2011; Le 2011). During this study, processors perceived several constraints, such as i) market issues/trade competition (86% of respondents) where the large number of pangasius exporters had resulted in high and unfair competition and trade fraud; ii) trademark or brand name building (63%) as without product trademarks, processors have to sell their products through export agents or importers, thereby reducing their profit and the competition of products on the market; iii) lack of an effective master plan for the processing sector (63%); iv) technical/trading barriers (50%) including increasing requirements of importers with regard to environmental protection and social responsibility; anti-dumping; traceability and standards requirements or food safety assurance; and v) policy/regulation issues (38%) where the policies on financial support were still not effective.

6.2.2. Brackish-water shrimp value chain: current constraints of key chain actors

An overview of information on the current situation of stakeholders along the shrimp value chain was presented in chapter 3, and the value chain of shrimp in the MKD has also been described in detail in previous studies (Vo 2003; Le et al. 2011; CBI 2012b; Vu et al. 2013; Tran et al. 2013). Based on the scoping survey, this section presents the current constraints of major stakeholder groups who affect the process of commodity flow:

a). Input suppliers

Input suppliers included i) feed manufacturers and traders; and ii) veterinary medicine manufacturers and traders. This group plays an important role in ensuring the quality of the inputs for production and affects the production efficiency of the shrimp value chain. The system of feed and veterinary product distributionis quite diversified; however, the diversity of distribution channels could make difficulties for quality control and management. At the time of this study, feed accounted for 55-60% of production cost per kg of shrimp in the semi-/intensive and rice-shrimp farming systems, and resulted in US$0.43-0.65/kg harvested shrimp net profit for feed suppliers. The cost of veterinary products used was 12-14% of production cost per kg of shrimp, and thus the chemical/drug suppliers could earn US$0.096-0.144/kg harvested shrimp. With the trend toward farm intensification, such input suppliers could increase profits with little risk compared to the farmers. However, they also faced several problems such as i) a crowded market with resultant intense competition between input suppliers (86% of respondents); ii) poorly developed operational linkages with customers resulting in unstable demand (43%); iii) instability of availability and quality of feed ingredients (29%); and iv) constrained access to both short-term and capital investment (14%).

b). Seed suppliers

There are several stakeholders related to seed production, including brood-stock suppliers, hatcheries, nurseries who produce only post-larvae from Nauplius stage, and seed traders who buy post-larvae from provinces in Central Vietnam and sell to local farmers. At the time of this study, the cost of seed for grow-out farming was 4.26-6.10% of production cost per kg harvested shrimp, so the seed suppliers could earn US$0.0337-0.0507/kg harvested shrimp. A large area of shrimp farming in the MKD brought opportunities for the development of the seed production sector. In their current practices, seed suppliers faced the following constraints: i) market issues/trade competitions (80% of respondents) as there were many hatcheries in the MKD and central provinces leading to high competition; ii) water sources (67%) where some hatcheries in Can Tho and Soc Trang faced problems with hyper-saline water sources (e.g. non availability water sources in local area, and higher cost of hyper-saline water use), and water quality degradation increased seed mortality and reduced seed quality; iii) brood-stock and seed quality (40%) as the hatcheries depended heavily on wild brood-stock sources, thus they were unsure about the quality of brood-stock, seed quality varied and was unstable between production cycles; iv) juvenile disease (33%) leading to high mortality rates at hatching and nursing stages; and v) capital investment (27%) where there was a lack of operational finances for operation and upgrading.

c). Grow-out farmers

This group is an important value chain actor that provides the main source of raw material for processing. The quality of raw material depends on technical skills, seed sources, type of feed, drugs/chemicals use and environmental conditions. Similar to catfish farms, shrimp farming has also developed mainly under three farm types: i) type 1: the farm is fully owned and operated by a seafood processor, and they are mainly intensive shrimp systems; ii) type 2: privately owned by aquaculture Ltd. company, they are contract farms with the processors and are mainly intensive shrimp systems; and iii) type 3: privately owned by independent farm enterprises, they are mainly individual mixed mangrove-shrimp, improved-extensive, rice-shrimp rotation and semi-intensive shrimp systems, and some aquaculture Ltd. companies with intensive-shrimp system.

Around 40 shrimp processors in the MKD are currently operating, and their raw material sources mainly come from independent shrimp farms (Le et al. 2011). Wholesalers had an important role to buy and collect shrimp for processors. Our survey found that shrimp farmers faced some problems, being i) lack of available credit was mentioned by 70% of respondents; ii) shrimp disease (69%) especially AHPNS and WSSV diseases; iii) seed quality (68%) being inconsistent and generally in decline leading to high mortality; iv) 59% of farms report water resources were degraded in terms of water quality due to increased use of chemical/drug; and v) 31% of farms faced technical issues regarding methods of disease prevention and treatment and also skills related to water management during extreme weather.

d). Shrimp processors

Processors regulated the value chain in terms of raw material sources and shrimp prices. Although the processors share a low proportion of the net added value per 1kg of shrimp produced (Table 3.6), with their large production capacity they play an important role in the value chain (Le et al. 2011; Vu et al. 2013). At the present, processors have faced several problems such as i) market issues/trade competition (88% of respondents) asthere was high competition with other country producers; ii) trademark or brand name building (63%) as without a trademark, processors have to sell their products through export agents or importers, so reducing profit and the competition of products on the market; iii) lack of an effective master plan for the processing sector (63%); iv) technical/and trading barriers (50%) where requirements of importers are increasing with regard to environmental protection and social responsibility; anti-dumping; traceability and standard requirements or food safety assurance; and v) policy/regulation issues (38%) where the policies on financial support was still not appropriate and effective.

6.3. Perceptions on sustainability issues and measurement

6.3.1. Sustainability issues perceived by different stakeholder groups

a). Seed producers group

✧ ***Striped catfish hatcheries:*** There were twelve different factors affecting their future development, of which *water quality & availability*, *disease management, unstable markets* and *management & technical skills*, were raised by 67% of respondents (Figure 6.1). The hatcheries suggested that *water quality & availability* and *disease management* should be considered as key factors for future development. Water quality & availability were viewed as negative impact factors as a reduction in water quality could affect production efficiency and contribute to high seed mortality and disease. Recently, seed quality degradation was raised as a main reason for slow growth rate and increasing fish mortality at the grow-out stage. The reduction of seed quality, an universal concern of hatchery managers in Asia (Little et al. 2012) may have derived from overuse of a brood-stock population over time with a low number of brooders being added or changed, and sometimes multi-spawning of the same brood-stock per year during periods of high demand and overuse of the hormone (HCG) to induce spawning (VIFEP 2009a; Bui et al. 2010; Le & Le 2010). It has been recommended that $3\text{-}6^{+}$ year old broodstock should be used for spawning, and that individual fish should not be spawned more than twice in a 12 month period (Phuong et al. 2011). Bui et al. (2010) noted a significant negative trend between the combined hormone dose rate for females and hatching rate during the peak season. Additionally, disease management is still a constraint for the future operation of hatcheries, especially during nursing stages from fry to fingerling. Hatcheries often faced disease in juveniles and difficulties on how to increase survival rate and seed quality. Maintaining seed quality was identified as critical to ensuring sustainable production of catfish, with attention to improved breeding practices and genetic factors being necessary (Bui et al. 2010; Le & Le 2010; Sang 2010).

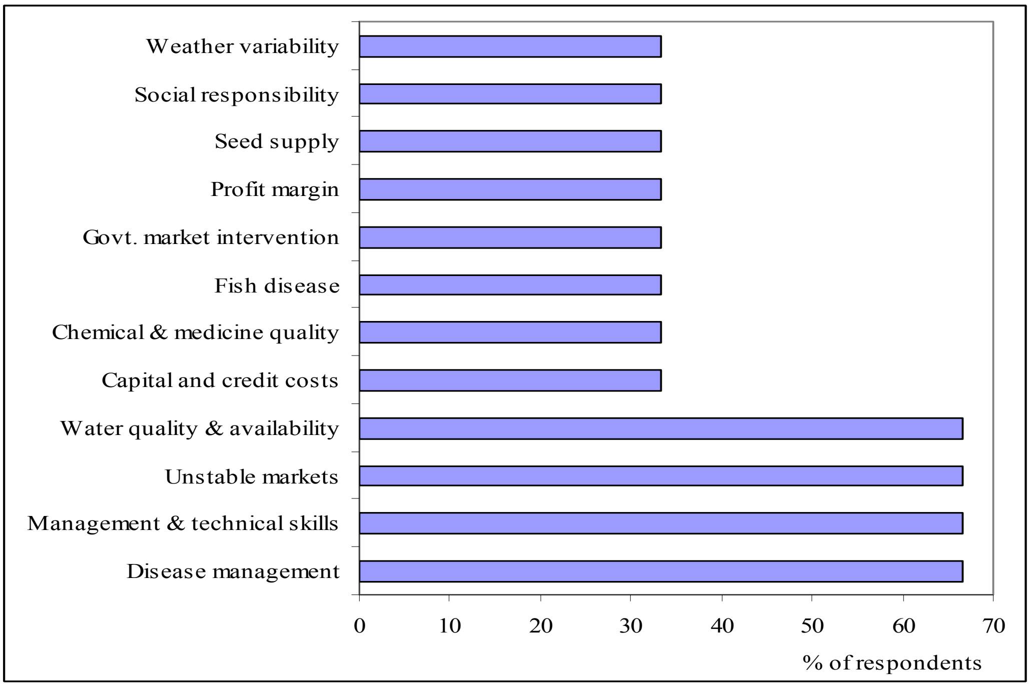


Figure 6.1. Sustainability issues perceptions by catfish hatcheries
Source: State of system workshop (2011)

✧ ***Shrimp hatcheries:*** The shrimp hatcheries group indicated that *water quality & availability* was a major factor and was identified by all respondents. This was followed by *seed quality* (83%), *shrimp disease* (67%), *weather variability* (50%) and *market demand* (50%) as the top five sustainability factors (Figure 6.2). However, *seed quality* factor was ranked at the most important issue followed by *water quality & availability*, *shrimp disease*, *weather variability* and *market demand*. A high rate of post-larvae not passing the PCR test was strong evidence for a reduction of seed quality (Nguyen*, pers.comm., 11/8/2013*). In 2012, 322 post-larvae samples from shrimp hatcheries were tested using PCR, of which 54% had been infected by *Vibrio sp. (V.parahaemolyticus, V.harveyi* and *V.Vulnificus)* (Fisheries Directorate 2012; DoAH 2013b). VIFEP (2009) indicated that the main obstacles for shrimp hatcheries so far were seed disease and lack of good brood-stock sources; the wild brood-stock of black tiger shrimp was often caught onshore resulting in a low maturity coefficient and white-legged shrimp brood-stock were also characterized by unstable quality leading to lower seed quality (Fisheries Directorate 2012). Le et al. (2011) also noted that the impacts of seed quality and weather variability attention by the sector. Additionally, factors of water quality & availability, shrimp disease, weather variability and market demand will continue to affect that hatchery operation in the future; and hence this sector needs to improve its practices, industry planning and management.

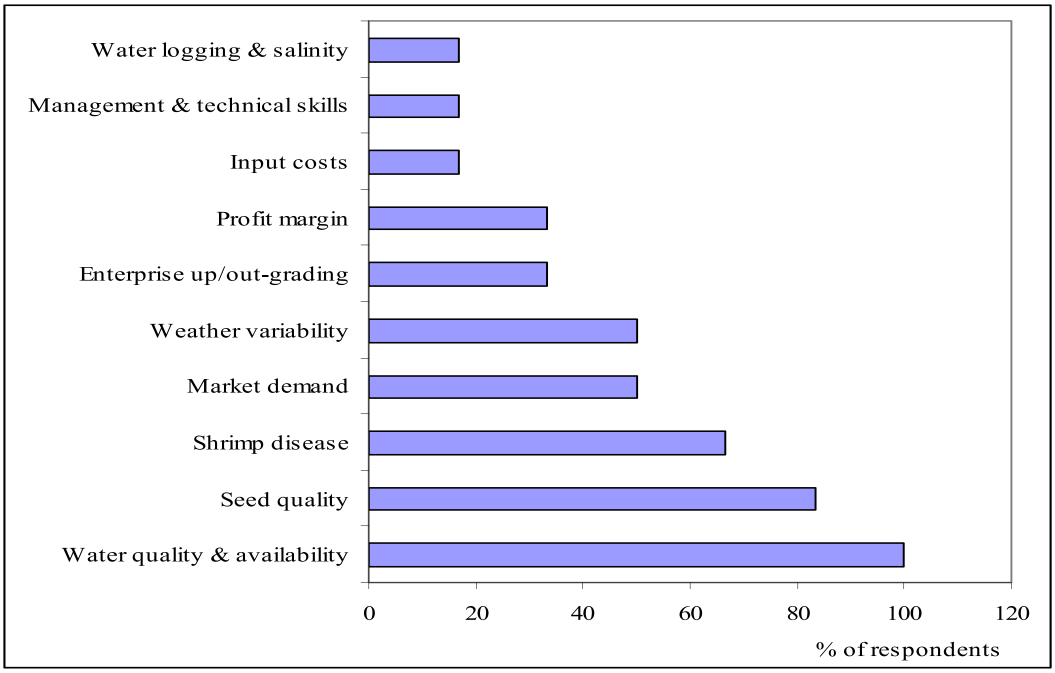


Figure 6.2. Sustainability issues perceptions by shrimp hatcheries

Source: State of system workshop (2011)

b). Grow-out producers group

✧ ***Striped catfish grow-out farmers:*** Almost all catfish farmers were more concerned with the negative aspects and less concerned with the positive and uncertain impacts of sustainability issues, because farmers tended to concentrate on the threats to sustained success (Figure 6.3).

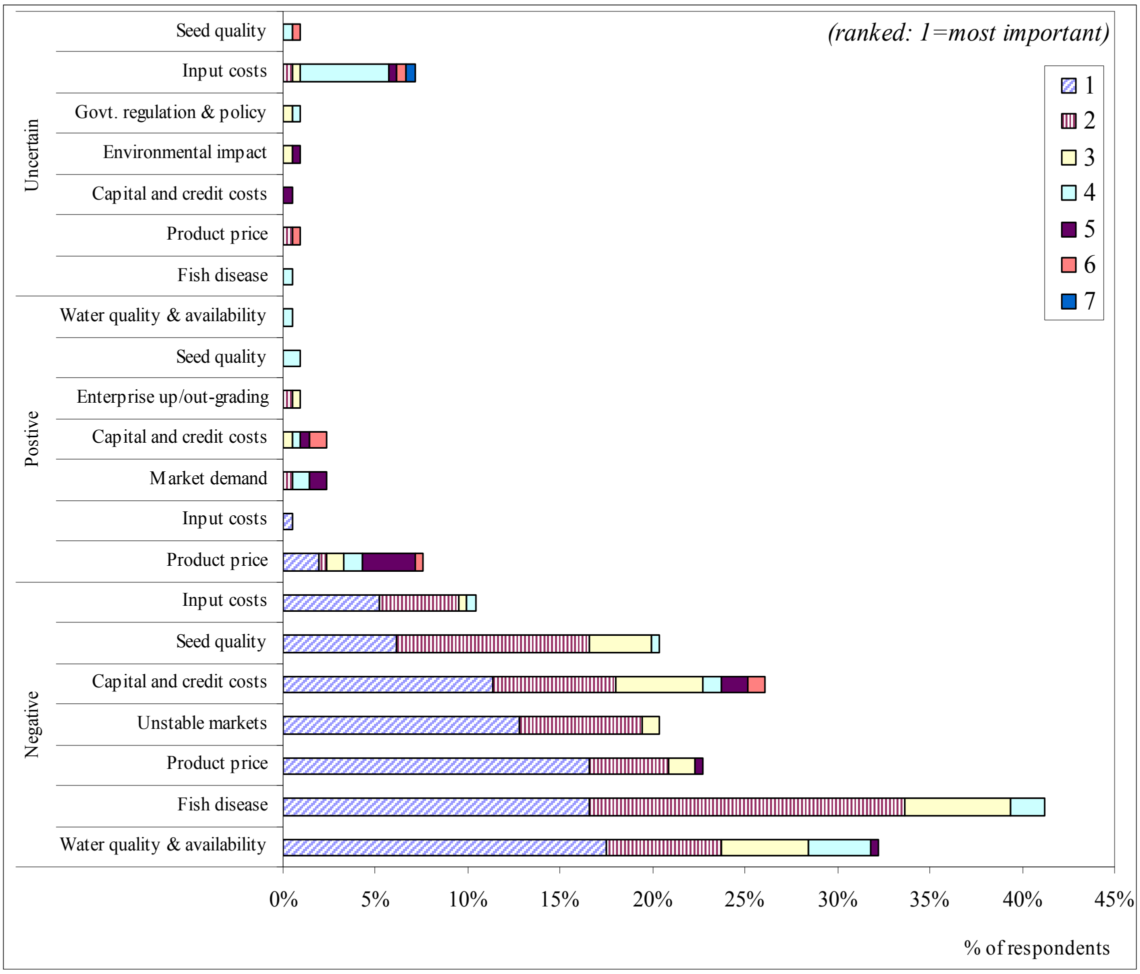


Figure 6.3. Sustainability issues perceptions by operational impacts of catfish farmers

Source: IFS survey ***(2011)***

In the short-run, the top five factors were *fish disease (45% of respondents)*, *water quality & availability (40%), product price (37%)*, *capital & credit costs (29%)* and *unstable markets (21%);* and they also had a higher ranking in terms of importance levels than other factors. *Product price* and *input cost* were also mentioned in terms of positive and uncertain impacts. Recently, *input cost* has been unstable and feed/chemical costs are gradually increasing while the farm gate price has reduced leading to exclusion of weaker farms from the catfish sector. *Product price* depends on the markets and culture season, so many farmers view this as a positive because they have had successful crops and sold fish at a good price (i.e. selling price is higher production cost).

Perceptions of sustainability issues (SIs) were significantly different by farmer scale ($P<0.05$). *Product price* was identified as a key factor by small-farmers ($P<0.05$) being relatively more important to this group than for larger-scale farms (Figure 6.4), and exacerbated by the lack of operational linkages that this group had with processors, low levels of production insufficient to meet processors' requirements and higher rates of yellow flesh-meat quality (15-20% compared to <15% in case of medium and large farms). If the farm gate price is low over the long term and input costs increased, these farms tended to temporarily stop farming. De Silva & Nguyen (2011) noted that a shift in low farm gate price, particularly in the wake of the increasing costs of inputs often makes the practices economically unviable. Small-farms often operated on an individual basis, and face this problem more so than contracted farms and large-farms that are vertically integrated with processors. It also was the same problem for the hatcheries sector during the low farm gate price, in 2012 there were 140 hatcheries, this was a reduction of 80 hatcheries compared to that in 2010. Most of the hatcheries that suspended operations temporarily were small scale, and they faced problems of marketing and low seed price (Fisheries Directorate 2013a). Generally, the small-/medium farms were more concerned about the economic aspects of sustainability issues (i.e. *product price*, *unstable markets,* and *capital & credit cost* factors), while large-farms were mainly concerned with environmental issues (i.e. *water quality & availability, environmental impact,* and *seed quality*). Large-farms are often corporations or aquaculture companies or contracted/linkage farms, and have activities linkages with other value chain actors; hence they were less impacted with issues of farm gate price and capital investment. *Seed quality* was identified as a negative impact factor and mentioned by all farm scales, and thus indicated the need for an improvement programme for brood-stock and seed quality supply.

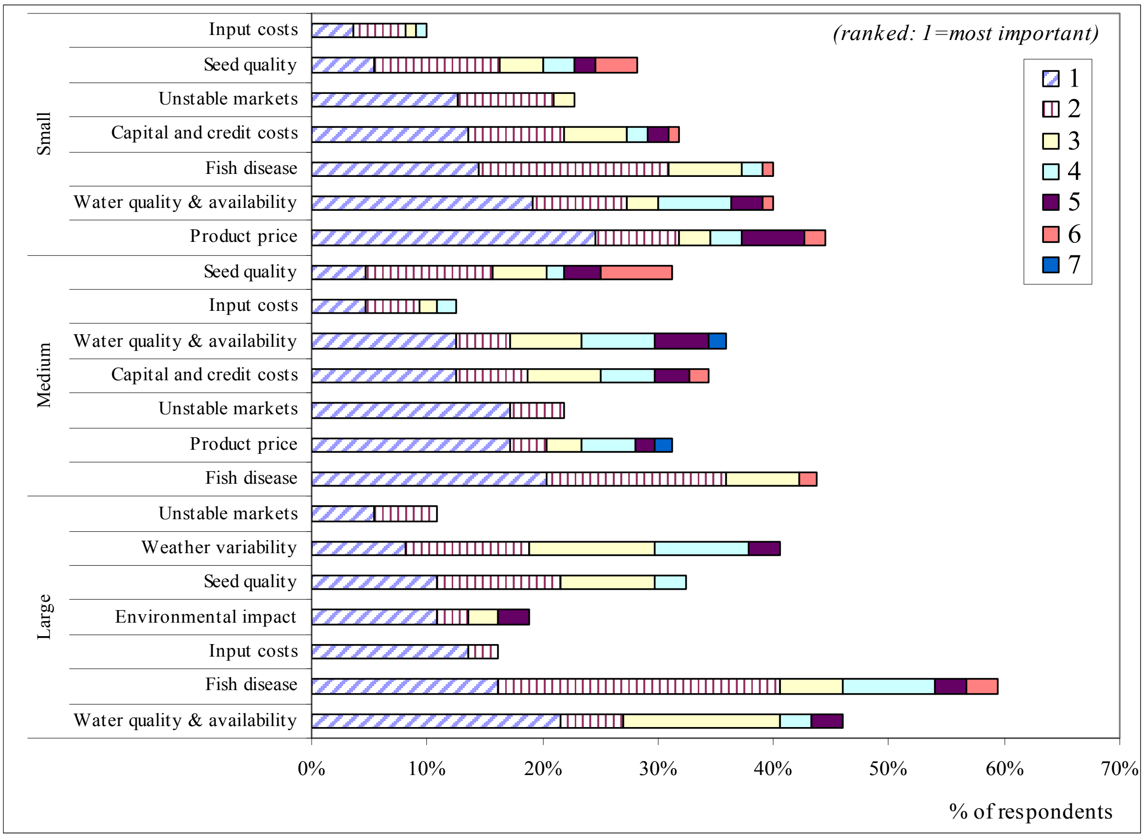


Figure 6.4. Sustainability issues perceptions by scale levels of catfish farmers

Source: IFS survey ***(2011)***

Many catfish farmers were unconvinced of pagasius farming being the future of choice for their children (Figure 6.5), reflecting the problems affecting in recent years. The main reason is the high-risk nature of farming in terms of product price and markets which are often unstable and fluctuating. Khiem et al. (2010) pointed out that the vulnerabilities of the catfish sector included global market vulnerabilities, production challenges and governing quality standards; and factors such as market diversification, development in export markets, global financial crisis, input use (feed, drug/chemicals), challenges of food standards, and governmental policy developments will impact on the vulnerability of this sector.

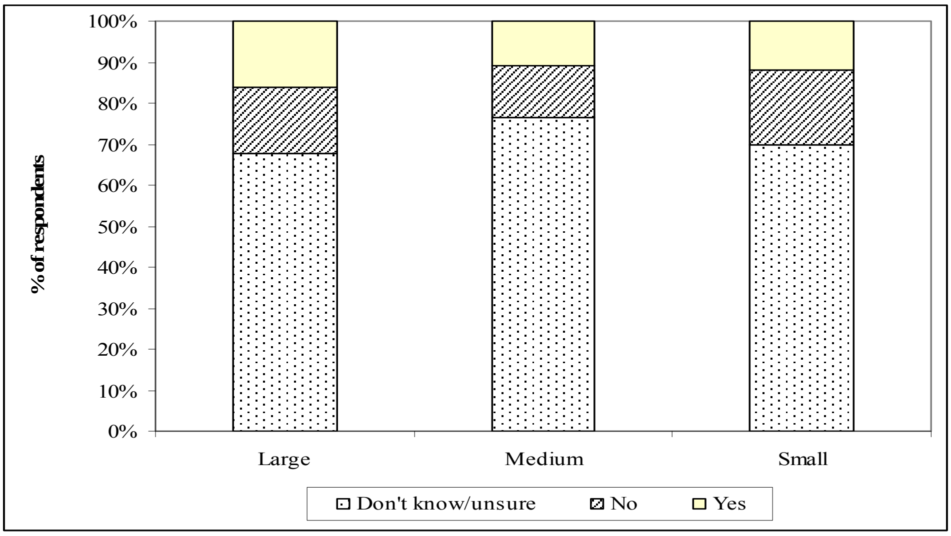


Figure 6.5. Children farming future by catfish farm scale

Source: IFS survey (2011)

✧ ***Shrimp grow-out farmers:*** similar to catfish farm's perceptions, most shrimp farmers were more concerned with negative impact factors than with positive and uncertain aspects (Figure 6.6). The main factors cited as concerns for development were *shrimp disease (54%), seed quality (44%), water quality & availability (46%), weather variability (62%)* and *capital & credit cost (25%);* and they were also ranked as most important. *Product price* and *market demand* were also positive factors, because both factors increased slightly between 2009 and 2013. Recently, shrimp disease outbreaks have become more serious, and this may have affected the perceptions reported. The serious shrimp diseases during this study were WSSV and YHV, and both occurred annually and tended to increase due to poor quality seed, poor water quality and spread of disease from the surrounding environment (Nguyen et al. 2009; Oanh & Phuong 2012). Pond-to-pond transmission is more likely a contributing factor to the spread of WSSV in semi-/intensive systems, while its transmission within the pond occurs in improved-extensive shrimp systems (Hoa et al. 2011). Before 2010, serious shrimp diseases were WSSV and YHV, both types of disease occurred yearly and have tended to increase. For example, in 2011, 1,000ha of shrimp farmed area was infected by WSSV and this increased to 12,250ha by 2013.WSSV disease affected both black tiger shrimp and white-legged shrimp in all shrimp systems (Fisheries Directorate 2010; DoAH 2013a). Since late 2010, AHPNS disease has been prevalent in semi-/intensive systems, over a wide area in the MKD and it is still causing serious losses for farmers (DoAH 2013b). Shrimp disease was a main cause of economic loss and it was perceived as a key factor driving sustainability of this sector, because lack of returns for shrimp farmers led to lack of investment.

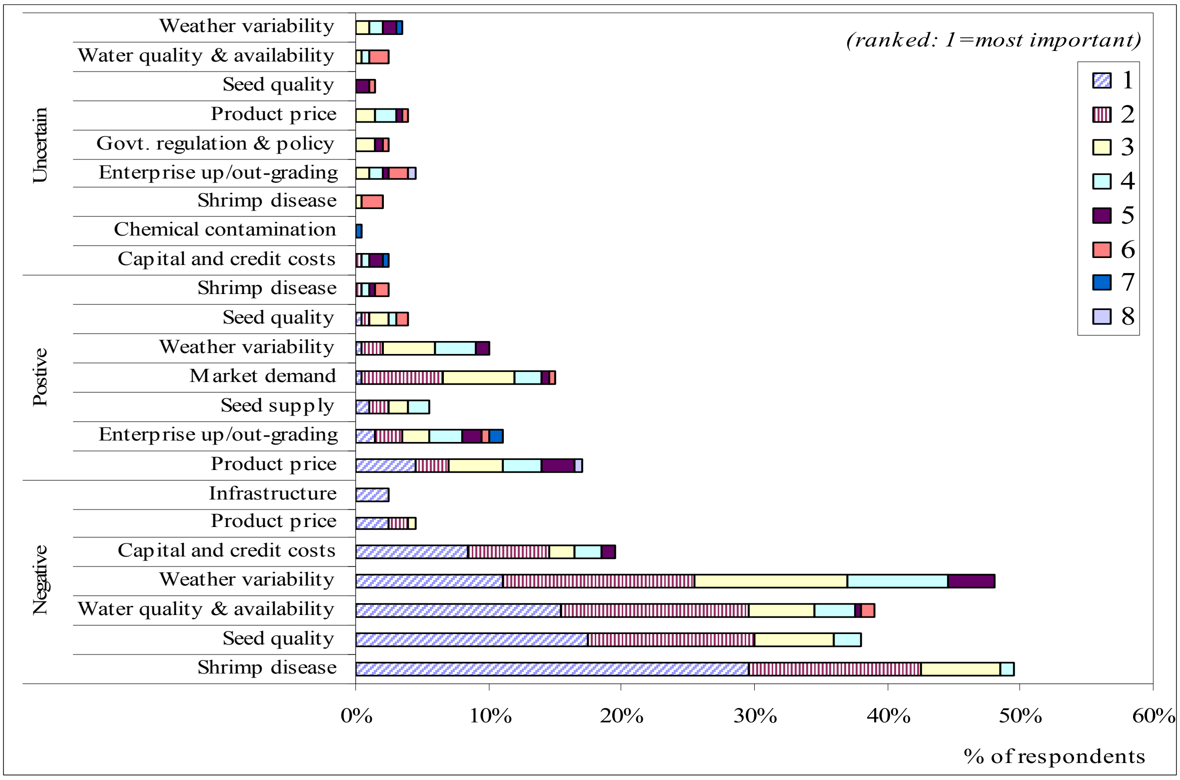


Figure 6.6. Sustainability issues perceptions by operational impacts of shrimp farmers
Source: IFS survey (2011)

There were different perceptions on SIs that were significantly affected by system system, per each shrimp system, there was a statistically significant difference in SIs perception for future development ($P<0.05$). Most farmers identified *shrimp disease* as a key factor undermining development and it was ranked as important by most farming systems (Figure

6.7), with a statistically significant difference among five shrimp systems (*P<0.05*). However, it was less important in the rice-shrimp rotation system due to the seemingly increased sustainability of this model (i.e. one crop for shrimp and one crop for rice). This helps to improve environmental conditions within ponds and reduce shrimp disease risk (MOFI 2006; RIA2 2009; FAO 2013a). *Seed quality* issue needs to be considered as a priority issue for development. *Weather variability* and *water quality/availability* have been resulting innegative impacts recently that are main factors affecting outbreak of shrimp disease. The result shows weather variability has a bigger impact on the most intensive system. Shrimp farmers said that with high stocking density, high fluctuation of weather (heavy rain, unstable weather etc.) makes water quality unstable and difficult to control, so it affects to shrimp health because shrimp is very sensitive with variation of water condition and farmers have to spend more money for chemical/probiotics use and labour for pond management.

Seed quality is percieved as a way to help farmers overcome this. *Seed quality* was a greater concern for the farm group with less than five years experience than the others, while *shrimp disease* was a greater issue for the farm group with more than five years experience.

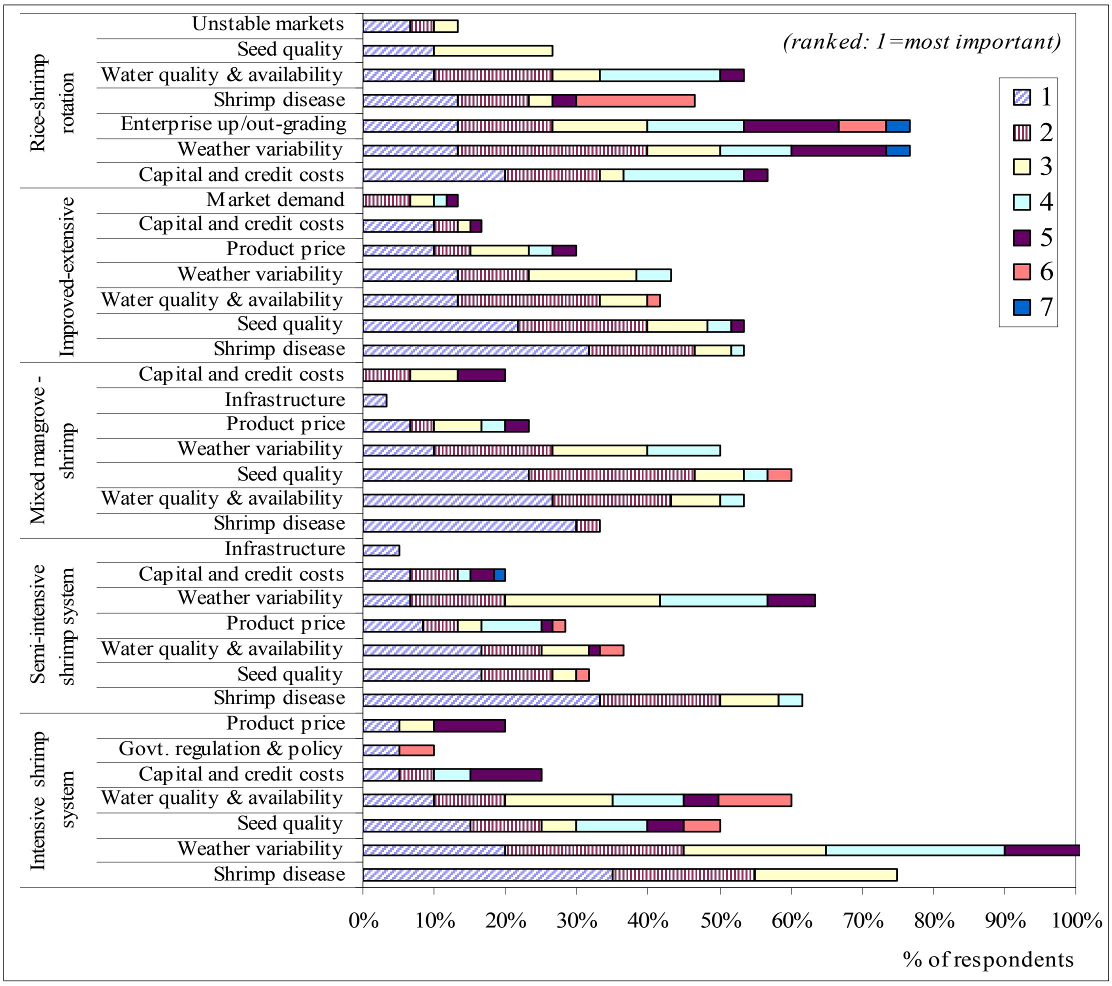


Figure 6.7. Sustainability issues perceptions by culture models of shrimp farmers

Source: IFS survey (2011)

The LoLI shrimp systems (mixed mangrove-shrimp, improved-extensive, rice-shrimp rotation) were more positive about their children working on shrimp farms than in the HiLI system (semi-/intensive system) (Figure 6.8), with a significant difference among farm systems ($P<0.05$). This reflects the more positive view of shrimp farming taken in the LoLI system with respect to future development than in the HiLI system. The LoLI systems were located in remote areas where shrimp culture is the main occupation and there is less livelihood diversification, so farmers had fewer options.

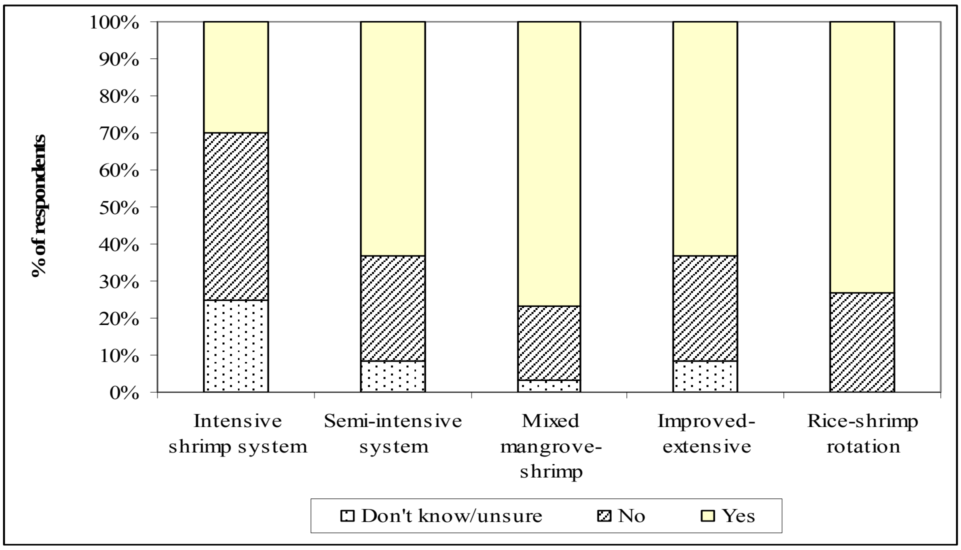


Figure 6.8. Children farming future by shrimp system

Source: IFS survey (2011)

c). Input suppliers group

Input suppliers group, including the chemical/feed processors and traders surveyed indicated concern over the following five factors: *input costs* (70% of respondents), *govt. regulation & policy* (50%), *unstable markets* (40%), *govt. market intervention* (40%), and *seed quality* (30%) (Figure 6.9). However, in terms of importance rank *input cost*s were ranked highest, followed by *unstable markets, seed quality, govt. regulation & policy,* and*govt. market intervention*. Input costs were given more consideration by the feed companies, because raw materials accounted for 80% of production costs (Tuan et al. 2013). While the other actors indicated that gradual increases in oil/fuel and electricity prices had increased transaction costs.

Unstable markets may be affected by fluctuations in the catfish farming sector and unpredictable nature of shrimp disease outbreak. Seed quality is also considered as an important factor as it affects farm production efficiency and business. This group gave more attention to the Government policy/regulation on import tax on feed ingredients and chemical/probiotics products, and regulations on the allowable chemicals and compounds for use in aquaculture. Additionally, the lack of appropriate Government planning on the market management of this group operation was raised as a concern. Despite rising input costs, the stakeholders in this group must prioritise improvements in management practices towards sustainable development rather than waiting for policy support from the Government.

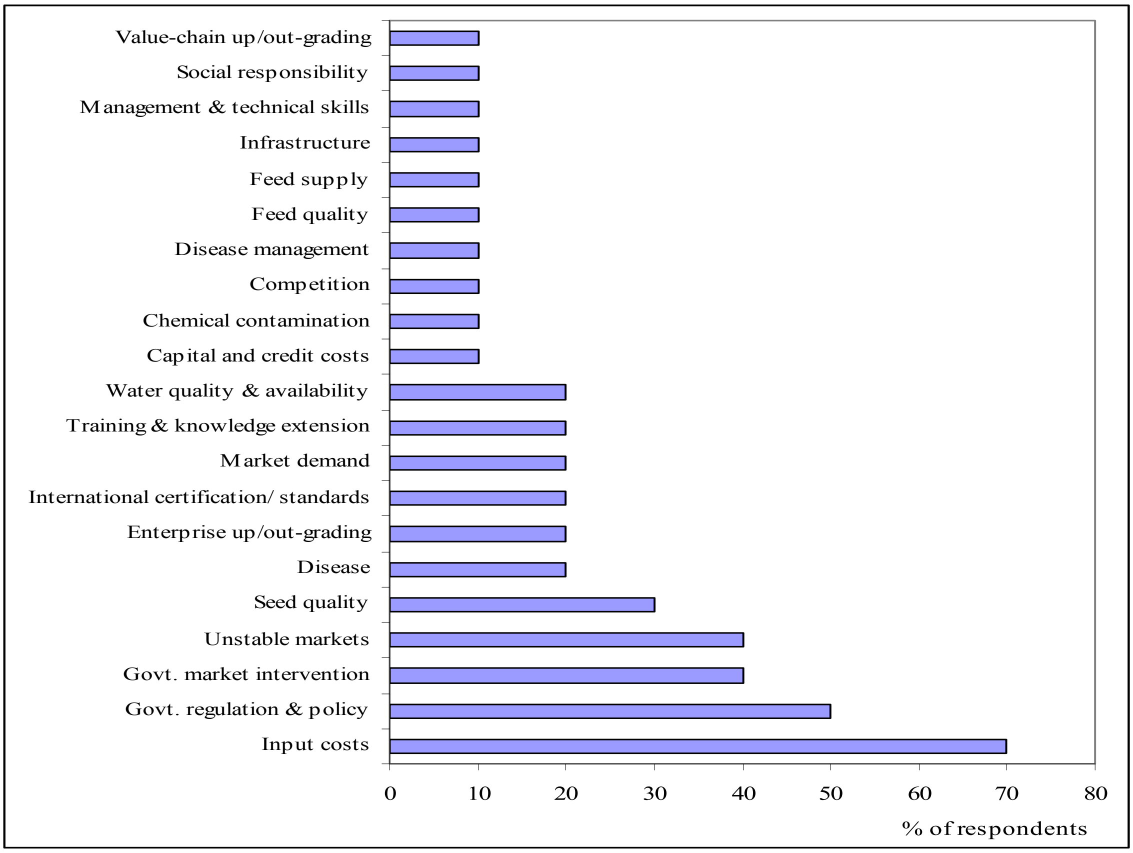


Figure 6.9. Perceptions of sustainability issues by input suppliers
Source: State of system workshop (2011)

d). Seafood processors group

Within this group the five sustainability factors with the highest number of citations were *capital & credit costs* (78% of respondents), *input supply* (67%), *product price* (56%), *input costs* (44%), and *international certification/standards* (44%) (Figure 6.10). However, the most important factor classified was *input supply*, followed by *capital & credit costs*, *product price, input costs* and *international certification/standards*.

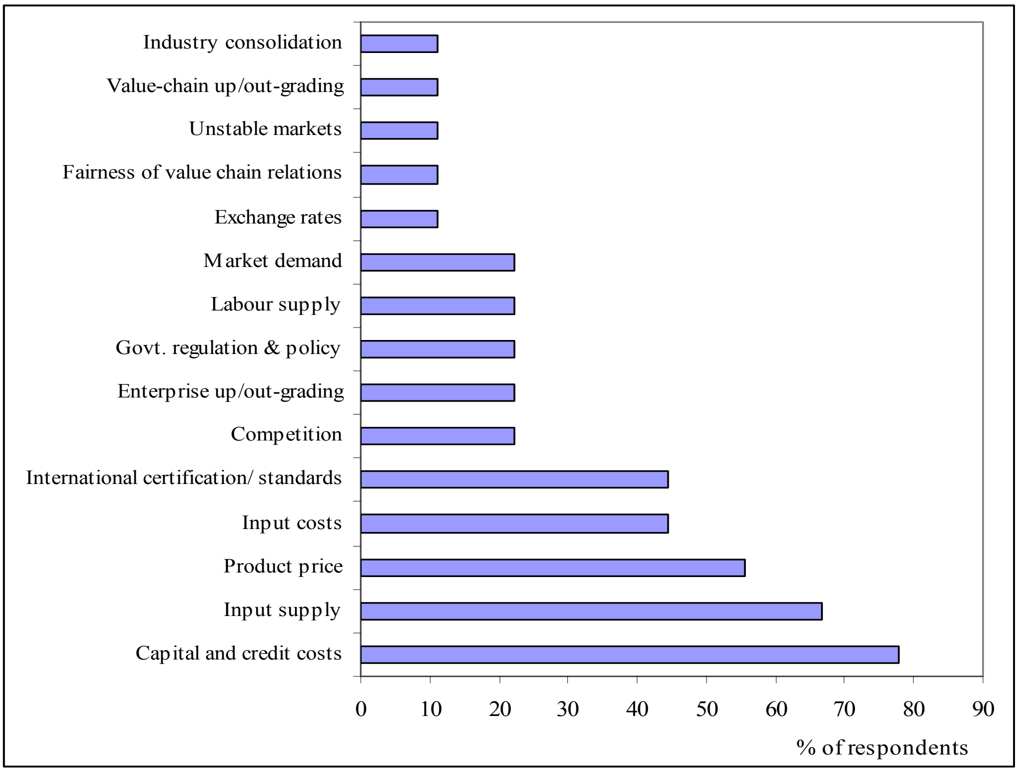


Figure 6.10. Perceptions of sustainability issues seafood processors
Source: State of system workshop ***(2011)***

Around 40 pangasius processors developed their own farms, and these farms contributed 50-70% of the total raw material for their processing lines (VASEP 2011; Khoi 2011; Trifković 2013). The remaining raw material came from independent catfish farms, although supplies from this source tended to fluctuate due to unstable farm gate price leading to suspension of some farm operations. The unpredictable nature of shrimp disease outbreaks resulted in instability and often a lack of shrimp production for processing lines. Additionally, this group also included the following in the product price from the buyers; the challenges of compliance for international certification/standards leading to increased production costs; input costs increasing as results of oil/fuel and electricity price hikes annually; and the lack of capital/credit costs used for operation and upgrading their business. Recent trends shows that the processors have developed their own farms or vertically integrated primary production, especially for pangasius processors (De Silva &

Nguyen 2011; Trifković 2013). However, the capital/credit cost was viewed as an important factor toward sustainability, so if the processors continue to run their business towards as strategy of self-vertical integration they will face big financial constraints. This study suggests that processors should invest in developing their operations in terms of adding value to the product (i.e. upgrading their processing technology for value added products, by-products, etc.) rather than expansion into farms and hatcheries, etc.; and manage raw-material sources through the vertically linkages with other value chain actors.

e). Management and supporting actors group

Twenty nine sustainability factors were identified by this group (Figure 6.11), the highest number of citations were for *seed quality* and *govt. regulation & policy* factors, with 100% of respondents identifying this, followed by *shrimp/fish disease* (71%), *input costs* (64%), and *water quality/availability* (64%). When ranked by importance, *seed quality* was the most important factor, followed by *govt. regulation & policy, water quality & availability, disease,* and *input cost* factors. Currently brood-stock (mainly for black tiger shrimp and partially for catfish) for seed production come from natural sources, so quality control is very difficult. While studies and programmes to improve broodstock populations are on-going they are carried out slowly and their efficiency is low, and thus the seed quality isnot well controlled and managed. For example, since 1998 RIA2 had implemented the study on improvement of black tiger shrimp brood-stocks in the artificial tanks; however, this study was not successful due to technical constraints. This study has been done again in 2007 when RIA2 applied the new system designed by the CSIRO organization and got successful results in 2008. This study created 3,500 brood-stock families, and produced around 5million PLs per year. Although there was successful study on the improvement of brood-stock population, this still faced the limitation on the techniques and the mass production of seed remained difficult until now (Phi 2010; MARD 2014). Seed quality is, therefore, an important factor determining production efficiency of farmers and affects the volumes of raw material available for processing. Moreover, limitations of *government regulation/policy* in terms of effective implementation in actual situations, was cited as an important factor, because overlap of functions and task remain between implementing agencies limiting their impact. Additionally, *water quality/availability* and *disease* were considered as constraints to the aquaculture sector, and challenges to its management.

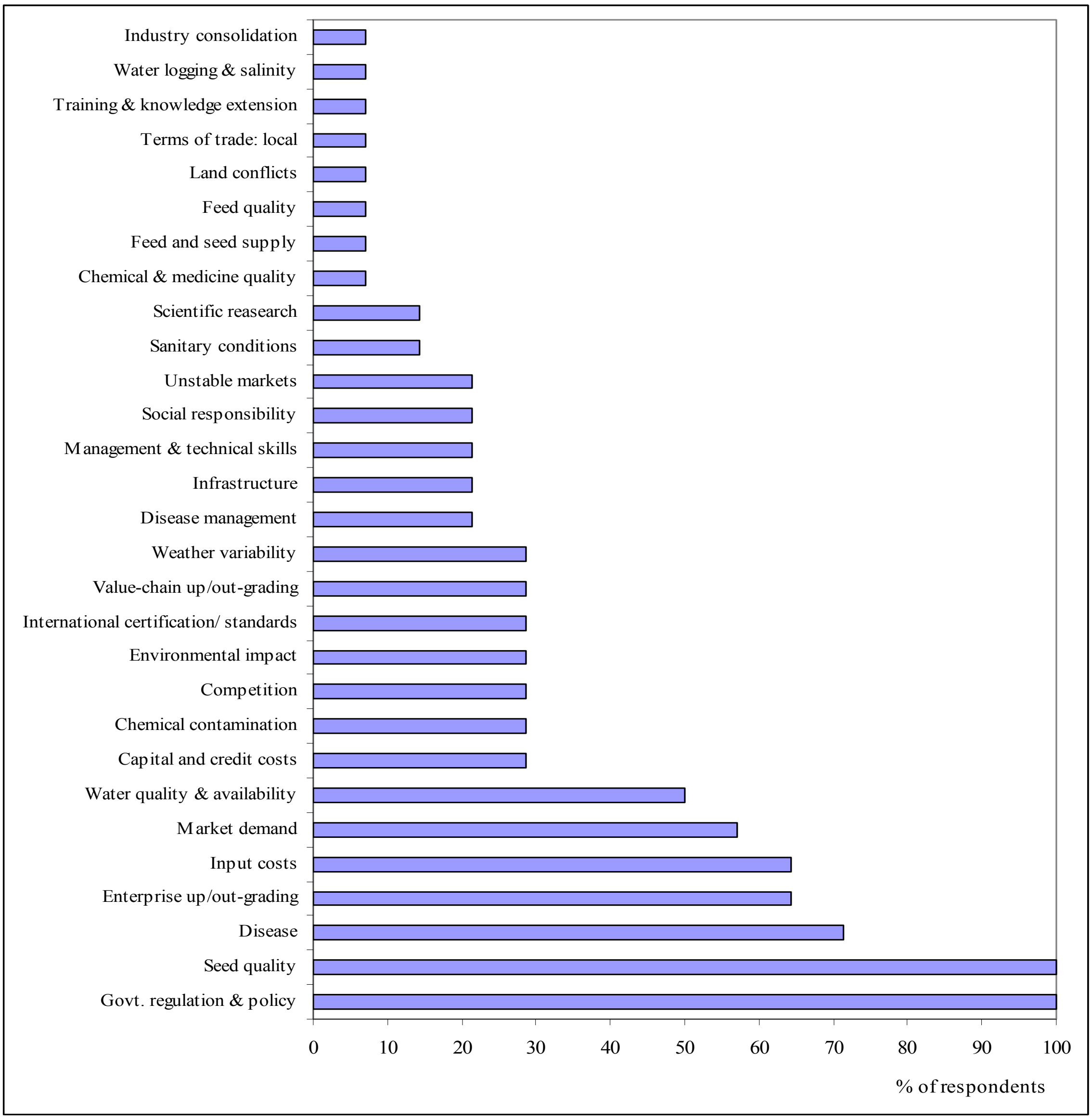


Figure 6.11. Perceptions of sustainability issues by supporting actors

*Source: State of system workshop **(2011)***

6.3.2. Perceived sustainability issues by farmed species systems

Based on the above results and stakeholder analysis approach (Bell & Morse 2008), a matrix was modified and developed to assess major issues for sustainable development. Major sustainability issues were addressed by key stakeholder groups based on similar characteristics and their nature of influence on the operation. All individual sustainability factors were classified and synthesized into three sustainability dimensions (i.e. economic, environmental, and social aspects), to pull out important factors along the value chain. Each stakeholder group identified particular SIs related to future development, and the top five SIs classified by each stakeholder group were aggregated to find major SIs for the whole value chain and are presented in the following sections:

a). Sustainability issues for stripped catfish value chain

Results show that 15 sustainability factors were considered important by the five main stakeholder groups, of which *input cost* was ranked highly by most stakeholder groups; followed by *capital & credit costs, unstable markets,* and *govt. regulation & policy*. The *catfish disease, seed quality,* and *water quality & availability* factors in the environmental dimension were also indicated by most stakeholder groups (Table 6.1). These seven sustainability factors were identified by most of stakeholder groups and could be key factors for future development of the striped catfish system. The hatcheries, grow-out farmers and managers groups were more concerned with the environmental dimension; while the input suppliers and processors were concerned with the economic dimension. Institutional/social dimensions were more important to input suppliers, processors and managers groups than to the farmers and hatcheries.

Table 6.1. Top five sustainability issues of actors along striped catfish value chain

Sustainability issues	Items	Major stakeholder groups in value chain					Impact
		Seed producers	Grow-out farmers	Input suppliers	Proce- -ssors	Offic- -ials	
Capital and credit costs	*Freq. (%)*	***33.33***	*28.91*	*10.00*	***77.78***	*28.57*	11
	Value	*2*	*2*	*1*	*4*	*2*	**
Enterprise up/out-grading	*Freq. (%)*	*0.00*	*1.90*	*20.00*	*22.22*	***64.29***	8
	Value	*0*	*1*	*1*	*2*	*4*	
Input costs	*Freq. (%)*	*0.00*	*11.85*	***70.00***	***44.44***	***64.29***	12
	Value	*0*	*1*	*4*	*3*	*4*	***
Input supply	*Freq. (%)*	*0.00*	*0.00*	*0.00*	***66.67***	*0.00*	4
	Value	*0*	*0*	*0*	*4*	*0*	
Product price	*Freq. (%)*	*0.00*	***37.44***	*0.00*	***55.56***	*0.00*	5
	Value	*0*	*2*	*0*	*3*	*0*	
Unstable markets	*Freq. (%)*	***66.67***	*20.38*	***40.00***	*11.11*	*21.43*	11
	Value	*4*	*2*	*2*	*1*	*2*	**
Fish disease	*Freq. (%)*	***33.33***	***44.55***	*20.00*	*0.00*	***71.43***	10
	Value	*2*	*3*	*1*	*0*	*4*	*
Disease management	*Freq. (%)*	***66.67***	*0.95*	*10.00*	*0.00*	*21.43*	8
	Value	*4*	*1*	*1*	*0*	*2*	
Seed quality	*Freq. (%)*	*0.00*	***29.86***	***30.00***	*0.00*	***100.00***	9
	Value	*0*	*2*	*2*	*0*	*5*	*
Water quality & availability	*Freq. (%)*	***66.67***	***39.81***	*20.00*	*0.00*	*50.00*	10
	Value	*4*	*2*	*1*	*0*	*3*	*
Weather variability	*Freq. (%)*	*0.00*	***45.50***	*0.00*	*0.00*	*28.57*	5
	Value	*0*	*3*	*0*	*0*	*2*	
Govt. market intervention	*Freq. (%)*	***33.33***	*0.00*	***40.00***	*0.00*	*0.00*	4
	Value	*2*	*0*	*2*	*0*	*0*	
Govt. regulation & policy	*Freq. (%)*	*0.00*	*3.79*	***50.00***	*22.22*	***100.00***	11
	Value	*0*	*1*	*3*	*2*	*5*	**
International standards	*Freq. (%)*	*0.00*	*0.47*	*20.00*	***44.44***	*28.57*	7
	Value	*0*	*1*	*1*	*3*	*2*	
Management & technical skills	*Freq. (%)*	***66.67***	*0.00*	*10.00*	*0.00*	*21.43*	7
	Value	*4*	*0*	*1*	*0*	*2*	

(Freq., %) percent of respondents; (Value) describes level of influence, and assumption as follows: 5= very much/significant influence, if Freq.>80%; 4=much/significant influence, if Freq.<=80% and >60%; 3=significant influence, if Freq.<=60% and >40%; 2=moderate influence, if Freq.<=40% and >20%; 1=influence, if Freq.<=20% and >0%; and 0= no influence; (Impact) = $\Sigma Value_i$ (i=stakeholder group 1…i) - describe level of impact/or aggregated influences, if score is higher it means that this issue is more important. Source: IFS survey (2011), Scoping survey (2010) & State of system workshop (2011).

b). Sustainability issues for shrimp value chain

Fourteen sustainability factors ranked as important by the five stakeholder groups, of which *seed quality* was more important for most stakeholder groups, followed by *input* *cost*, *shrimp disease, water quality & availability,* and *govt. regulation & policy* factors (Table 6.2).

Table 6.2. Top five sustainability issues of actors along shrimp value chain

Sustainability issues	Items	Major stakeholder groups in value chain					Impact
		Seed producers	**Grow-out farmers**	**Input suppliers**	**Proce- -ssors**	**Offic- -ials**	
Capital and credit costs	*Freq. (%)*	*0.00*	*25.00*	*10.00*	***77.78***	*28.57*	9
	Value	*0*	*2*	*1*	*4*	*2*	*
Enterprise up/out-grading	*Freq. (%)*	*33.33*	*20.50*	*20.00*	*22.22*	***64.29***	11
	Value	*2*	*2*	*1*	*2*	*4*	**
Input costs	*Freq. (%)*	*16.67*	*5.50*	***70.00***	***44.44***	***64.29***	13
	Value	*1*	*1*	*4*	*3*	*4*	***
Input supply	*Freq. (%)*	*0.00*	*0.00*	*0.00*	***66.67***	*0.00*	4
	Value	*0*	*0*	*0*	*4*	*0*	
Product price	*Freq. (%)*	*0.00*	***25.50***	*0.00*	***55.56***	*0.00*	5
	Value	*0*	*2*	*0*	*3*	*0*	
Unstable markets	*Freq. (%)*	*0.00*	*4.50*	***40.00***	*11.11*	*21.43*	6
	Value	*0*	*1*	*2*	*1*	*2*	
Market demand	*Freq. (%)*	***50.00***	*15.50*	*20.00*	*22.22*	*57.14*	10
	Value	*3*	*1*	*1*	*2*	*3*	*
Shrimp disease	*Freq. (%)*	***66.67***	***54.00***	*20.00*	*0.00*	***71.43***	12
	Value	*4*	*3*	*1*	*0*	*4*	***
Seed quality	*Freq. (%)*	***83.33***	***43.50***	***30.00***	*0.00*	***100.00***	15
	Value	*5*	*3*	*2*	*0*	*5*	****
Water quality & availability	*Freq. (%)*	***100.00***	***45.50***	*20.00*	*0.00*	*50.00*	12
	Value	*5*	*3*	*1*	*0*	*3*	***
Weather variability	*Freq. (%)*	***50.00***	***61.50***	*0.00*	*0.00*	*28.57*	9
	Value	*3*	*4*	*0*	*0*	*2*	*
Govt. market intervention	*Freq. (%)*	*0.00*	*0.00*	***40.00***	*0.00*	*0.00*	2
	Value	*0*	*0*	*2*	*0*	*0*	
Govt. regulation & policy	*Freq. (%)*	*0.00*	*6.50*	***50.00***	*22.22*	***100.00***	11
	Value	*0*	*1*	*3*	*2*	*5*	**
International standards	*Freq. (%)*	*0.00*	*0.00*	*20.00*	***44.44***	*28.57*	6
	Value	*0*	*0*	*1*	*3*	*2*	

(Freq., %) percent of respondents; (Value) describes level of influence, and assumption as follows: 5= very much/significant influence, if Freq.>80%; 4=much/significant influence, if Freq.<=80% and >60%; 3=significant influence, if Freq.<=60% and >40%; 2=moderate influence, if Freq.<=40% and >20%; 1=influence, if Freq.<=20% and >0%; and 0= no influence; (Impact) = $\Sigma Value_i$ (i=stakeholder group 1…i) - describe level of impact/or aggregated influences, if score is higher it means that this issue is more important. Source: IFS survey (2011), Scoping survey (2010) & State of system workshop (2011).

These five major factors should be kept in mind when building plans or creating strategies for the shrimp industry in the future. Similar to the key perceptions of sustainability in the catfish value chain, shrimp hatcheries, grow-out farmers and managers groups were more concerned with the environmental dimension; while the input suppliers and processors were concerned with the economic dimension. Institutional/social dimensions were more important to input suppliers, processors and managers groups than to the farmers and hatcheries.

6.3.3. Measurement of sustainability issues

The DPSIR framework approach (Smeets & Weterings 1999; Bell & Morse 2008) was used to develop a matrix of measurements and mitigation actions for sustainability issues identified. The results from a stakeholder meeting, secondary/primary data collection and the above analysis were the basic data and information used to build a matrix of measurement and response to the major sustainability issues. To find appropriate tools for measuring, the stakeholder groups were requested to discuss them and identify options. Their opinions were classified by comparing them to similar ideas and/or other comparable tools for measuring factors, hence several stakeholder groups with the same sustainability factors were grouped and responses for measuring tools were synthesized in the same field. Measurement tools and mitigation actions/responses are presented in the section below and the suggestions of the major sustainability factors identified from group discussions.

a). Catfish value chain: SIs and their measurements

Seven major sustainability factors were identified and are presented in Table 6.1. These were used as a basis for discussion with stakeholder groups to discover potential measurement tools and their responses to them. The aggregated results of group discussions are presented in Table 6.3. The main reasons for factor selection is described in three sustainability dimensions as follows:

- ***Environmental issues:*** *water quality & availability; seed quality;* and *catfish disease* issues were important factors driving the performance of the production chain. *Seed quality* was very important as many farmers reported that seed source is the main reason for low productivity and fish disease.

Table 6.3. Major sustainability issues with catfish value chain and their measurements

Factor:	***Measurement and Responses (mitigation action)***
Input cost	- *Measurement tools:* It can be reached by cost-benefits analysis, and monitor fluctuation of materials and product price from producers and processors.
	- *Responses:* Need a suitable master planning for catfish production and consumption by the Government; create strong linkages (horizontal- and vertical integration) to reduce costs from the intermediate nodes of the value chain.
Unstable market	- *Measurement tools:* It can be measured by analysis of market variation in term of importers' demand, number of importers, value and volume of exporting products.
	- *Responses:* Need a suitable master planning by the Government; find new markets; and create strong linkages among value chain actors.
Capital & credit costs	- *Measurement tools:* Monitor capacity of self-investment and loan; and assess available financial sources.
	- *Responses:* Need a suitable master planning by the Government; create strong linkages (horizontal- and vertical integration) to reduce costs from the intermediate nodes of the value chain; adjust financial policy supports.
Water quality & availability	- *Measurement tools:* Monitor water quality parameters; pond designed and water exchange mechanism.
	- *Responses:* Create strong linkages among value chain actors; zoning and strict regulation and management of water treatment and effluent treatment.
Seed quality	- *Measurement tools:* Monitor growth rate; mortality rate and check record keeping data of hatcheries about brood-stocks, breeding techniques, and frequency of brood-stock using for breeding.
	- *Responses:* Improve the brood-stock sources and breeding techniques; technical training; Policy support for brood-stock improvement.
Fish disease	- *Measurement tools:* Monitor mortality rate; type and frequency of disease appearances; level of risk from fish disease; any changes as negative impacts from fish disease outbreak.
	- *Responses:* Increase disease studies; technical training; policy support for brood-stock improvement.
Govt. regulation & policy	- *Measurement tools:* Check overlap of regulations among sub-sectors; assess the feasible regulation in term of enforcements and implementing stage; assess the effectiveness of support policy.
	- *Responses:* Updated and adaptive policy on financial supports; updated regulation on chemical/antibiotic used, food safety, animal welfare; VietGAP implementing.

Source: IFS survey (2011), Scoping survey (2010) & State of system workshop (2011)

✧ ***Economic issues:*** *input costs* was an important factor driving sustainable development. The fish price fluctuated over time and has shown a downward trend, while input cost (i.e.

feed, chemicals, labour cost) increased yearly, therefore net profit or marginal profit was also reduced. The *unstable markets* in terms of quantity affected the strategies and plans of catfish systems, and could be a major factor considered along the whole value chain. Movement in markets over the last decade showed that an importing market can be a controlling factor affecting the operation of producers. By reducing import seafood volume from main markets such as the US and EU the fish price can fall due to over-supply. *Capital & credit costs* were also important factor as policies on financial support are less effective or inappropriate and the lack of operation cost leads it to be considered as important SIs.

✧ ***Institutional/social issues:*** *government regulation & policy* can help to support system development, especially policies on finance, regulation of practices and management. Most existing financial policies for the catfish industry were mainly target support over a short term that unsuitable for the catfish sector that needs long term investment.

b). Shrimp value chain: SIs and their measurements

There were five major sustainability issues that were deemed important and have had an effect on shrimp systems (Table 6.4). The main reasons for factor selection can be presented in three sustainability dimensions as follows:

✧ ***Environmental issues:*** *water quality & availability; seed quality;* and *shrimp disease* issues were important driving forces influencing the performance of the production chain. *Seed quality* was very important and many farmers reported that seed source was the main reason for low productivity and shrimp disease outbreaks. *Water quality & availability* will be become more important in the future due to climate changed and its impacts cannot be predicted. As shrimp are more sensitive to fluctuating water conditions, so water quality will be the main factor affecting shrimp health and performance.

Table 6.4. Major sustainability issues with shrimp value chain and their measurements

Factor:	***Measurement and Responses (mitigation action)***
Input costs	- *Measurement tools:* It can be assessed by cost-benefits analysis, and monitor fluctuation of materials and product price from producers and processors.
	- *Responses:* Need a suitable master plan for shrimp production and consumption by the Government; create strong linkages (horizontal- and vertical integration) to reduce costs from the intermediate nodes of the value chain, improving management, adjust investment at suitable level..
Water quality & availability	- *Measurement tools:* Monitor water quality parameters; pond preparation skills; chemical use and water treatment methods.
	- *Responses:* Create strong linkages among value chain actors; zoning and strict regulation and management of water treatment and effluent treatment.
Seed quality	- *Measurement tools:* Monitor growth rate; mortality rate and check record keeping data of hatcheries about brood-stocks, breeding techniques, frequency of brood-stock using for breeding, and PCR test results.
	- *Responses:* Improve the brood-stock sources and breeding techniques; technical training; policy support for brood-stock improvement.
Shrimp disease	- *Measurement tools:* Monitor mortality rate; type and frequency of disease appearances; level of risk for shrimp disease; any changes as negative impacts from shrimp disease outbreak.
	- *Responses:* Increase disease studies; technical training; policy support for brood-stock improvement.
Govt. regulation & policy	- *Measurement tools:* Check overlap of regulations among sub-sectors; assess the feasible regulation in term of enforcements and implementing stage; assess the effectiveness of support policy.
	- *Responses:* Updated and adaptive policy on financial supports; updated regulation on chemical/antibiotic used, food safety, animal welfare; VietGAP implementing.

Source: IFS survey (2011), Scoping survey (2010) & State of system workshop (2011)

✧ ***Economic issues:*** *input cost* was an important factor of sustainable development. Input cost (i.e. feed, chemicals, labour cost etc.) increases yearly, while shrimp price slowly increases and farms find the have a lack of operating capital after facing shrimp disease outbreaks, thus net profit has also reduced.

✧ ***Institutional/social issues:*** *govt. regulation & policy* can help to support system development, especially financial policies and regulations on practices and management. The existing financial policy for the shrimp industry is supported mainly over the short tem and is not suitable for shrimp systems that require long-term investment. With the long-term loan source, for example, the farmers can have enough money and time for improvement farm infrastructure (e.g. pond dykes, water supplying/draining system) and upgrading.

6.4. Discussion and conclusions

6.4.1. Role and operational constraints of major stakeholders

Value chain of catfish and shrimp can be buyer-driven in which large retailers, branding enterprises and trading companies control decentralized production networks (Simard et al. 2008; Tran et al. 2013). Seafood production and consumption is driven by the market, and thus international buyers and customers play important roles (Young et al. 2011; Ponte et al. 2014; Jespersen et al. 2014). Setthasakko (2007) noted that international buyers tended to purchase on the basis of hygienic quality, safety and cheapness, and did not take the environmental and social impact of seafood production into consideration when making agreements. Societal concerns have resulted in demand from consumers and retailers for assurances that the food they purchase has been produced respecting environmental and social sustainability standards (Bush & Oosterveer 2007; Young et al. 2011; Bush & Oosterveer 2012b; EU 2013). To meet the high requirements from retailers and customers, large-scale seafood buyers are seeking products resulting from responsible methods to satisfy an increasing consumer demand (Boyd et al. 2007; Pham et al. 2011). Additionally, among buyer-driven agro-food commodity chains in the international seafood markets, some are driven by large supermarket retailers, but others are dominated by processors, international traders, or global branders (Islam 2008). Retailers rapidly become more global and oligopolistic, and retailers together with private standards are at the center of the transformation of the global agri-food system (Busch & Bain 2004). Vertical linkages between value chain actors are still limited, and the relationship between them was commonly by verbal agreements. Farmers and seafood processors still play important roles in the development of value chains in the MKD. As production capacity is small, the farmers do not have a role in regulating the market, especially pricing decisions, whereas, processors with large production capacity play an important role in the regulation of production and price decision (Vo et al. 2009a; Le et al. 2011; Le 2011; Tran et al. 2013; Jespersen et al. 2014). Previous studies such as Vo (2003), Kai (2006), Khoi (2007), Vo et al. (2009a), Le (2010) and Le (2011) also illustrate the important role of processors and producers in the value chain of catfish and shrimp.

Certification schemes specific to aquaculture have emerged over the last decade (Bostock et al. 2010; Washington & Ababouch 2011; Tran et al. 2013) and increasing consumers are interested in the process through which a product is produced (Corsin et al. 2007; Reilly 2007; Yamprayoon & Sukhumparnich 2010; Young et al. 2011). To ensure products meet standards, appropriate solutions need to be in place from the first link of the value chain and small-farms, especially, often face big challenges of compliance with such certification (Umesh et al. 2009; Subasinghe et al. 2009; Bush et al. 2010b; Bosma & Verdegem 2011; Pham et al. 2011; Belton & Little 2011; Bush & Belton 2012). Moreover, there are many seafood exporters for striped catfish and shrimp, and the linkages among them is very poor. This is a major driver for the unfair competition such as dumping leading to price fluctuations and the 'race to the bottom' (Volden 2002; Aurthur & Nierentz 2007) that has characterised pangasius over the last few years (Nguyen 2008; Tuan et al. 2013). The processors purchase raw material from independent farmers, however, lack of vertical integrated linkages leads to increased transaction and production costs. Market access remains a key constraint for both the striped catfish and shrimp industries as competition between seafood producing countries has intensified, and the number and costs of adoption to meet and overcome the technical and trade barriers of the importers has continued to increase (Nguyen 2008; Tuan et al. 2013). Consumer demand in international seafood markets will continue to drive policies for strengthening trade barriers (Young et al. 2011). Food safety regulations, HACCP processes, and technical barriers to trade have introduced high costs that tend to exclude the small producers/processors from the supply chain (Dey & Ahmed 2005; Tran et al. 2013). To overcome this, a vertical linkage between farms with the processors, small-farmers need to form groups to fill capacity associated with the processors. Farmer groups may bring opportunities for small-farmers to upgrade production and production efficiency (Vo et al. 2009a; Pham et al. 2011; Ha et al. 2013), because through the groups farmers can improve their position by horizontal and vertical coordination (Umesh 2007; Umesh et al. 2009; Khoi 2011). Moreover, small-scale farms can enhance competitiveness and achieve improved economies of scale by collaborating and through working as clusters (Tain & Diana 2007; Zhang 2014). The question is how to establish such linkages that are feasible and effective, and thus the role of state agencies is potentially very important. State agencies must be involve in supporting the production linkages with appropriate policies and regulations on financial support that provide proper terms of loan in the short- and long-term for aquaculture activities; and also provide appropriate sanctions to ensure the linkages run legally. Previous attempts to strengthen the sector have tended to identify constraints to striped catfish and shrimp industries that have, mainly focused on technical aspects and referred to constraints of specific stakeholders rather than the general picture of the value chain (Vo 2003; Kai 2006; Khoi 2007; Vo et al. 2009b; Phan et al. 2009; Le & Le 2010; Bui et al. 2010; Anh et al. 2010b; Anh et al. 2010a; Pham et al. 2011; Da et al. 2012).

6.4.2. Farm sustainability perceptions and standard criteria

Food certification has been identified as an easy way of demonstrating sustainability (Bush & Oosterveer 2007; Bush et al. 2010b; Bush & Oosterveer 2012b; Kelling 2012; Mohan 2013). Striped catfish farm sustainability is assessed through a comparison of external (standards) and internal (perceptions) formulations of aquaculture sustainability (Table 6.5).

Table 6.5. Catfish farming: comparison between sustainability perceptions and standards

Sustainability issues	Small		Medium		Large		Standards category
	SIs[1]	SC[2]	SIs[1]	SC[2]	SIs[1]	SC[2]	
Fish disease	40%	xx	44%	xx	59%	xx	Fish health & welfare
Seed quality	28%	x	31%	x	32%	x	Fish health & welfare
Environmental impact	0%	xx	3%	xx	19%	x	Environmental issues
Water quality/availability	40%	xx	36%	xx	46%	xx	Environmental issues
Weather variability	52%	x	38%	x	41%	x	Environmental issues
Capital and credit costs	32%	xx	34%	xx	11%	x	Aquaculture production
Input costs	10%	xx	13%	xx	16%	x	Chain-related issues
Unstable markets	23%	xx	22%	xx	11%	x	Chain-related issues
Product price	45%	xx	31%	xx	27%	x	Chain-related issues

[1] SIs: sustainability perceptions (% of respondents); [2]Standards' category: presents the level of emphasis on the criteria acquired – (xx): lower level of standards criteria acquired; (x): higher level of standards criteria acquired. Sources: IFS (2011)

There were different perceptions on sustainability issues between catfish farm-scales, the small-/medium farms were more concerned about the economic aspects of sustainability issues (i.e. *product price*, *unstable markets,* and *capital & credit cost* factors), while large-farms were mainly concerned with environmental issues (i.e. *water quality & availability, environmental impact, seed quality; and fish disease*). Comparison between sustainability perceptions and the standards criteria acquired shows that the small-/medium catfish farms tended to be quite weak in relation to standards criteria acquired such as: i) fish health/welfare (fish disease management, seed quality); ii) environmental impact management (effluent management; water quality control; management of fish pond conditions in the weather variability); iii) aquaculture production (lack of capital cost for investment on the farm re-structures, water monitoring, and certification cost); and iv) chain-related issues (input cost: it relates to the high quality feed, chemical use; unstable market and price product: it reflects lack of vertical linkages with other actors in order to manage the production, e.g. market information constraints, traceability recordkeeping). Large-farms also faced the same issues, but they were generally at a higher level in relation to indicators to meet the standard criteria.

Meanwhile, shrimp farmers were more interested in the environmental issues of sustainability development compared to the catfish farmers (Table 6.6). Similar to the catfish sector, the comparison between sustainability perceptions and standards categories found that the LoLI shrimp farms tended to be weak in relation to standards criteria acquired, such as shrimp health/welfare, environmental impact management, aquaculture production, and chain-related issues. The LoLI and small-scale semi-intensive farms have limited infrastructures and operational capital revealing the larger gap in meeting the standard criteria than that of larger farms, mainly intensive farms greater financial and physical resources.

Table 6.6. Shrimp farming: comparison between sustainability perceptions and standards

Sustainability issues	LoLI		HiLI		Standards category
	SIs[1]	SC[2]	SIs[1]	SC[2]	
Shrimp disease	47%	xx	65%	xx	Shrimp health & welfare
Seed quality	48%	xx	36%	x	Shrimp health & welfare
Water quality/availability	48%	xx	43%	x	Environmental issues
Weather variability	53%	x	74%	x	Environmental issues
Capital and credit costs	28%	x	21%	xx	Aquaculture production
Enterprise up/out-grading	20%	xx	0%	x	Aquaculture production
Market demand	7%	x	5%	x	Chain-related issues
Govt. regulation & policy	0%	x	3%	x	Chain-related issues
Product price	21%	x	23%	x	Chain-related issues

[1] SIs: sustainability perceptions (% of respondents); [2]Standards' category: presents the level of emphasis on the criteria acquired – (xx): lower level of standards criteria acquired; (x): higher level of standards criteria acquired. Sources: IFS (2011)

The key risk profiles between striped catfish and shrimp farms showed that there were differences on the risks between smaller and larger farms for both these species, smaller farms often faced higher level of operation risks such as the low farm gate price and shrimp disease compared to the larger farms. The small-scale farms were the most vulnerable actors in the value chain, and they had to cope with higher level barriers for upgrading compared to larger farms on both these species. In contrast, the larger farms tended to demonstrate farm sustainability to sustained success. With a higher capacity of infrastructure (large farm-size, feed/chemicals storage, pond construction, water supply system) and financial resources, large-farms were better able to improve their operations towards standards or upgrading than small-/medium farms. The larger farms, especially catfish farms, were most likely to achieve certification since they tend to possess organizational structures and characteristics amenable to the adaptation which will be needed to meet standard requirements, and the requisite capitals required to facilitate proactive engagement with certifiers (Bush et al. 2010; Belton et al. 2011; Bush & Belton 2012; Jespersen et al. 2014).

6.4.3. Value chain: sustainability perceptions of stakeholders

Sustainable development is a concern of all stakeholders in the production chain (Sheriff 2004). Each stakeholder involved in the production chain addressed the issues related to sustainable development affecting their business specifically and generally the whole value chain. The hatcheries, farmers and fisheries managers were more interested in the environmental aspects, because this is a fundamental issue to ensure long-term resources used for aquaculture development. While, the input suppliers and seafood processors paid more attention to input cost, capital & credit costs, unstable markets and product prices in the economic dimension. This reflects that the stakeholders are looking for business and economic profit, so they are less interested in the environmental aspects. Setthasakko (2007) indicated that smaller and younger producers tend to focus more on economic aspects rather than social and environmental sustainability, reflecting the lack of a long-term view of environmental and social sustainability for the seafood supply chain is major barrier to the creation of corporate sustainability.

An outstanding issue related to environmental sustainability focused on *water availability and quality*. Further aquaculture development is being increasingly constrained by environmental problems caused by poorly managed aquaculture operations and by resource-use conflicts (Simard et al. 2008; Gandini et al. 2009; Valenti et al. 2011; Samuel-Fitwi et al. 2012; EU 2013; USAID 2013). A major challenge to a sustainable industry is to improve production performance, and simultaneously to minimize environmental impacts (Martinez-Cordero & Leung 2003), particularly for an industry where the aquaculture production is mainly operated by small-scale farms and lack of horizontal/vertical integrated linkages. Thus, the state agencies should produce and regularly update aquaculture development strategies and plans, as required, to ensure that aquaculture development is ecologically sustainable and to allow the rational use of resources shared by aquaculture and other activities (Pullin et al. 2007). The continued expansion of aquaculture will require the adoption of production technologies that minimize damage to the environment (Whitmarsh et al. 2006). Aquaculture must become more integrated with other sectors that use natural resources (Pullin et al. 2007), for example, sediment from fish ponds can be reused for agriculture production crops such as rice farming, orchards and cash crops (Rahman & Yakupitiyage 2004; Dang et al. 2008; Anh et al. 2010; Cao et al. 2010; Wang et al. 2011).

Shrimp and fish diseases continue to increase in occurrence and severity, for example the BNP/MAS in striped catfish (Crumlish et al. 2002; Phan et al. 2009; Crumlish et al. 2010; De Silva & Nguyen 2011) and WSSV/AHPNS in shrimp (Hoa et al. 2011; Oanh & Phuong 2012; Loc et al. 2013; DoAH 2013b). Main causes from degradation of water quality, poor brood-stock sources and seed quality (Le & Le 2010; Bui et al. 2010; Oanh & Phuong 2012). Diseases of aquatic animals are closely linked to the environment and environmental issues, including disease control must be considered in the broader context of farming systems design, sitting and management (Kutty 1995; Kongkeo 1997; Shang et al. 1998). Additionally, *Seed quality* was perceived as key factor for sustainability of both shrimp and catfish industry. Environmental condition combined with other factors such as poor seed quality and degradation of pond condition after many years of exploitation, have made increase disease issues and will continue to be problems in the coming years. Aquatic animal disease will limit future food supply from global aquaculture sectors (Valenti et al. 2011; Stentiford et al. 2012), and shrimp/catfish disease is still a main factor future development (Primavera 1998; Shang et al. 1998; Lebel et al. 2002; Biao & Kaijin 2007; Kongkeo & Davy 2009; Bush et al. 2010a; Bush et al. 2010b; CBI 2012b; Rico et al. 2012; SFP 2013; Paul & Vogl 2013). In addition, one problem is intensive use of natural coastal habitats for monoculture technology, often exceed the carrying capacity of the area (Primavera 1998; Valenti et al. 2011). This often causes environmental degradation and disease outbreaks (Neiland et al. 2001; Frankic & Hershner 2003; Valenti et al. 2011). Thus, relevant stakeholders should consider any environmental concerns carefully and develop strategies that will sustain the industry in the long-run with minimal environmental perturbations (Whitmarsh et al. 2006; De Silva & Nguyen 2011). Environmental impacts caused by aquaculture may be quantified monetarily and included in the production costs

(Valenti et al. 2011), and there needs for a partnership approach between environmental agencies and the industry (Abreu et al. 2011).

One important issue related to sustainable development is *capital/investment costs*; the lack of operational cost is not only difficult for the aquaculture industry but also the concerns of the other industries. *Input cost* is increasing yearly, while the own saving of farmers is still limited for investment, large amount was borrowed. To solve the constraints of capital/investment costs, input cost, and lack of financial source and cost adapting technical barriers, the catfish and shrimp industries need to self-improve their operations to make a reasonable return on investment. The main production cost comes from feed cost (i.e. 80% of catfish production cost and 60% in shrimp culture), and thus to save the operation cost the feed management should be considered as a priority. Until now, aqua-feed processing plants still heavily depend on imported raw materials (CBI 2012b; Tuan et al. 2013), so the feed prices are often higher than that of the other seafood producing countries leading to reduced trade competitiveness. Thus improving policy to encourage the domestic production of raw materials is essential to help reduce operational costs for the aquaculture sector. Feed requirements affecting sustainable growth of the aquaculture sector (Focardi et al. 2005), and important prerequisites for sustainable production are appropriate governmental policies (Olesen et al. 2010). Although input cost is rising and affecting operations of most stakeholders along value chain, the stakeholders need to adjust their business at the suitable investment level and self-improve practices to sustainable development. The striped catfish industry is more interested in the issue of capital/investment costs than the shrimp industry. Financial sustainability of fish farming depends mainly on market-prices of products and inputs, and the production efficiency depend on the farmer's management capabilities, institutional support and the scale of production, etc. (Bosma & Verdegem 2011). By way of contrast, the shrimp price increases and tends to have less negative impact on the production chain. Moreover, the shrimp market is large and always has a high demand while production did not meet demand because shrimp industry affected often by shrimp disease.

6.4.4. Sustainability issues: measurement and mitigation actions

The DPSIR framework approach (Smeets & Weterings 1999; Bell & Morse 2008) was used to develop a matrix of measurements and mitigation actions for sustainability issues. The findings of this study were more qualitative than quantitative sustainability indicators (SIn) that were obtained through the state of system workshop (SoS). The qualitative method allowed respondents to participate in development discussions. Bell & Morse (2008) set out a system sustainability analysis approach that takes the participatory deconstruction and negotiation of what sustainability means to a group of people, along with the identification and method of assessment of indicators to assess that vision of sustainability. However, SIn developed in the SoS workshop were more focused on economic aspects, especially at the farm level. The unbalanced SIn reveals stakeholders perspective from a bottom-up approach (Zhang 2014). SIn at broader levels, such as value chain level and macro level, are more difficult to measure than those SIn at local or farm level. This also raised the question of who will use these SIn, as different stakeholders may focus on different levels of the value chain coordination, they may be more efficient in using particular SIn. For example, it may be more appropriate that farmers apply SIn for farm level than government officers, while government officers are better able to apply SIn at the city level (Shen et al. 2011; Rametsteiner et al. 2011; Zhang 2014).

Sustainability perceptions that were identified in exercise 1 of the SoS workshop were used as a basis for discussion with stakeholder groups to discover potential measurement tools and their responses to them (Table 6.3 & 6.4). Each emerging challenge to sustainable development also requires specific solutions and broader sustainability should incorporate as many different aspects as being manageable (Wurts 2000). This study found several potential sustainability indicators that were suggested to measure the risks of sustainability development. Firstly, sustainability issues in relation to economics dimension, such i) 'input cost' should be monitored through the fluctuation of materials and product price from producers and processors; 'capital & credit costs' could be assessed by monitor on capacity of self-investment and loan; and iii) 'unstable market' can be measured by analysis of market variation in term of importers' demand, number of importers, value and volume of exporting products. To cope with the sustainability issues, a suitable master planning for production and consumption by the Government were suggested. Additionally, horizontal and vertical integration among chain actors were identified to reduce costs from the intermediate nodes of the value chain and also reduce the risks of unstable markets and product prices (Khiem et al. 2010; Bolwig et al. 2010; Khoi 2011; Tran et al. 2013; Trifković 2013). Secondly, measurement of the key environmental issues include i) 'water quality & availability' may be measured by monitoring on water quality parameters, water treatment and water exchange mechanism; ii) 'seed quality' should be measured by the monitor of growth rate, mortality rate, record keeping (brood-stocks, breeding techniques, and frequency of brood-stock use), and results on the seed disease-pathogen screened; and iii) 'fish/shrimp diseases' monitored mortality rate, type and frequency of disease appearances, level of risk from disease, and any changes indicating a disease outbreak. Solutions for the seed quality and animal disease are discussed as improvement of the brood-stock sources and breeding techniques, technical training, policy support for brood-stock improvement, and increase disease studies (Nguyen & Dang 2009; Umesh et al. 2010; Kongkeo & Davy 2009; Sang 2010; De Silva & Nguyen 2011). Meanwhile, create strong linkages among value chain actors, zoning and strict regulation and management of water treatment and effluent treatment are potential responses as mitigation actions of 'water quality/availability' (Nguyen et al. 2009; Umesh et al. 2010; Kongkeo & Davy 2009; Oanh & Phuong 2012; Rico et al. 2012). Thirdly, regarding institutional sustainability issues, 'government regulation & policy' could be measured by inventory on the overlap of regulations among sub-sectors, assess the feasible regulation in term of enforcements and implementing stage, and assess the effectiveness of support policy. The updated and adaptive policy on financial supports, updated regulation on chemical/antibiotic use, food safety and animal welfare are suggested to cope with this sustainability concerns (World Bank 2006; Nguyen et al. 2009; Klerkx et al. 2010; EU SCAR 2012; World Bank 2012; Kilelu et al. 2013).

As mentioned above, the findings were more qualitative than quantitative sustainability factors, so follow on research should focus on the quantitative indicators. However, the proposed sustainability indicators also need to be tested in reality before using them (Choi & Sirakaya 2006; Bell & Morse 2008). The sustainability focus changes with the stage of development from social in developing countries to environmental in developed countries (OECD 2001; Valenti et al. 2011; USAID 2013), and SIn need to be adjusted over time (Bell & Morse 2008; Rametsteiner et al. 2011; Zhang 2014). Although the measurements of sustainability issues were generally suggested, our findings outline what those in value chain think are the key drivers of business risk. Sustainability factors are not only useful for measuring progress but also for identifying problems, setting sustainable development goals and identifying suitable management strategies (Reed et al. 2006). Moreover, the use of sustainability factors has proved to be both an objective and efficient monitoring tool to assess the rational use and management of natural resources, thus contributing to conserve the natural capital for future generations, by establishing useful criteria and parameters for decision-making processes (Moctezuma-Malagón et al. 2008).

CHAPTER 7

Overall Discussion and Conclusions

7.1. Role of farmed species for seafood exporting

Aquaculture is a significant source of income contributing to the national economy as well as a considerable source of dietary animal protein for the Vietnamese people, with nearly half the fish consumed now being farmed (Fisheries Directorate 2013b; GSO 2013). The Mekong Delta has a particularly important role in Vietnam seafood exports. Aquaculture in the MKD contributed around 71% of national aquaculture production, mainly coming from the striped catfish, shrimp, giant freshwater prawn and tilapia (accounting for 71% of MKD aquaculture production). Striped catfish and shrimp are mostly produced for export; while giant freshwater prawn and tilapia are mainly consumed by domestic market. Although the Government strategy is more focused on catfish and shrimp for export, both freshwater prawn and tilapia were identified as desirable species for diversification (VIFEP 2009b; MARD 2010; GOV 2013).

Most shrimp and striped catfish production are exported, accounting for over 83% and 95% of production respectively (Vo et al. 2009a; Le 2011; Le et al. 2011; CBI 2012b). Vietnam's trade policy reforms in 1994, the subsequent advent of reliable hatchery technology, improvement of culture techniques, policy supports and more access to international seafood markets were key drivers in the emergence of the burgeoning export-orientated trade in both of these farmed species (De Silva & Nguyen 2011; Sebesvari et al. 2012; Tuan et al. 2013; Tran et al. 2013). Additionally, trade restrictions on striped catfish and shrimp exports to the US market provided motivation for seeking new markets (De Silva & Nguyen 2011; Tuan et al. 2013; MARD 2014). The highly competitive price of striped catfish compared to alternative whitefish was also a driving force for successful market access (Little et al. 2012). Substitution of black tiger for white legged shrimp in other major shrimp producing countries has resulted inVietnam becoming the biggest producer of black tiger shrimp; large areas are still used for the species, usually culture at a lower level of intensity presenting opportunities for Vietnam to differentiate it's shrimp export. Overall, striped catfish and shrimp have come to dominate Vietnam's seafood exports over the last decade (Fisheries Directorate 2013b; Tuan et al. 2013). Striped catfish has shown the highest growth in seafood export value, with annual growth rates of over 60% compared to that of shrimp (12%) since 2001. With current emerging trends, it is likely that both commodities will continue to head towards sustainable production practices promoted strongly by the third party standards food safety animal welfare, environmental integrity and social responsible (De Silva & Nguyen 2011; Tuan et al. 2013; MARD 2014).

By way of contrast, the production of tilapia and GFP has also expanded in the MKD, but has limited production in comparison with shrimp and catfish, and are mostly domestically consumed. The reasons for limited development of tilapia industry for export are inconsistent hatchery performances that lead to unstable seed production; high domestic demand; unstable grow-out production (i.e. more scattered farmed area and unstable production because lack of detailed master plans); the small harvest size of farmed tilapia, often around 400gram while the required size for export is around 600gram (Phan et al. 2011); and lack of market or high market competition from other country producers such as China (tilapia) (Tran et al. 1998; Pham 2010; MARD 2010). According to Zhang (2014) the success factors of Chinese tilapia in export market is its good texture and flavour; lower cost and competitive price; large volume and stable supply; and success in all-male tilapia seed producing and improvement in both nursing and grow-out technologies. Chinese tilapias with greater geographical concentration and intensification have come greater dependence on export markets; however, they still face problems with fish disease and the labour shortage problems in the near future. The competitor of China in tilapia exports is Thailand; and the high quality of Thai processed products and good reputation of processing methods are advantages, including efficient logistics and strong institutional support. However, the major constraints facing processors in relation to tilapia are still the quality (muddy/off-flavour and chemical/antibiotic residues) and quantity (enough supply of raw material of the right size as per orders) (Nietes-Satapornvanit 2011; Nietes-Satapornvanit 2014). The issue of off-flavour in tilapia is recognized as a constraint for the Thai processors if farmers could not produce on-flavour tilapia, especially if they do not see the importance of investing capital and management to improve their systems (Nietes-Satapornvanit 2014).

Similar to the tilapia industry, the giant freshwater prawn is also an important farmed species in the MKD; however, this species was still be limited in term of production for export due to reasons of inconsistent hatchery performances; unstable seed production; unstable grow-out production, high domestic demand; and lack of market or high market competition from other country producers such as Bangladesh (prawn) (Tran et al. 1998; Pham 2010; MARD 2010). Nietes-Satapornvanit (2014) pointed out that Thai freshwater prawn also faced limitted with export market and its domestic demand will remain high; and volume production of processed praw seems to be limited by vulnerability to diseases and cannibalism at higher densities and higher costs of production than competitors such Bangladesh (prawn). Vietnamese and Thai hatcheries (prawn) also faced technical and management-related difficulties such as quality of brood-stock sources related to genetic deterioration leading to slow growth and disease in seed production (Nguyen et al. 2006; Nietes-Satapornvanit et al. 2011; Nietes-Satapornvanit 2014). In addition, the domestic market for freshwater prawn is stable i.e. good price and higher demand as it is a favoured food item in Thai cuisine (Nietes-Satapornvanit 2014), and this may be the same issue in case of Vietnam. The situation is similar in China where high prices and a cultural preference for live seafood has led to a domestic focus (Zhang 2014). Processing of freshwater prawns in general results in a loss of their differentiated qualities; for example the heads, which are comparatively larger than penaieds, are particularly favoured in Asia for use in soup on account of their high fat content.

7.2. Farming sustainability

7.2.1. Farming practices dynamic

Striped catfish and shrimp farming have developed rapidly in the 10 years between 2001 and 2010, and both species have shown changes in farm design and management and operational linkages within the value chain over time. Catfish farming began with small-farms operated by households but there has been an increase in large-scale farms mostly owned and operated by seafood processors (Phan et al. 2009; De Silva & Nguyen 2011; Bosma & Verdegem 2011; Trifković 2013; Jespersen et al. 2014). De Silva & Nguyen (2011) forecast that the catfish farming sector will shift torwards large-scale farming prractices. This trend was the same as that of tilapia industry in China (Ponte et al. 2014; Jespersen et al. 2014) and salmon industry in Europe (Kvaløy & Tveterås 2008). For example, salmon industry supply chains are developed with an increasing degree of vertical coordination from salmon farms to the supermarkets. Most striking is the rise in large vertically integrated companies with direct ownership of production activities including hatcheries, fish processing and exporting (Kvaløy & Tveterås 2008).

Farm gate price instability and a downward trend in fish price have been important factors leading to poor economic performances of many small/medium farms, and lack of operational finance resources has also lead some stopping, temporarily stopping or leaving catfish farming (Table 7.1). Another was come from the trend of vertical integration of the processors (Hansen & Trifković 2014), because the pangasius processors have tended to cycle their production processes leading to develop their own farms instead of dependence on the independent farms (small-/medium farms).

This study found that there were not significant differences on the production and economic efficiency among catfish farm scale, and this suggests that farm performance was relatively independent of farm scale. Many small farms made money and some larger farms did not (Chapter 4 & 5), this reflects that persistence of small farms if well managed such as management (e.g. feeding, stocking) and timing of fish sales in the economic cycle (that greatly affected the farm-gate price achievable). The smaller scale farms can still maintain themselves in the value chain if they can improve their farming practice and management.

However, the small-scale farms can be considered as more vulnerable actors in the value chain due to many constraints compared to the others. Therefore, the small-/medium farms showed a tendency to develop linkages with the processors through contract farming systems in order to maintain their farms, as this helps to ensure that they can sell their product to processors in both the fish quantity and quality. Moreover, contract farming between processors and small-scale farms was seen as a way to increase income for farmers (Miyata et al. 2009; Zhang 2014); through the diversification of small contract farmers, the increased income permeates their households and communities (Glover & Kusterer 1990; Miyata et al. 2009). Dorward (2009) and Zhang(2014) suggested that there were three broad types of livelihood strategy or transformation for smaller scale farmers in the face of the threats of stresses and shocks, including i) 'hanging-in' strategies, which are concerned to maintain and protect current levels by keeping farming at a low level; ii) ‘stepping-up’ strategies, which involve investments in assets to expand the scale by upgrading with strategies such as commercialization and specialization; and iii) ‘stepping-out’ strategies, involving the accumulation of assets to allow investments or switches into new activities and assets, or leaving farms and entering paid employment off-farm.

Table 7.1. Comparison of farm change status between shrimp and catfish

Items	Shrimp		Striped catfish	
	LoLI farms	HiLI farms	Small /medium	Large scale
Farm operation as normal (%)	45.00	14.61	45.69	40.00
Farm operation with changes (%)	55.00	85.39	54.31	60.00
- *Permanent stopped farms*	*1.82*	*0.00*	*6.35*	*0.00*
- *Temporarily stopped farms*	*0.00*	*15.79*	*34.92*	*11.11*
- *Some changes implemented*	*98.18*	*84.21*	*65.08*	*88.89*
Main factors driving forces				
- *Shrimp/fish price*	*na*	*na*	✓✓	✓
- *Financial sources*	✓	✓✓	✓✓	✓
- *Shrimp/fish disease*	✓	✓✓	✓	✓
Main changes implemented				
- *Reduce investment*	*na*	✓✓	✓✓	✓
- *Livelihood diversification*	✓	✓	✓✓	*na*
- *Switch to other species*	✓	✓✓	✓✓	✓

(%): percent of survey farms; na: not applicable; (✓) less emphasis; (✓✓) high emphasis. Source: TLS (2013), IDS (2013)

Meanwhile, the shrimp farming sector has grown rapidly since the end of the 1990s as a result of the Government Decree 09/2000/NQ-CP, the availability of artificial seed and increasing demand from seafood markets. Shrimp farming systems are diverse; but two of the major shrimp systems are improved-extensive and rice-shrimp rotation system. The more extensive nature of some Vietnamese systems allow differentiation with industrial shrimp system and there are opportunities being applied for organic production. The LoLI system with low stocking density, no feeding and less chemical use could be a less risky and more sustainable model that are potential models for organic certification (Nguyen et al. 2009; Naturland 2012; Vu et al. 2013). Additionally, semi-/intensive shrimp systems have also developed rapidly, and although limited in terms of the area occupied produce an increasingly level of the total harvested crop. However, the rapid growth of semi-intensive and intensive system faced several challenges during the development such as the slow improvement of irrigation canals; seed quality and inputs quality; and infrastructure (e.g. electricity networks; transportation etc.). These are cited as major constraints for expanding of industrial shrimp systems and are reasons why these systems were geographically limited to specific sites (VIFEP 2009b; Nguyen et al. 2009; Anh et al. 2010a). Since 2008 many black tiger shrimp farms (mainly semi-intensive, and intensive systems) have moved into white-legged shrimp culture, due to the short production cycle and better economic efficiency. The dramatic shift to white-legged shrimp farming system also faced similar constraints as the black tiger shrimp intensive system. White-legged shrimp systems were sometimes farmed outside aquaculture zone, and they more difficulties on the electricity use. They also made the pollution for the local areas due to high stocking density, high feed use and weak irrigation system for water discharge in this area (VIFEP 2009b; Nguyen et al. 2009). Electricity use for aeration system in white-legged shrimp is higher than black tiger shrimp culture (i.e. 20h of aeration operation per day in WLS compared to around 5h of BTS culture), but the current situation of the electricity network cannot meet all requirement for this system. Thus, white-legged shrimp farms still based on the machine run by diesel, this make more costly and increasing production cost compared to that of the electric use (VASEP 2012; Fisheries Directorate 2012).

Since late 2010 the AHPNS disease began to appear with identification and negative effects becoming clear during 2011 and 2012. By 2013, the AHPNS disease situation was being managed, through better control of seasonal culture time, control of seed quality and improvement of farm management. In particular, all intensive shrimp farms changed over time, and the main cause was shrimp disease, especially the AHPNS epidemic. Shrimp disease was perceived as the main reason leading to the suspension of operation of many semi-/intensive shrimp farms. In contrast, the LoLI farms showed fewer changes in farming practices over time compared to the HiLI farms (Table 7.1). Shrimp farmers locate mainly in the coastal areas, and their land is mostly used for shrimp culture. Although the shrimp farms affected by disease outbreak and financial constraints (i.e. mainly on the semi-/intensive system), most shrimp farms are still maintained due to very difficult shift to the other occupations in the coastal areas where are only suitable for aquaculture (Nhuong et al. 2002; Le 2009). However, in order to maintain the position in the value chain, they should improve their practices to make a reasonable return on the investment. Similar to the catfish farming sector, shrimp farms should consider to the three type of livelihood strategies including i) 'hanging-in'; ii) 'stepping-up'; and iii) 'stepping-out' strategies (Dorward 2009; Zhang 2014). Aquaculture contributes to inequality-reducing, and there was very little evidence that aquaculture contributes to the marginalisation of the smallholders (Irz et al. 2007). Moreover, until now most shrimp farms are small-scale farms, and thus the small-farms should be included in the future development of the aquaculture sector. However, the possible solutions for the inclusion of smaller scale farms in the value chain could be horizontal coordination and vertical coordination (Umesh et al. 2009; Khiem et al. 2010; Khoi 2011; De Silva & Nguyen 2011).

7.2.2. Main constraints to sustainable farming and proposed responses

Catfish and shrimp farms are likely to face increasing problems with aquatic animal diseases, especially as disease complexes emerge such as BNP/MAS in catfish and WSSV/AHPNS in shrimp. Disease was perceived as the most important factor affecting long-term development. Rico et al. (2012) also noted that the proliferation of viral, bacterial and fungal infections and parasitic pests has resulted in large economic losses, and these problems have become one of the major constraints to the sustainable growth of the aquaculture sector (Shang et al. 1998; Bush et al. 2010b; Rico et al. 2012; Stentiford et al. 2012; Rico et al. 2013). Seed quality is also a key factor of sustainability and the evidence for a decline in quality has been linked to broodstock quality. Wild black tiger shrimp brood-stock are limited and often contaminated with disease, because they were often caught onshore resulting in a low maturity coefficient (Fisheries Directorate 2012); and the inconsistent quality of seed from genetic improvement programmes of catfish and white-legged shrimp are common perceptions (VIFEP 2009a; Bui et al. 2010; Le & Le 2010; CBI 2012b). Additionally, trends in poorer water quality have been related to the impact of waste water released by other industries into the rivers (Nguyen et al. 2009; De Silva et al. 2010; Sebesvari et al. 2012; Nguyen et al. 2013; Tuan et al. 2013), and was also considered as an important factor for sustainability of the farming sector. This suggests that a sectoral plan for water use based on watershed management principle is overdue in Vietnam and that a zonal approach is urgently required to accommodate multiple uses and users (Sebesvari et al. 2012; Han & Immink 2013).

On the other hand, the consumption of certified products increased gradually in importing countries (Belton et al. 2011; Nguyen 2012; Bush & Oosterveer 2012b). Product quality was also a major sustainability factor, and thus the quality of products needs to be improved to meet current and expanded market demands. Ababouch (2007) noted that is that emerging standards, safety and quality requirements were serious constraints for both producers and exporters. Vertical integration has been advanced as a the most likely mechanism that would allow for the necessary levels of self-improvement (Nguyen 2008; Nguyen 2009; Khoi 2011; MARD 2014; Jespersen et al. 2014; Ponte et al. 2014), particularly the level of control necessary to ensure quality and food safety (Young et al. 2011; Jespersen et al. 2014; Hansen & Trifković 2014). Used extensively in the livestock sector, the high degree of vertical integration in the Danish pork sector is viewed as an advantage, ensuring stable supplies and homogeneous quality (Grunert et al. 2005). Although this study found that medium to large catfish producers with close relationships to, or integrated with, processors enjoyed better outcomes, fluctuations in catfish value were a major challenge to the whole sector. In agreement with our own study, Le & Cheong (2010) found that catfish price was perceived as the most significant risk to catfish farming in the MKD. Concern about the variability of price that catfish farmers receive and lack of any guarantee of a sales price (Bremer et al. 2013). Moreover, the payment schedule was often delayed by processors, and this led to increase the operation cost of farmers due to their interest payment of loan for this delayed period. Hence, Government intervention is needed to create and enforce legal contracts between farmer groups and processors in term of payment schedules and minimum price (Bush et al. 2010; Le & Cheong 2010).

Financing of catfish and shrimp farms requires capital investment, however the catfish farms need a higher operational finance than shrimp farms, for example total cost for a catfish production cycle was around US$300,000 per ha compared to US$19,000 per ha of a crop in the intensive shrimp system. Catfish farms used around 60% of financial source from the loans, especially from the commercial banks. Capital has become increasingly limited and dependent on the commercial banks; however, low returns has eroded this source recently. In contrast, shrimp farms mainly used their own savings but these are limited and shrimp farmers faced difficulties to access loans from commercial banks due to outstanding debts. Farmers often loan with small amount that did not reach their need because their collateral cannot meet the requirements from the banks. Additionally, farmers can only access short-term loans, so the farms can become default or cannot reinvest their operation if they face the economics loss. There is an urgent need to improve long-term regulation of loans and operational linkages (horizontal and vertical) to reduce transaction costs, production cost and financial constraints (Grunert et al. 2005; CBI 2012b). Although a government's commitment is necessary for aquaculture development, it is not sufficient to ensure sustainability (Subasinghe et al. 2009). Actors within value chains need to self-improve to make a reasonable return on investment. This has been demonstrated by Norwegian farmed salmon trade with Japan, that adjusted to price declines of 20% between 1998 and 2004 through restructuring, and consolidation of many small-farmers into several major producer- exporter networks, and on-going improvements in salmon farming technology (Grunert et al. 2010). The rapid growth of aquaculture production and increasing competition between exporters led to price reduction, and thus suitable way for producers to survive and remain profitable is to reduce production costs through productivity growth (Asche et al. 2008; Zhang 2014).

7.2.3. Food certification: challenges for small-scale farms

Small catfish and shrimp farms faced more difficulties and constraints in meeting standards criteria than large-scale farms. Nietes-Satapornvanit (2014) notes that looking more specifically on the compliance to various standards and certifications, it will be a bit difficult and more complicated for smaller scale farms to comply with them. The large scale farms are more able to comply with the various criteria set by the global standards and certifications, because these standards were designed with the "industrial" and "intensive" nature of production in mind (Nietes-Satapornvanit 2014). This is a major social issue affecting small-scale farms which are still dominant in Asia, and potentially the large numbers of other, often poor, actors in associated value chains (Busch & Bain 2004; Subasinghe et al. 2009; De Silva & Davy 2009; Melba G. Bondad-Reantaso et al. 2009; Umesh et al. 2009; Bush et al. 2010b; Bosma & Verdegem 2011; Belton & Little

2011). Belton et al. (2011) indicated that catfish producers at the smaller-scale end of the spectrum were at a disadvantage to attain certification; while larger operations are most likely to achieve certification since they tend to possess organizational structures and characteristics amenable for adaptation to standard requirements (Belton & Little 2011; Bush & Belton 2012; Hansen & Trifković 2014).

Meanwhile, Bush et al. (2010a; 2010b) indicated that certification would play an important role in restructuring the shrimp industry, however the small-scale shrimp producers will be left with the choice of compliance due to the high cost. The small-/medium catfish farms and the LoLI shrimp farms showed a long way to go to meet the standard criteria, because they had small farm size and poor farm infrastructure compared to the larger scale farms. Additionally, small-farms also faced financial constraints to adjust farm construction and improve farming practices to meet standard criteria. Certification has financial costs (e.g. cost for adjust farm construction, improvement of farming practices, certify fee and annual certified fee) which may be burden some for value chain actors, and compliance for certification requirements could be costly for small-farmers (Siar & Sajise 2009; Washington & Ababouch 2011; Tran et al. 2013). Washington & Ababouch (2011) noted that certification might require the introduction of new management systems and farms to invest to adjust infrastructure and improve practices that may be a financial constraint for small-farmers (Siar & Sajise 2009; Washington & Ababouch 2011; Omoto 2012; Trifković 2013; Tran et al. 2013). This is a main reason why the certification for aquaculture has not become more widespread (Bush & Belton 2012; USAID 2013). With the current situation, most small-farms could be excluded from international certification regimes and the certification may be a substantial barrier for the future development of this group.

The standards tend to marginalize the small-farmers who are unable to meet the strict requirements due to a lack of technical skills (Dey & Ahmed 2005; Oosterveer 2006; Subasinghe et al. 2009; Belton 2010; Khiem et al. 2010; Belton et al. 2011; Pham et al. 2011; Haugen et al. 2013); therefore, certification creates market barriers that specifically exclude these small-producers from the markets, and/or by denying them access to wider international markets (Trifković 2013; Haugen et al. 2013). In addition, technical barriers to trade have introduced high costs that tend also to exclude the small-producers from the export supply chain (Dey & Ahmed 2005; Bostock et al. 2010; Belton et al. 2011). Small-scale farmers are facing difficulties in producing for export, as these farmers strive to meet export consumer requirements, they might become uncompetitive (Muir 2005; Siar & Sajise 2009; Dasgupta & Durborow 2009; De Silva & Nguyen 2011). If small-scale producers are excluded from the certified products supply chains, they are likely to divert their attention to lower-quality markets that require lower product quality and cheap price such as pangasius export to Russia, Ukraine, South America markets (Bush et al. 2010b; Bush et al. 2010a; Belton & Little 2011; Bush & Belton 2012; Belton 2013) and export of raw shrimp materials to China (Fisheries Directorate 2012; VASEP 2014a).

Certification for individual small-farmers is not only prohibitively expensive, but also impractical (Subasinghe et al. 2009; De Silva & Davy 2009b; Melba G. Bondad-Reantaso et al. 2009). To overcome this issue and ensure market access where applicable, the small-/medium should be linked into groups or clusters and work together to obtain group certification. Collective action through farmers' organizations such as cluster management and group certification can help small-scale farmers overcome challenges related to market liberalization, globalization and increasingly stringent quality and safety requirements for aquaculture products (Kassam et al. 2011; Zhang 2014). Working in farmers group can help to solve difficulties in land use, to share experiences on farm management and to save operation cost. Grouping small-farmers that share common natural resources becomes imperative to extend coverage to all small-scale farmers in a cost-effective manner (Umesh et al. 2009; De Silva & Nguyen 2011). There is growing evidence that a cluster based approach can save on certification costs (Bush et al. 2010b; Ha et al. 2012), small-scale farmers need to cooperate in groups to share the cost of infrastructure and input (Umesh 2007; Pham & Truong 2011; Khoi 2011). However, to enable cooperative groups to develop the necessary skills, they also need supports from the government and the private sector to ensure a successful business model (Bush et al. 2010). The government and the private sector can help farmers expand and upgrade their capabilities and practices to meet the quality requirements of global markets (Umesh 2007; Umesh et al. 2009; Khoi et al. 2011). Moreover, encouraging farms towards certification markets for certified products, premium prices would be a major incentive. If farmers are not able to improve market access or an increased price for their product, they are unlikely to continue on a certification path (Ha & Bush 2010). Although farmers' groups can bring good opportunities for smaller farms, a range of compliance constraints remain, particularly difficulties in meeting the technical requirements of traceability and the high costs of certification (Pham et al. 2011). Strengthening farmer organizations would support implementation (Pongthanapanich & Eva 2006; RIA2 2009), and the Government needs to improve the cooperative law, with special attention to smaller scale groups to improve economic performance (Bush et al. 2009; Ha & Bush 2010; Pham et al. 2011).

7.3. Sustainability factors and theirs responses

7.3.1. Major sustainability factors

Striped catfish and shrimp have been identified as target farmed species for Vietnam seafood exports up to 2020, and they will be steered towards sustainable development

(MARD 2009b; MARD 2009c; GOV 2013). The status of catfish and shrimp industries over time has shown unstable development, such as market volatility (i.e. fluctuation of price and production), aquatic disease occurrence with increasing frequency and high risk level of serious disease. Sustainability in aquaculture has received increasing attention and this issue is not only a concern of government, but also of direct stakeholders participating in the value chain. Many perceptions of sustainability have been identified by the stakeholders along the value chain, however, seven sustainability issues showing agreement among the highest number of stakeholders were *input cost, capital & credit costs, unstable markets, govt. regulation & policy*, *disease, seed quality,* and *water quality & availability* factors (Table 7.2).

Table 7.2. Major sustainability issues perceived by catfish and shrimp value chain

Sustainability issues	**Catfish value chain**	**Shrimp value chain**
Capital & credit cost	✓✓✓	✓
Input cost	✓✓✓	✓✓✓
Unstable market	✓✓✓	✓
Fish/shrimp disease	✓✓	✓✓✓
Seed quality	✓✓	✓✓✓
Water quality & availability	✓✓	✓✓
Govt. regulation & policy	✓✓✓	✓✓

(✓) less emphasis; (✓✓) moderate emphasis; (✓✓✓) high emphasis. Source: SoS (2011), IFS (2010)

Although each stakeholder group pointed out specific issues for their development, environmental sustainability was still the most important issue to the stakeholders. From the analysis on the technical efficiency and sustainability of the four seafood farmed species in Asia, Kruijssen et al. (2013) found that environmental factors are the most important compared to the other, including market supply and demand, input quality and production costs. Water quality degradation was an important reason leading to increase frequency of disease occurrence and seed quality, and the problems are still complicated in the future as a result of an asynchronous development. Seed quality and aquatic animal disease factors were mentioned often, as negative impacts of environmental degradation were the reasons leading to increased frequency of disease occurrence. Cooperation across policy sectors is required such as with irrigation authorities to improve water availability and quality improvements. Aquatic animal disease will limit future food supply from global aquaculture sectors (Valenti et al. 2011; Stentiford et al. 2012), and in particular shrimp/catfish disease is a main factor affecting future development (Primavera 1998; Shang et al. 1998; Lebel et al. 2002; Biao & Kaijin 2007; Kongkeo & Davy 2009; Bush et al. 2010a; Bush et al. 2010b; CBI 2012b; Rico et al. 2012; SFP 2013; Paul & Vogl 2013). Generally, aquaculture development is being increasingly constrained by environmental problems caused by poorly managed aquaculture operations and by resource-use conflicts (Simard et al. 2008; Gandini et al. 2009; Valenti et al. 2011; Samuel-Fitwi et al. 2012; EU 2013; USAID 2013). In an industry where the aquaculture production is mainly operated by small-scale farms and lacks of horizontal/vertical integrated linkages, in order to ensure growth in this industry while concentration on environmental protection and certification is big challenge. Thus, the state agencies should produce and regularly update aquaculture development strategies and plans, as required, to ensure that aquaculture development is ecologically sustainable and to allow the rational use of resources shared by aquaculture and other activities (Pullin et al. 2007). The continued expansion of aquaculture will require the adoption of production technologies that minimize damage to the environment (Whitmarsh et al. 2006). Efficient aquaculture systems requiring fewer inputs and producing wider benefits and fewer wastes could be expected to be more sustainable (Muir 2005; Zhang 2014).

7.3.2. Responses to sustainability issues

Each emerging challenge to sustainable development requires specific solutions and broader sustainability should incorporate as many different aspects as being manageable (Wurts 2000). Since the growth of certified products in the international seafood markets, programmes to encourage farmers to develop their production to meet this trend have been implemented for some time but often lacked linkages to related policies and regulations that could support producers. Ideally, such policies and regulations would support the various stakeholders' rights and obligations throughout the value chain. The government and private sector must cooperate in a proactive way to establish confidence among consumers (Yamprayoon & Sukhumparnich 2010). The government has plans to restructure the fisheries sector towards sustainable development and increase value added products until 2020, especially for striped catfish and shrimp industries that are targeted national seafood products (MARD 2014). The policy support aims to be bottom-up but encourages state agencies to participate actively in the process of initiating and final decision-making. Stakeholder participation can lead to more effective and durable decisions; however, the quality of decisions made through stakeholder participation is strongly dependant on the nature of the process leading to them (Reed et al. 2006; Reed 2008; Bell & Morse 2008). Sustainability policy is a set of ideas in particular situations that has been officially agreed by a group of people, a business organization and/or a political party (Glavič & Lukman 2007; Olesen et al. 2010). The planning process should look at suitable and potential zones for the development of aquaculture (Frankic & Hershner 2003; Simard et al. 2008).

Sustainable development is the right direction for striped catfish and shrimp industries; and the Vietnamese Government has dealt with many trade-related issues, and has tried to ensure that the catfish producers have not been impacted adversely, except for some short-term shocks and that the sector continues to retain its growth (De Silva & Nguyen 2011). Instituting an effective minimum price for pangasius, suggested by many observers (VIFEP 2009; De Silva & Nguyen 2011; Khoi 2011; Le 2011) has not been forthcoming and may have resulted the sectors perceived 'race to the bottom' with negative impacts on many, particularly poorer stakeholders. The highly competitive prices of pangasius compared to substitute whitefish in the international markets (Beukers et al. 2012; Little et al. 2012) may have encouraged this passivity and undermined a longer term strategy to build a more sustainable sector that is required to ensure food quality and safety. To reach the sustainability purpose, apart from the requirements of the direct stakeholders' efforts in improving their practices, the role of state agencies e.g. MARD and VASEP is essential in the negotiation and diplomacy to create partnerships with the seafood importing countries. Efforts to develop a sustainable production would become impossible without the participation of importers, retailers and consumers. Vertical and horizontal business relations between the producers and different levels of sellers and buyers of their products are crucial for business negotiations and building trust (Lebel et al. 2009; Nietes-Satapornvanit 2014). Until now, retailers have played an important role in operationalizing regulations over aquaculture at a global scale (Busch & Bain 2004; Bush & Duijf 2011; Ponte et al. 2014; Jespersen et al. 2014), while producers have mainly responded to the consumers' requirements on the food safety, animal welfare and sustainability conditions when forced to do so. Development of aquaculture in a sustainable manner requires benefits to farmers, local communities and other stakeholders to be attractive (Frankic & Hershner 2003), thus, requiring any planning process to be a package of measures that offers highly integrated solutions to achieve development effectiveness. Planning for change in production and processing requires balance in stakeholders' benefit sharing.

There needs to be increased managerial and technical skills of value chain actors if these developments are to be possible. Farmers should enhance their performance measurement capability to improve their technology for disease and environmental control. Additionally, farmers also need to improve their farming practices to make a reasonable return on investment, which will often require some level of consolidation and increase in farm size. Kruijssen et al. (2013) indicated that farms could reach higher efficiency scores when farmed holdings were increased and reached a certain threshold, beyond which they again became less efficient. Irz1 & Stevenson (2012) also poited out that there exists a significant inverse relationship between farm size and productivity in some cases. For example, the relationship between farmed area and production efficiency shows an inverted U-shape for pangasius farmers in Vietnam; and the catfish farm achieved the highest efficiency scores in the farm-size at 15ha (Kruijssen et al. 2013). On the other hand, techniques of processing plants should be developed to improve the fillet yield, portion size and product range, value added products and by-products, and to build trade brand-names (Tuan et al. 2013; MARD 2014). Markets pay more interest in seafood products with affordable prices; food and brand safety; optimal portion sizes; and product range (Brunori et al. 2011; Kelling 2012; Bremer et al. 2012). Moreover, ready-to-cook and ready-to-eat meals, and pre-packaged food have increased their market share because customers have paid more attention to the convenience food products that could help to make the cooking easier and faster (CBI 2012a; Kelling 2012; Bremer et al. 2012; Spaargaren et al. 2012; CBI 2013a; CBI 2013b).

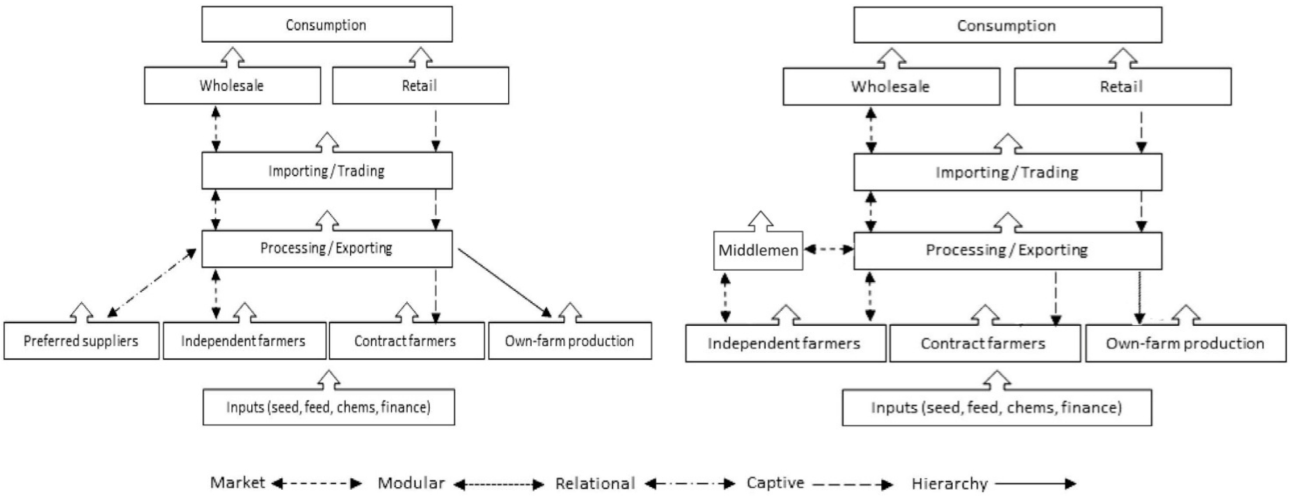
The development of tools and indicators for sustainable development are essential to evaluate and adjust production in terms of sustainability issues (Moctezuma-Malagón et al. 2008; Bell & Morse 2008). Based on the current difficulties and sustainability issues addressed, upgrading the value chain or setting up and improving the efficiency of operational linkages among actors is essential, the horizontal/vertical operational linkages will strongly contribute to the articulation of production chains and reduce intermediate costs and improve competitiveness. Vertical integration occurs when an enterprise owns or controls more than one sector of the value chain, such as integration of producing, processing, transporting and distribution; whereas horizontal integration means an enterprise owns or controls multiple business in the same sector of the value chain, i.e. different branches (Abila 2003; Zhang 2014). Additionally, improving the regulation of production and supporting policies should be carried out to bring them in line with the actual practices. All relevant stakeholders should be involved in the key steps to improve regulations and supporting policies, resulting in their greater commitment to, and responsibility for, implementation and increased efficiency. Sustainable development of the shrimp and catfish sectors also requires the involvement of state agencies that have an important role in the regulation of production. The state agencies should make a detailed plan for the farming, processing and service sectors; and regulations to manage the producing, processing and exporting at the farm level, processing level, and the operation of input supplying level. For example, Decree 36/2014/ND-CD on conditions for catfish production, processing and exporting dated 29/4/2014 by the Vietnamese Government is a legal regulation to manage catfish sector, according to the decree, all catfish farms and processors have to meet requirements on the specific conditions when they participate in the value chain, and that seem to be a license for the value chain actor (GOV 2014). This management form seem to be ‘intentional development’ that is a focussed and directed process whereby government implement programmes to help develop the under-developed. However, the ‘immanent development’ also occurs in parallel, this is a broad process of change in human societies driven by a host of factors including advances in science, communication, governance etc. (Belton & Little 2011).

7.4. Value chain coordination

7.4.1. Value chain governance forms

Several recent studies have co included that the value chains of striped catfish and shrimp are 'buyer-driven' whereby large retailers, importers and trading companies define what is to be produced and under which conditions (Tran et al. 2013; Trifković 2013; Jespersen et al. 2014; Ponte et al. 2014). In these chains, production functions are usually out-sourced and key actors concentrate on branding, design and marketing functions (Gereffi & Korzeniewicz 1994; Bolwig et al. 2010). Agro-food value chains are often characterised by highly asymmetrical power relations and the terms of participation in these chains are, to a large extent, controlled by downstream actors (Bolwig et al. 2010). Value chain coordination mechanisms, including 'captive' and 'market' forms, were similar between shrimp and catfish sector in terms of 'processors-importers' and 'importers-wholesalers-retailers' relationships. They were different in the relationship between primary actors and processing actors (Figure 7.1). Generally, the value chain coordination is moving towards a 'captive' form due to buyers' increased focus on quality, safety and sustainability and increased monitoring of suppliers for both these species (Tran et al. 2013; Jespersen et al. 2014; Ponte et al. 2014). This trend is the same as the tilapia value chain in China (Jespersen et al. 2014; Ponte et al. 2014).

At the present, most catfish were sold directly to the processors (>95%), and a 'hierarchy' was the main coordination form between catfish farmers and processors due to 70% of catfish production coming from the processers' own-farm production. However, around 30% of catfish production also came from the independent (20%) and contract farms (10%) (VASEP 2014; Anh 2014), and thus 'market' and 'captive' coordination forms continue to exist, respectively. By way of contrast, the shrimp processors often purchased shrimp raw materials through middlemen (accounting for 70% of shrimp production), the 'market' coordination form remains most popular in terms of 'middlemen-processors' and 'farmers-middlemen' relationships that are the same as the tilapia value chain in China (Jespersen et al. 2014; Ponte et al. 2014). The remaining raw materials come directly from the shrimp farmers, and the processors may thus operate different forms such 'hierarchy', 'captive', 'market' coordination of suppliers depending on the nature of relationship.



(a) Pangasius value chain
Source: Jespersen et al. (2014); Ponte et al. (2014)

(b) Shrimp value chain
Source: modified after Jespersen et al. (2014); Ponte et al. (2014)

Figure 7.1. The value chain governance forms in the MKD

7.4.2. Vertical and horizontal coordination

This study states that there is the high potential, including challenges and opportunities, for future development of the catfish and shrimp industries for export, but the requirement for environmental sustainability (food quality and safety) will be stringent. However, the challenges and opportunities need to be integrated in the sense that actions along the value chain cannot be dealt with independently of each actor and cannot be addressed without considering social and economic factors. Because the implication is that interaction, collaboration, and coordination are increasingly important ingredients of economic success (World Bank 2006).

Our findings provide insights to the changing risk profile of catfish and shrimp farming in the MKD, of which the risks of economic change to catfish and shrimp disease are most critical. Vertical and horizontal dimensions of coordination in value chains are suggested to reduce the risk and vulnerability of both these species. Riisgaard et al. (2008) indicated that value chain coordination through an 'upgrading strategy' may be strengthened to improve value chain participation. However, this study showed that both catfish and shrimp producers have faced several major barriers that influence to their capacity for upgrading. Smaller farms have to cope with a higher level of these barriers for upgrading compared to the larger farms for both these species. Both these species sectors, especially small farms faced the same influence level of barriers to the process upgrading (i.e. limited improvement of water quality, seed quality and disease management), the product upgrading (i.e. guarantee on the absence of chemical residues), the functional upgrading (i.e. limited vertical and horizontal contractualisation), and the inter-chain upgrading (i.e. limited certification skills acquired in monitoring on the food safety). Therefore, an improvement in the current GVC governance forms is required for both these species. The improvement of each sector requires coordinated actions at different stages of the value chain, and not only has to raise profitability but also comply with social and environmental conditions. Both vertical and horizontal coordination are required in the value chain, and expected that they might help to mitigate this risk and vulnerability of different production systems in the MKD.

a). Horizontal coordination

As discussed details in the chapter 3, 4 and 5, the catfish processors have preferred to develop the contract with a farmers' group instead of individual small farms, and the independent LoLI shrimp farms also faced difficulties to make contract with the prestigious input suppliers. Therefore, small farmers need to organize as groups or cooperatives, which, through the cooperative action, could help their members to cope with risks and vulnerability, such as fluctuation of fish price and shrimp disease. Such collective action can help small-scale farmers overcome challenges related to market liberalization, globalization and increasingly stringent quality and safety requirements for aquaculture products (Kassam et al. 2011). Moreover, working in the group can provide important explicit incentives for process, product and functional upgrading (Khiem et al. 2010). Bijman (2007) reveals that producer organizations can help their members obtain market information, negotiate prices with buyers, and learn from international best practices. Producer organization can train farmers on production technology knowledge, drug application, disease control and overall management of the production to ensure that quality products are produced (Francesconi 2009; Umesh et al. 2009). Umesh et al. (2009) recognizes that the organization of shrimp farmers' groups in India through clusters become attractive to buyers who are looking for ways to ensure traceability and reduce transaction costs. Additionally, the internal economies of scale are also reinforced through the establishment of farmers' associations (Ruben et al. 2007; Khoi 2011). The salmon farming industry in Europe is a good example of the significant consolidation moving from smaller scale production to large-scale production, and upgrading with innovative technologies, producing better quality and cheaper products, more educated labour and mergers in the sector (Roth 2002; Zhang 2014). As society becomes more industrialised, greater focus on food safety and the environment is needed rather than food supply and social/poverty concerns. Once industrialisation of the aquaculture sector begins, the smallholder sector tends to diminish in relative importance (Edwards 2010). Steinfeld et al. (2006) stated that the governments' policy needs to fit in to the social and economic situation. Policy needs to be rebalanced among four dimensions, namely food supply, food safety, environment and social/poverty concerns (Steinfeld et al. 2006; Zhang 2014).

b). Vertical coordination

Our findings show that the lack of operational linkages among chain actors, and limited access to capital/credit were cited as important constraints for development of both these species. Moreover, the LoLI shrimp farms and small-/medium catfish farms have operated independently, and they faced higher levels of risks and barriers to upgrading compared to the larger farms. In this situation, the processors are powerful actors in the pangasius sector as they are able to dictate the terms in the market (Trifković 2013); while the intermediaries and shrimp processors are more control on the shrimp value chain, and input suppliers have strongly influenced to the performance of farm's production in terms of production and profit efficiency. On the other hand, the processors cannot control the quality of inputs (fingerlings, feeds) and usage of drugs on independent farms, and independent farms are less acquainted with export quality requirements and regulations (Khoi 2011; Bush & Belton 2012). Maintaining smaller scale farms in the value chain, requires closer horizontal and vertical coordination (Umesh et al. 2009; Khiem et al. 2010; Khoi 2011; De Silva & Nguyen 2011). Because if processors lack of competences in the control food safety and quality on the raw material sources, vertical integration (i.e. own farm production or 'hierarchy' governance form) tends to be developed and occurs when are difficult to codify and captive (Pietrobelli & Rabellotti 2011). In our findings, capital/credit cost was viewed as an important factor affected to the chain actors' operation and upgrading toward sustainability. We suggest that to solve the constraints of rising input cost, lack of financial resources, technical barriers and increasing the competitive price, the farmers need to make i) a reasonable return on investment, and ii) institute the main 'costs' associated with the main certification schemes. Meanwhile, the processors should invest in developing their operations in terms of adding value to the product rather than expansion into farms and hatcheries, etc., and they may manage raw-material sources through the vertically linkages with other value chain actors. In this situation, the GVC governance form is likely to change from 'market' and 'hierarchy' toward more 'captive' coordination (i.e. contract farms or vertical contractualisation) (Khiem et al. 2010; Khoi 2011; Pietrobelli & Rabellotti 2011; Tran et al. 2013). Moreover, to guarantee the quality standards, vertical coordination between farmers or group of small-farmers and their chain actors is crucial (Ziggers & Trienekens 1999; Schulze et al. 2006; Khoi 2011). Vertical coordination is important when examining ways to reduce transaction costs, and this reduction is beneficial to the firms (e.g. processors) and the farmers mutually (Khoi 2011). The firm receives an assured and timely supply of the desired raw material; while the farmers acquire an assured market for their production. Moreover, farmers gain more reliable access to production inputs, capital, technology and market information (Ruben et al. 2007; Khoi 2011).

Moving from 'market' to 'captive' form of value chain coordination or increased number of contract farmers could be translated into rural poverty reduction. However, contract farming schemes should be exercised, as a lot of effort needs to go into the design of contracts that are equitable and inclusive of smaller farmers' group or cooperatives who would not be selected for contracting without a third-party intervention (Trifković 2013). Therefore, the government intervention is needed to create and enforce legal contracts between farmer groups and processors, and pay more control on the quality of farming input products, especially seed quality and chemical products. The government institutional environment plays a decisive role in guaranteeing the legal framework and defining transparent rules for conflict settlement (Key & Runsten 1999; Ruben et al. 2007; Amanor 2009).

c). Aquaculture innovation system

The GVC represent an increasingly important opportunity for chain actors to learn and to innovate (Pietrobelli & Rabellotti 2011). For chain actors in developing countries inclusion in GVC not only provides opportunities markets for their products, it also plays a growing and crucial role in access to knowledge and enhanced learning and innovation. Innovation is one of the policy instruments to mitigate negative external effects such as environmental pollution (EU SCAR 2012). Development of aquaculture sector is often concerned with production and profit, but also need to gives attention to the environmental and social conditions in which it operates (Juma 2011). Technology may be at the heart of some but certainly not all innovation (Temel et al. 2003; Sumberg 2005), and innovation is also about investing in the capacity to apply novelty on a large scale (World Bank 2006). The innovation process may fail because there are no financial means to introduce change on a large scale, and weak sector upgrading when organizations are ineffective at dealing with changing trade standards or developing a national brand image (World Bank 2006). Striped catfish farming sector in the MKD was an example for this, the technology (stocking density, productivity etc.) at farm-level has been grown rapidly, moving from shallow ponds and cage culture to deep pond practices led to increasing production from less than 15tonnes/ha to around 300tonnes/ha. The rate of growth and levels of intensification of their systems in geographically restricted areas is unprecedented, leading to serious sustainability concerns. The lack of interaction of multiple actors was a main constraint of innovation of this sector. The main reasons are cited as weak integration of social and environmental concerns into sector planning and development, weak sector upgrading (i.e. functional upgrading: horizontal and vertical coordination), and weak connection to sources of financing for innovation.

Spielman et al. (2008) noted that innovation depends on the ability of agents to interact and exchange information and knowledge. Hence, interactions can occur at any stage in the processes of producing, exchanging, or applying knowledge, through various types of networks, linkages and interventions. The industrialisation of cassava in Ghana and Colombia is an example of the integrated nature of innovation challenges (World Bank 2006; World Bank 2012). Industrialisation required processing and drying innovations to convert cassava into starch or animal feed, cassava varieties more suited to processing, more efficient agronomic practices, new organizational forms to connect smallholder-based production systems with processing plants, and new financial instruments. These issues had to be tackled in an integrated way, requiring a high degree of coordination between the actors involved (World Bank 2006; World Bank 2012). There are many actors in the food chain that directly influence the decision making of each chain actors and their innovations, especially farmers and processors (Figure 7.2) (EU SCAR 2012).

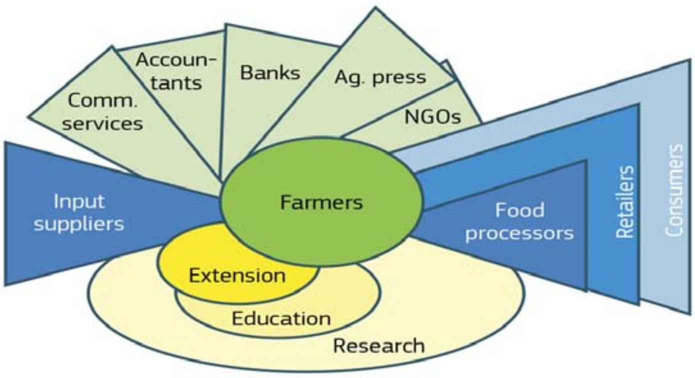


Figure 7.2. Chain actors directly relevant for agricultural innovation
Source: EU SCAR (2012)

An innovation system needs to be the encouragement of value chain coordination. Value chain coordination leads to stronger interactions, greater agreement on challenges to a sector, and greater willingness to pursue innovation (World Bank 2006). The chain actors, their roles, and the types of interaction need to be analysed from an innovation systems perspective. The potential synergy of combining the effective market-based and knowledge-based interactions needed for innovation in the value chain could form the basis for a powerful new form of intervention (World Bank 2006; World Bank 2012). Additionally, to promote innovation, the public sector could further support interactions, collective action, and broader public private partnership programmes (Juma 2011). Governments can also play a central role in convincing nationally funded research and academic institutions to participate actively with businesses and individual producers in the innovation process (Juma 2011).

d). Role of information exchange

Governance in the value chain cannot be understood without highlighting the role a strong institutional framework (Jespersen et al. 2014), and thus interactions between external and internal chain actors along various nodes need to be considered (Figure 7.3). The governments of seafood exporting and importing countries use regulation to control the food quality and safety. NGOs and customers groups play an important role in relation to influence on the GVC governance forms such as entry barriers, terms of participation and distribution of gains. Additionally, the producer associations in both sides also interact with value chain governance e.g. influence on the operation of the producers/processors in the export side or retailers/producers in the import side.

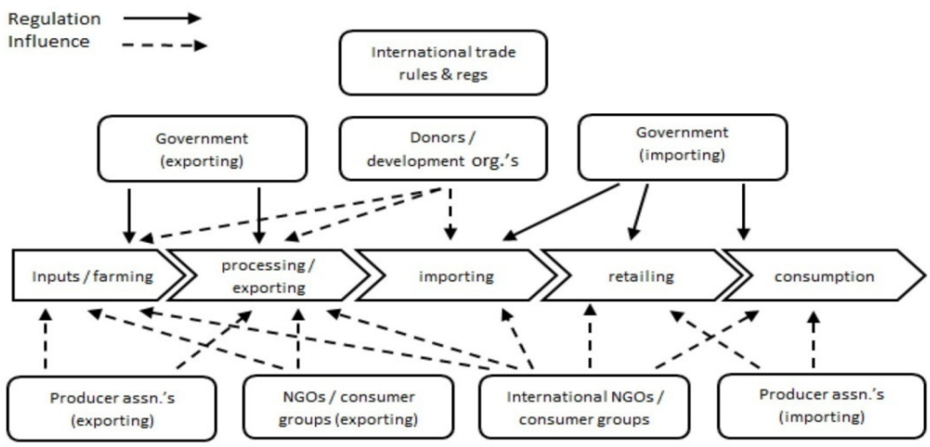


Figure 7.3. Interactions between internal and external value chain actors

Source: Jespersen et al. (2014)

The global market for seafood is becoming increasingly demanding in terms of standards and labels, and it focuses on quality, safety, traceability, sustainability, animal health and welfare and socioeconomic aspects along the value chain (Kelling 2012; Trifković 2013). Therefore, the production and market information flows play important roles in the value chain governance. In the seafood producing countries, the information is needed not only to be able the produce the right product and to supply what is demanded, but also to provide the right incentive to smallholders (Page & Slater 2003; Kambewa 2007; Khoi 2011). The information on the production and market were currently come to farmers through the technical training courses, media channels (e.g. VASEP, VINAFIS, DoFIs websites and VTV television programmes), farmers' associations or transferred from processors who signed contract with farmers. However, the farmers, especially small farmers faced difficulties to access the market information sources, because most farmers have lived in the rural or remote areas and they are not familiar with this type of information disseminations. Additionally, market information reaching farmers was often infrequent, late and less effective. In contrast, the production information (i.e. regulation on chemical/drug use, stocking time, and information on the environmental monitoring) were more effective in terms of the frequency and update data. For example, most catfish and shrimp farms know and follow the regulations on drug, chemicals and antibiotics ban/or limitation for manufacturing and trading in the aquaculture sector promulgated by MARD (2009a). This reflects the position that the Vietnamese government and producers have strived to comply with the requirements set by the international markets in order to retain access to them. Several literatures show that lack of market information constrains farmers, especially smaller farms, to link to export markets (Page & Slater 2003; Kambewa 2007; Umesh et al. 2009; Khoi 2011). It is often difficult and costly for smaller farms to obtain appropriate information on market demand (Page & Slater 2003; Segura 2006;

Bijman 2007). Smaller farms lack information on type and quality of the product demanded, and information on market regulations, seasons of demands, and price fluctuations (Umesh et al. 2009; Khoi 2011). Kelling (2012) illustrated that weaknesses in relationships among chain actors undermine supplier power by reducing access to market information, lessening incentives for sharing information, and restricting response capabilities.

Agri-food products are subject to information asymmetry problems because consumers cannot easily verify all the quality characteristics before the purchase (Trifković 2013). When information about product quality is imperfect, consumers will be buying a product of uncertain quality; and thus the imperfect information in product markets will lead to an inefficient level of food quality and safety and lower quality products will dominate (Akerlof 1970; Trifković 2013; Hansen & Trifković 2014). Since a production chain will start early from farm to fork, value chain can only reach sustainable development when both sides of the importers and producers engage to participate in the value chain with a level of responsibility and shared vision of mutual benefit through sustained trade. Transparency in both commercial aspects and product quality is required to support such linkages. Although the exchange of information on the production and market should be transparent among value chain actors (Grunert et al. 2005; Bush & Oosterveer 2007; Grunert et al. 2010), Bush et al. (2007) indicated that information flows are currently clear down the chain between retailers, distributors, importers and exporters, but less clear from exporters down to producers. The same authors noted that the strong link between consumers and producers could lead to more effective ethical trade practices through the improved management of social and environmental outcomes. Additionally, the sustainability conditions will require a marked improvement in the availability of quantitative information locally, nationally and internationally (Frankic & Hershner 2003;

Pullin et al. 2007). There are several methods for overcoming these constraints such as develop directly links between market and value chain agents (Kelling 2012). On the other hand, certified standards are another popular response to imperfect information because the main reason behind the emergence of various standards and codes of conducts is the response to the information asymmetry between producers and buyers (Khoi 2011; Hansen & Trifković 2014). These standards can disclose different product attributes and the elements of the production process, which must be identified and preserved as the product moves along the value chain (Trifković 2013; Hansen & Trifković 2014). In this situation, previous relationships that were based on the exchange of private information are altered as the information becomes codified through standards (Trifković 2013). These trends towards higher degree of value chain coordination (i.e. moving from 'market' to 'captive' and 'hierarchy' forms) are induced by market failures such as asymmetric information, failures in markets for credit, inputs or services (Key & Runsten 1999; Trifković 2013). The information and knowledge system is composed of research, extension and educational organizations, structured and governed by the government through a sectoral agricultural policy. In all cases the historical goal was to increase the productivity of the agricultural sector, by making farmers more professional (EU SCAR 2012).

REFERENCES

Ababouch, L. (2007). Causes of detentions and rejections in international fish trade. In W. Einarsson, H.; Emerson (Ed.), *International seafood trade: challenges and opportunities* (pp. 57–65). Akureyri, Iceland: FAO Fisheries & Aquaculture Proceeding 13. FAO.

Abila, R. O. (2003). *Fish Trade and Food Security: Are they Reconcilable in Lake Victoria. Report of the Expert Consultation on International Fish Trade and Food Security. FAO Fisheries Report. No. 708. FAO* (Vol. 708, pp. 128–154). Rome.

Abreu, M. C. S. De, Mattos, P. De, Lima, P. E. S., & Padula, A. D. (2011). Shrimp farming in coastal Brazil: Reasons for market failure and sustainability challenges. *Ocean & Coastal Management*, *54*(9), 658–667.

Akerlof, G. A. (1970). The Market for “Lemons”: Quality Uncertainty and the Market Mechanism. *The Quarterly Journal of Economics*, *84*(3), 488–500.

Ahmed, N., Alam, F., & Hasan, M. R. (2010). The economics of sutchi catfish (*Pangasianodon hypophthalmus*) aquaculture under three different farming systems in rural Bangladesh. *Aquaculture*, 1–15.

Ali, H., Haque, M. M., & Belton, B. (2012). Striped catfish (*Pangasianodon hypophthalmus*, Sauvage, 1878) aquaculture in Bangladesh: an overview. *Aquaculture Research*, *44*(6), 950–965.

Allsopp, M., Johnston, P., & Santillo, D. (2008). *Challenging the Aquaculture Industry on Sustainability: Technical overview. Greenpeace Research Laboratories Technical Note 01/2008* (p. 59). Exeter. Retrieved from http://www.greenpeace.to/publications/aquaculture_report_technical.pdf

Amanor, K. S. (2009). Global food chains, African Smallholders and World Bank governance. *Journal of Agrarian Change*, *9*(2), 247–262.

An Giang DoF. (2012). *Annual statistics on the aquaculture sector in An Giang province (in Vietnamese). An Giang Department of Fisheries* (p. 30). Long Xuyen.

Anh, N. (2014). Thoi An Pangasius Cooperative: A successful story of new coperative model. *Vietnamese Fisheries Mangarzine*. Retrieved June 19, 2014, from http://thuysanvietnam.com.vn/htx-thuy-san-thoi-an-chung-suc-chung-long-article-8178.tsvn

Anh, P. T. (2010). *Mitigating water pollution in Vietnamese aquaculture production and processing industry: The case of pangasius and shrimp*. Wageningen University. Retrieved from http://edepot.wur.nl/152031

Anh, T. P., Kroeze, C., Bush, S. R., & Mol, A. P. J. (2010a). Water pollution by intensive brackish shrimp farming in south-east Vietnam: Causes and options for control. *Agricultural Water Management*, *97*(6), 872–882.

Anh, T. P., Kroeze, C., Bush, S. R., & Mol, A. P. J. (2010b). Water pollution by Pangasius production in the Mekong Delta, Vietnam: causes and options for control. *Aquaculture Research*, *42*(1), 108–128.

ASC. (2010). *ASC Pangasius Standard. Version 1.0. Aquaculture Stewardship Council (ASC)* (pp. 1–62). Retrieved from http://www.asc-aqua.org/upload/ASC Pangasius Better Management Practices_v1.01.pdf

Asche, F., & Guttormsen, A. G. (2009). Introduction to the special issue: innovation, production and new markets in aquaculture. *Economics & Management*, *13*(2), 71–75.

Asche, F., Roll, K. H., & Tveterås, S. (2008). Future Trends in Aquaculture: Productivity Growth and Increased Production. In M. Holmer, K. Black, C. M. Duarte, N. Marba, & I. Karakassis (Eds.), *Aquaculture in the Ecosystem* (pp. 271–292). Springer.

Auer, M. R. (2012). Group Forest Certification for Smallholders in Vietnam: An Early Test and Future Prospects. *Human Ecology*, *40*(1), 5–14.

Aurthur, R., & Nierentz, J. (2007). *Global Trade Conference on Aquaculture. FAO Fisheries proceedings* (p. 271). Qingdao.

Avnimelech, Y. (2003). Shrimp and fish pond soils: processes and management. *Aquaculture*, *220*(1-4), 549–567.

Bacon, C. (2005). Confronting the Coffee Crisis: Can Fair Trade, Organic, and Specialty Coffees Reduce Small-Scale Farmer Vulnerability in Northern Nicaragua? *World Development*, *33*(3), 497–511.

Bacon, C. M. (2010). A Spot of Coffee in Crisis: Nicaraguan Smallholder Cooperatives, Fair Trade Networks, and Gendered Empowerment. *Latin American Perspectives*, *37*(2), 50–71.

Barrington, K., Ridler, N., Chopin, T., Robinson, S., & Robinson, B. (2008). Social aspects of the sustainability of integrated multi-trophic aquaculture. *Aquaculture International*, *18*(2), 201–211.

Baur, H., Poulter, G., Puccioni, M., Castro, P., Lutzeyer, H.-J., & Krall, S. (2003). Impact assessment and evaluation in agricultural research for development. *Agricultural Systems*, *78*(2), 329–336.

Bell, S., & Morse, S. (2008). *Sustainability Indicators: Measuring the Immeasurable?* (p. 223). London: Earthscan.

Belton, B. (2010). *The Social Relations of Aquaculture Development in South and South East Asia*. The University of Stirling. Retrieved from http://dspace3.stir.ac.uk/bitstream/1893/3424/3/Belton thesis_The Social Relations of Aquaculture Development in South and Southeast Asia.pdf

Belton, B. (2013). Small-scale aquaculture, development and poverty: a reassessment. In M. G. Bondad-Reantaso & R. P. Subasinghe (Eds.), *Enhancing the contribution of small-scale aquaculture to food security, poverty alleviation and socioeconomic development: report and proceedings of an expert workshop. FAO Fisheries and Aquaculture Technical Paper. No. 572* (pp. 27–42). Rome.

Belton, B., & Bush, S. R. (2014). Beyond net deficits: new priorities for an aquacultural geography. *The Geographical Journal*, *180*(1), 3–14.

Belton, B., Haque, M. M., Little, D. C., & Le, S. X. (2011). Certifying catfish in Vietnam and Bangladesh: Who will make the grade and will it matter? *Food Policy*, *36*(2), 289–299.

Belton, B., Le, S. X., & Little, D. C. (2008). *The Development and Status of Catfish Seed Production Systems in Vietnam. PMI2 project report.* (p. 49). Intitute of Aquaculture, The University o Stirling, Stirling.

Belton, B., & Little, D. C. (2011a). Contemporary visions for small-scale aquaculture. In R. Chuenpagdee (Ed.), *World Small-scale Fisheries: Contemporary Visions* (pp. 151–170). Delf: Eburon.

Belton, B., & Little, D. C. (2011b). Immanent and Interventionist Inland Asian Aquaculture Development and its Outcomes. *Development Policy Review*, *29*(4), 459–484.

Belton, B., Little, D. C., & Le, S. X. (2010). Pangasius catfish seed quality in Vietnam - Part 2. User and producer perceptions on broodstock and hatchery production. *AQUA Culture Asia Pacific Magazine*, (May/June 6 (3)), 24–26.

Belton, B., Little, D. C., & Le, S. X. (2011). The social relations of catfish production in Vietnam. *Geoforum*, *42*(5), 567–577.

Belton, B., Little, D., & Grady, K. (2009). Is Responsible Aquaculture Sustainable Aquaculture? WWF and the Eco-Certification of Tilapia. *Society & Natural Resources*, *22*(9), 840–855.

Berdegué Sacristán, J. A. (2001). *Cooperating to compete: associative peasant business firms in Chile*. *PhD diss.,* Wageningen University.

Beukers, R., van der pijl, W., & Pieter van duijn, A. (2012). *Pangasius in the EU market: prospects for the position of (ASC certified) pangasius in the EU retail and food service sector* (p. 29). Wageningen. Retrieved from http://www.cbi.eu/system/files/marketintel/Tailored intelligence Pangasius in the EU market - Prospects for the position of %28ASC-certified%29 pangasius in the EU retail and food service sector.pdf

Biao, X., & Kaijin, Y. (2007). Shrimp farming in China: Operating characteristics, environmental impact and perspectives. *Ocean & Coastal Management*, *50*(7), 538–550.

Biggs, S. D. (1990). A multiple source of innovation model of agricultural research and technology promotion. *World Development*, *18*, 1481–1499.

Bijman, J. (2007). The role of producer organizations in quality-oriented agrifood chains; an economic organization perspective. In R. Ruben, A. V. Tilburg, J. Trinekens, & M. V. Boekel (Eds.), *Tropical food chains. Governance regimes for quality management* (pp. 257–277). Wageningen Academic Publishers.

Binh, C. T., Phillips, M. J., & Demaine, H. (1997). Integrated shrimp-mangrove farming systems in the Mekong delta of Vietnam. *Aquaculture Research*, *28*(8), 599–610.

Bolwig, S., Ponte, S., Toit, A., & Halberg, N. (2010). Integrating Poverty and Environmental Concerns into Value-Chain Analysis: A Conceptual Framework. *Development Policy Review*, *28*(2), 173–194.

Bondad-reantaso, M. G., Subasinghe, R. P., Josupeit, H., Cai, J., & Zhou, X. (2012). The role of crustacean fisheries and aquaculture in global food security: Past, present and future. *Journal of Invertebrate Pathology*, *110*(2), 158–165.

Bosma, R., Anh, P. T., & Potting, J. (2011). Life cycle assessment of intensive striped catfish farming in the Mekong Delta for screening hotspots as input to environmental policy and research agenda. *International Journal-Life Cycle Assess*, *16*, 903–915.

Bosma, R. H., Hanh, C. T. T., Potting, J., Anh, P. T., Dung, V. V., Fransen, M., Ut, V. N. (2009). Environmental impact assessment of the pangasius sector in the Mekong Delta. Retrieved from http://www.narcis.nl/publication/RecordID/oai:library.wur.nl:wurpubs/381127/coll/person/id/8

Bosma, R. H., & Verdegem, M. C. J. (2011). Sustainable aquaculture in ponds: Principles, practices and limits. *Livestock Science*, *139*(1-2), 58–68.

Bostock, J., McAndrew, B., Richards, R., Jauncey, K., Telfer, T., Lorenzen, K., Corner, R. (2010). Aquaculture: global status and trends. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *365*(1554), 2897–912.

Boyd, C. E., & Michael, F. S. (1996). *Suggested Management to Improve Quality and Reduce Quantity of -Channel Catfish Pond Effluents* (p. 4). Alabama. Retrieved from http://aurora.auburn.edu/repo/bitstream/handle/11200/1273/0397LEAF.pdf?sequence=1

Boyd, C. E., Queiroz, J., Lee, J., Rowan, M., Whitis, G. N., & Gross, A. (2000). Environmental Assessment of Channel Catfish Zctalurus punctatus Farming in Alabama. *Journal Of The World Aquaculture Society*, *31*(4), 511–544.

Boyd, C. E., Tucker, C., Mcnevin, A., Bostick, K., & Clay, J. (2007). Indicators of Resource Use Efficiency and Environmental Performance in Fish and Crustacean Aquaculture. *Reviews in Fisheries Science*, *15*, 327–360.

Brambilla, I., Porto, G., & Tarozzi, A. (2009). *Adjusting to Trade-Policy Changes in Export Markets: Evidence from U.S. Antidumping Duties on Vietnamese Catfish. Policy Research Working Paper 4990, The World Bank* (No. 4990) (p. 50). Retrieved from https://openknowledge.worldbank.org/bitstream/handle/10986/4182/WPS4990.pdf?sequence=1

Bremer, S., Haugen, A. S., & Kaiser, M. (2012). *European consumer perspectives on seafood from aquaculture; a review of consumer values, knowledge and perceptions. SEAT Deliverable 8.8, Centre for the Study of the Sciences and Humanities, University of Bergen* (pp. 1–36). Bergen. Retrieved from http://www.extranet.seatglobal.eu/download.php?f=deliverable88europeanconsumerperspectiveson_1385241705.pdf

Bremer, S., Johansen, J. C., Gram, W., Haugen, S., & Kaiser, M. (2013). *Mapping Asian aquaculture stakeholders' realities as "ethical landscapes". SEAT Deliverable 8.10, Centre for the Study of the Sciences and Humanities, University of Bergen* (p. 129). Bergen. Retrieved from http://www.extranet.seatglobal.eu/download.php?f=d810mappingasianethicallandscapes_1385242151.pdf

Briggs, M., Funge-Smith, S., P Subasinghe, R., & Phillips, M. (2005). Introductions and movement of two penaeid shrimp species in Asia and the Pacific. *Organization*, *FAO fisher*. Retrieved from http://www.mendeley.com/research/introductions-movement-two-penaeid-shrimp-species-asia-pacific/

Browdy, C. L., & Hargreaves, J. A. (2008). *Overcoming Technical Barriers to the Sustainable Development of Competitive Marine Aquaculture in the United States* (p. 120). Florida. Retrieved from http://www.nmfs.noaa.gov/aquaculture/docs/aquaculture_docs/noaanist_techbarriers_final.pdf

Brunori, G., Damianova, Z., Faroult, E., Gomis, J. G. i, O´Brien, L., & Treyer, S. (2011). *Sustainable food consumption and production in a resource-constrained world. 3rd SCAR Foresight Exercise, Standing Committee on Agricultural Research (SCAR), European Commission* (p. 232). Luxembourg. doi:10.2777/49719

Bueno, P. B. (2009). Indicators of sustainable small-scale aquaculture development. In M. Bondad-Reantaso M.G.; Prein (Ed.), *Measuring the contribution of small-scale aquaculture: an assessment. FAO Tecnical paper 534* (pp. 145–161). Rome: FAO.

Bui, T. M., Phan, L. T., Ingram, B. A., Nguyen, T. T. T., Gooley, G. J., Nguyen, H. V., De Silva, S. S. (2010). Seed production practices of striped catfish, Pangasianodon hypophthalmus in the Mekong Delta region, Vietnam. *Aquaculture*, *306*(1-4), 92–100.

Busch, L., & Bain, C. (2004). New! Improved? The Transformation of the Global Agrifood System. *Rural Sociology*, *69*(3), 321–346.

Bush, S. R. (2008). The social science of sustainable bioenergy production in Southeast Asia. *Biofuels, Bioprod. Bioref*, *2*, 126–132.

Bush, S. R. (2009). Governing “Spaces of Interaction” for Sustainable Fisheries. *The Royal Dutch Geographical Society*, *101*(3), 305–319.

Bush, S. R., & Belton, B. (2012). Out of the Factory and Into the Fish Pond Can Certifi cation Transform Vietnamese Pangasius? In and A. L. Gert Spaargaren, Peter Oosterveer (Ed.), *Food practices in Transition: changing food consumption, retail and production in the Age of reflexive modernity* (pp. 257–290). New York: Routledge.

Bush, S. R., Belton, B., Hall, D., Vandergeest, P., Murray, F. J., Ponte, S., Kusumawati, R. (2013). Certify Sustainable Aquaculture ? *Science*, *341*(September), 1067–1068.

Bush, S. R., & Duijf, M. (2011). Searching for (un)sustainabilty in pangasius aquaculture: A political economy of quality in European retail. *Geoforum*, *42*(2), 185–196.

Bush, S. R., Khiem, N. T., & Chau, N. M. (2010). Is there a business case for small-holders in Vietnamese Pangasius? *Aquaculture Asia Magazine*, *XV*(4), 18–23.

Bush, S. R., Khiem, N. T., & Sinh, L. X. (2009). Governing the Environmental and Social Dimensions of Pangasius Production in Vietnam: a Review. *Aquaculture Economics & Management*, *13*(4), 271–293.

Bush, S. R., & Oosterveer, P. (2007). The Missing Link: Intersecting Governance and Trade in the Space of Place and the Space of Flows. *Sociologia Ruralis*, *47*(4), 385–399.

Bush, S. R., & Oosterveer, P. (2012a). Environment, governance and global markets. *Fishponds in Farming Systems*, 203–210.

Bush, S. R., & Oosterveer, P. (2012b). Linking global certification schemes and local practices in fisheries and aquaculture. *SPC Traditional Marine Resource Management and Knowledge Information Bulletin*, *29*, 15–21.

Bush, S. R., Toonen, H., Oosterveer, P., & Mol, A. P. J. (2013). The “devils triangle” of MSC certification: Balancing credibility, accessibility and continuous improvement. *Marine Policy*, *37*, 288–293.

Bush, S. R., Zwieten, P. A. M. Van, Visser, L., Dijk, H. Van, Bosma, R., Boer, W. F. de, & Verdegem, M. (2010a). Rebuilding Resilient Shrimp Aquaculture in South-east Asia: Disease Management, Coastal Ecology and Decision Making. In C.T. Hoanh et al. (Ed.), *Tropical Deltas and Coastal Zones: Food Production, Communities and Environment at the Land–Water Interface* (pp. 117–132). CAB International 2010.

Bush, S. R., Zwieten, P. A. M. Van, Visser, L., Dijk, H. Van, Bosma, R., Boer, W. F. de, & Verdegem, M. (2010b). Scenarios for Resilient Shrimp Aquaculture in Tropical Coastal Areas. *Ecology and Society*, *15*(2), 15.

Cannon, J., & Johnson, H. (2013). *Assessment of the vulnerability of the Mekong Delta Pangasius catfish industry to development and climate change in the Lower Mekong Basin. Report prepared for the Sustainable Fisheries Partnership* (p. 95). Retrieved from http://cmsdevelopment.sustainablefish.org.s3.amazonaws.com/2013/01/22/Pangasius Mekong Delta-4b2036ad.pdf

Cao, L., Diana, J. S., Keoleian, G. A., & Lai, Q. (2011). Life Cycle Assessment of Chinese Shrimp Farming Systems Targeted for Export and Domestic Sales. *Environmental Science & Technology*, 6531–6538.

Cao, P. V., Nguyen, B. P., Tran, H. K., & Bell, R. W. (2010). *Nutrient recovery by rice crops as a treatment for aquaculture solid waste: crop yield, nutrient status and nutrient budgets. Cuu Long Rice Research Institute* (p. 24). Can Tho. Retrieved from http://researchrepository.murdoch.edu.au/18524/1/nutrient_recovery_by_rice_crops.pdf

Cao, P. V., Stephanie, B., Nguyen, T. T., & Bell, R. (2010). *Solid waste treatment through vermi-culture – including market potential and returns for vermin-compost and worms for fish food, financial analysis, and benefits to smallholders. Cuu Long Rice Research Institute (in Vietnamese)* (p. 37). Can Tho. Retrieved from http://yeumoitruong.vn/forum/attachment.php?attachmentid=2429&d=1304589229

CBI. (2012a). *CBI Product Factsheet: Pangasius in Germany* (p. 12). Wageningen. Retrieved from http://www.cbi.eu/system/files/marketintel_documents/2013_pfs_pangasius_in_germany_-_fish_and_seafood_0.pdf

CBI. (2012b). *The Vietnamese seafood sector A value chain analysis* (p. 87). Wageningen. Retrieved from http://www.wageningenur.nl/web/file?uuid=6cd9c1db-11ee-4761-a51e-54c0dc077b32&owner=c66d6b72-d1ee-455e-8ebc-9490063f80b3

CBI. (2013a). *CBI Product Factsheet: Frozen cultured Black Tiger shrimp in the EU* (p. 13). Wageningen. Retrieved from http://www.cbi.eu/system/files/marketintel_documents/2013_pfs_monodon_in_the_eu_-_fish_and_seafood.pdf

CBI. (2013b). *CBI Product Factsheet: Frozen cultured Vannamei shrimp in the EU* (p. 13). Wageningen. Retrieved from http://www.cbi.eu/system/files/marketintel_documents/2013_pfs_vannamei_in_the_eu_-_fish_and_seafood.pdf

Challies, E. R. T., & Murray, W. E. (2011). The Interaction of Global Value Chains and Rural Livelihoods : The Case of Smallholder Raspberry Growers in Chile. *Journal of Agrarian Change*, *11*(1), 29–59.

Choi, H. C., & Sirakaya, E. (2006). Sustainability indicators for managing community tourism. *Tourism Management*, *27*(6), 1274–1289.

Corsin, F. (2013). Value-chain arrangements and the business case for certification. In *VIETFISH 2013: Trade Show and Conference in Vietnam, Vietnam Association of Seafood Exporters and Producers*. Ho Chi Minh.

Corsin, F., Funge-Smith, S., & Jesper, C. (2007). *A qualitative assessment of standards and certification schemes applicable to aquaculture in the Asia – Pacific region. RAP PUBLICATION 2007/25. FAO Regional Office for Asia and the Pacific*. *Office* (p. 106). Bangkok, Thailand.

Costa-Pierce, B. A. (2010). Sustainable Ecological Aquaculture Systems: The Need for a New Social Contract for Aquaculture Development. *Marine Technology Society Journal*, *44*(3), 88–112. doi:10.4031/MTSJ.44.3.3

Costa-Pierce, B. A., Bartley, D. M., Hasan, M., Yusoff, F., Kaushik, S. J., Rana, K., Yakupitiyage, A. (2011). Responsible use of resources for sustainable aquaculture. In *Global Conference on Aquaculture 2010, Sept. 22-25, 2010* (pp. 1–38). Phuket: FAO.

Council, C. N., & Cooperatives, F. (1987). Recent developments in the theory of agricultural cooperation. *Journal of Agricultural Cooperation*, *2*, 74–95.

Crab, R., Avnimelech, Y., Defoirdt, T., Bossier, P., & Verstraete, W. (2007). Nitrogen removal techniques in aquaculture for a sustainable production. *Aquaculture*, *270*(1-4), 1–14.

Cripps, S. J., & Bergheim, A. (2000). Solids management and removal for intensive land-based aquaculture production systems. *Aquacultural Engineering*, *22*(1-2), 33–56.

Crumlish, M., Dung, T. T., Turnbull, J. F., Ngoc, N. T. N., & Ferguson, H. W. (2002). Identification of Edwardsiella ictaluri from diseased freshwater catfish, *Pangasius hypophthalmus* (Sauvage), cultured in the Mekong Delta, Vietnam. *Journal of Fish Diseases*, *25*, 733–736.

Crumlish, M., Thanh, P. C., Koesling, J., Tung, V. T., & Gravningen, K. (2010). Experimental challenge studies in Vietnamese catfish, *Pangasianodon hypophthalmus* (Sauvage), exposed to Edwardsiella ictaluri and Aeromonas hydrophila. *Journal of Fish Diseases*, *33*(9), 717–722.

Cruz, G. L. A. (2006). The contribution of fair trade towards market access by smallholder banana producers. In R. Ruben, M. Slingerland, & H. Nijhoff (Eds.), *Agro-food* *chains and networks for development* (pp. 69–78). Wageningen: Springer Netherlands.

Culver, K., & Castle, D. (2008). *Aquaculture, Innovation and Social Transformation*. (K. Culver & D. Castle, Eds.). Springer Science + Business Media B.V.

Cuyvers, L., & Tran, B. V. (2008). *Aquaculture export development in Vietnam and the changing environment: the case of Pangasius in the Mekong Delta. CAS Discussion paper No 59, Centre for ASEAN Studies and Department, Can Tho* (p. 26). CAS Discussion paper No 59, Centre for ASEAN Studies and Department, Can Tho. Retrieved from http://webh01.ua.ac.be/cas/PDF/CAS59.pdf

Da, C. T., Hung, L. T., Berg, H., Lindberg, J. E., & Lundh, T. (2013). Evaluation of potential feed sources, and technical and economic considerations of small-scale commercial striped catfish (*Pangasius hypothalamus*) pond farming systems in the Mekong Delta of Vietnam. *Aquaculture Research*, *44*(3), 427–438.

Da, C. T., Lundh, T., & Lindberg, J. E. (2012). Evaluation of local feed resources as alternatives to fish meal in terms of growth performance, feed utilisation and biological indices of striped catfish (*Pangasianodon hypophthalmus*) fingerlings. *Aquaculture*, *364-365*(null), 150–156.

Dalsgaard, A., Popovic, M., & Clausen, J. (2013). *Identification and characterization of main food safety hazards in seafood imported into EU. SEAT Deliverable 6.1, SEAT project* (pp. 1–36). Stirling.

Dang, B. T., Cao, D. N., & Truong, P. Q. (2008). *Nitrogen Removal in wastewater of catfish fish ponds by Pseudomonas stutzeri and Rhodopseudomonas sp. in the Mekong Delta (in Vietnamese)*. *Delta* (p. 19). College of Aquaculture and Fisheries, Can Tho University, Can Tho.

Dannson, A. (2004). *Strengthening farm-agribusiness linkages in Africa, Agricultural Management, Marketing and Finance Service. Occasional Paper 6, FAO*. Rome.

Dasgupta, S., & Durborow, R. (2009). *Small-Scale Marketing of Aquaculture Products* (p. 8). SRAC Publication No. 350. Southern Regional Aquaculture Center. Retrieved from http://ces.ca.uky.edu/aquaculture-files/SRAC_350_Small_Scale_Marketing_of_Aquaculture_Products.pdf

De Silva, S. S. (2012). Aquaculture: a newly emergent food production sector—and perspectives of its impacts on biodiversity and conservation. *Biodiversity and Conservation*, *21*(12), 3187–3220.

De Silva, S. S., & Davy, F. B. (2009a). Aquaculture Successes in Asia: Contributing to Sustained Development and Poverty Alleviation. In S. S. De Silva & F. B. Davy (Eds.), *Success Stories in Asian Aquaculture* (Vol. 0, pp. 1–15). Springer and IDRC, Canada, Drodecht, The Netherlands.

De Silva, S. S., & Davy, F. B. (2009b). *Success Stories in Asian Aquaculture* (Vol. 0, p. 214). Springer.

De Silva, S. S., & Hasan, M. R. (2007). Feeds and fertilizers: the key to long-term sustainability of Asian aquaculture. In M. R. Hasan, T. Hecht, S. S. De Silva, & A. G. J. Tacon (Eds.), *Study and analysis of feeds and fertilizers for sustainable aquaculture development.* (pp. 19–47). Rome: FAO Fisheries Technical Paper. No. 497, FAO.

De Silva, S. S., Ingram, B. A., Nguyen, P. T., Bui, T. M., Gooley, G. J., & Turchini, G. M. (2010). Estimation of Nitrogen and Phosphorus in Effluent from the Striped Catfish Farming Sector in the Mekong Delta, Vietnam. *Ambio*, *39*(7), 504–514.

De Silva, S. S., & Nguyen, P. T. (2011). Striped catfish farming in the Mekong Delta, Vietnam: a tumultuous path to a global success. *Reviews in Aquaculture*, *3*(2), 45–73.

Dey, M. M., & Ahmed, M. (2005). Aquaculture—Food and Livelihoods for the Poor in Asia: a Brief Overview of the Issues. *Aquaculture Economics & Management*, *9*(1-2), 1–10.

Dillemuth, J., Frederick, S., Parker, R., Gereffi, G., & Appelbaum, R. (2011). Traveling Technologies: Societal Implications of Nanotechnology Through the Global Value Chain. *Journal of Nano Education*, *3*(1-2), 36–44.

Dinh, T. D. (2006). *Trade and Environment Dimensions in the Food and Food Processing Industries in Asia and the Pacific: A Country Case Study of Vietnam* (p. 22). Faculty of Environmental and Natural Resource Economics, Vietnam National Economics University, Ha Noi.

DoAH. (2012). *Report on status of shrimp disease outbreak and management 2011-2012 (in Vietnamese). Department of Animal Health, Ministry of Agriculture & Rural Developemnt* (p. 46). Ha Noi.

DoAH. (2013a). *Report on status of shrimp disease outbreak and management 2012-2013 (in Vietnamese). Department of Animal Health, Ministry of Agriculture & Rural Developemnt* (p. 8). Ha Noi.

DoAH. (2013b). *Report on the shrimp disease outbreak in Vietnam in 2012 (in Vietnamese). Department of Animal Health, Ministry of Agriculture & Rural Developemnt* (p. 15). Ha Noi.

Dolan, C., & Humphrey, J. (2000). Governance and Trade in Fresh Vegetables: The Impact of UK Supermarkets on the. *Journal of Development Studies*, *37*(2), 147–176.

Dorward, A. (2009). Integrating Contested Aspirations, Processes and Policy: Development as Hanging In, Stepping Up and Stepping Out. *Development Policy Review*, *27*(2), 131–146.

Dries, L., & Swinnen, J. F. M. (2004). Foreign Direct Investment, Vertical Integration, and Local Suppliers: Evidence from the Polish Dairy Sector. *World Development*, *32*(9), 1525–1544.

Edwards, P. (2010). Review of small-scale aquaculture: definitions; characterization; numbers. In *FAO Expert Workshop on Enhancing the Contribution of Small-Scale Aquaculture (SSA) to Food Security* (p. 36). Ha Noi.

Ekins, P. (2011). Environmental sustainability: From environmental valuation to the sustainability gap. *Progress in Physical Geography*, *35*(5), 629–651.

EU. (2013). *Strategic guidelines for the sustainable development of EU aquaculture* (p. 12). Brussels. Retrieved from http://ec.europa.eu/fisheries/cfp/aquaculture/official_documents/com_2013_229_en.pdf

EU SCAR. (2012). *Agricultural Knowledge and Innovation Systems in Transition – a reflection paper*. Brussels. doi:10.2777/34991

Exequiel, G. P., Tinkham, S., & Phillips, M. J. (2009). *Development of an APEC: Strategy on sustainable aquaculture* (p. 90). Singapore. Retrieved from http://sta.epa.gov.tw/cooperation/APEC MRC web/wwwroot/RI/RI001.pdf

FAO. (1995). Dimensions of need: An atlas of food and agriculture. Food and Agriculture Organization, Rome. Food and Agriculture Organization, Rome: http://www.fao.org/docrep/u8480e/U8480E0l.htm#Sustainable agriculture and rural development. Retrieved March 11, 2014, from http://www.fao.org/docrep/u8480e/U8480E0l.htm#Elements for sustainable agriculture and rural development

FAO. (1997). *Marketing Research and Information Systems. (Marketing and Agribusiness Texts - 4)*. Rome: FAO. Retrieved from http://www.fao.org/docrep/W3241E/W3241E00.htm

FAO. (2012). *The state of world fisheries and aquaculture 2012* (p. 209). Food and Agriculture Organization, Rome.

FAO. (2013a). *FAO/MARD Technical Workshop on Early Mortality Syndrome (EMS) or Acute Hepatopancreatic Necrosis Syndrome (AHPNS) of Cultured Shrimp (under TCP/VIE/3304)* (Vol. 1053, p. 65). Ha Noi.

FAO. (2013b). Fishery Statistical Collections: Commodity Trade and Production. Fishery Commodities Global Production and Trade (online query). Retrieved February 11, 2014, from http://www.fao.org/figis/servlet/SQServlet?file=/work/FIGIS/prod/webapps/figis/temp/hqp_1773611564069290434.xml&outtype=html

Fisheries Directorate. (2010). *Review on the achievements of 2010 plan and implementation of 2011 plan (in Vietnamese), Ministry of Agriculture & Rural Developemnt* (p. 23). Ha Noi.

Fisheries Directorate. (2011). *Review on the achievements of 2011 plan and implementation of 2012 plan (in Vietnamese), Ministry of Agriculture & Rural Developemnt* (p. 18). Ha Noi.

Fisheries Directorate. (2012). *Report on the Vietnam shrimp production and consumption in 2012 and plan of 2013 (in Vietnamese). Ministry of Agriculture & Rural Development* (p. 13). Ha Noi.

Fisheries Directorate. (2013a). *Report on the striped catfish production and consumption at the Mekong Delta in 2012 and plan of 2013 (in Vietnamese). Ministry of Agriculture & Rural Development* (p. 12). Ha Noi.

Fisheries Directorate. (2013b). *Review on the achievements of 2012 plan and implementation of 2013 plan (in Vietnamese), Ministry of Agriculture & Rural Developemnt* (p. 12). Ha Noi.

Fisheries Directorate. (2014). *Review on the achievements of 2013 plan and implementation of 2014 plan (in Vietnamese), Ministry of Agriculture & Rural Developemnt* (p. 17). Ha Noi.

Focardi, S., Corsi, I., & Franchi, E. (2005). Safety issues and sustainable development of European aquaculture: new tools for environmentally sound aquaculture. *Aquaculture International*, *13*(1-2), 3–17.

Francesconi, G. N. (2009). *Cooperation for competition-Linking Ethiopian farmers to markets*. Wageningen University, the Netherlands.

Frankic, A., & Hershner, C. (2003). Sustainable aquaculture: developing the promise of aquaculture. *Aquaculture International*, *11*(6), 517–530.

Frederick, S., & Gereffi, G. (2011). Upgrading and restructuring in the global apparel value chain: why China and Asia are outperforming Mexico and Central America. *International Journal of Technological Learning, Innovation and Development*, *4*(1-3), 67–95.

Funge-smith, S., & Briggs, M. (2003). Is white shrimp (Penaeus vannamei) a threat to Asian shrimp culture? *FAO Aquaculture Newsletter*, *30*, 19–23.

GAA. (2009). *Aquaculture Facility Certification: Shrimp Farms. Best Aquaculture Practices Certification Standards, Guidelines. Global Aquaculture Alliance (GAA)* (pp. 8–22). Retrieved from http://www.gaalliance.org/cmsAdmin/uploads/BAP-ShrimpF-612S.pdf

GAA. (2010). *Aquaculture Facility Certification: Pangasius Farms. Best Aquaculture Practices Certification Standards, Guidelines. Global Aquaculture Alliance (GAA)* (p. 20). Retrieved from www.gaalliance.org/cmsAdmin/uploads/BAP-PangasiusF-612S.pdf

Gandini, G., Ababouch, L., & Anichini, L. (2009). From eco-sustainability to risk assessment of aquaculture products. *Veterinary Research Communications*, *33 Suppl 1*, 3–8.

Garrido, S. (2007). Why Did Most Cooperatives Fail? Spanish Agricultural Cooperation in the Early Twentieth Century. *Rural History*, *18*(02), 183–200.

Gereffi, G., Humphrey, J., & Sturgeon, T. J. (2005). The governance of global value chains. *Review of International Political Economy*, *12*(1), 78–104.

Gereffi, G., & Korzeniewicz, M. (1994). *Commodity Chains and Global Capitalism* (p. 352). Westport: Praeger.

Gibbon, P. (2001). Upgrading Primary Production: A Global Commodity Chain Approach. *World Development*, *29*(2), 345–363.

Gildemeister, A. T. (2012, June). *A study into the effects and environmental risk of antibiotics used in freshwater aquaculture on environmental bacteria*. The University of Stirling. Retrieved from http://hdl.handle.net/1893/9930

Giuliani, E., Pietrobelli, C., & Rabellotti, R. (2005). Upgrading in Global Value Chains: Lessons from Latin American Clusters. *World Development*, *33*(4), 549–573.

Glavič, P., & Lukman, R. (2007). Review of sustainability terms and their definitions. *Journal of Cleaner Production*, *15*(18), 1875–1885.

GlobalGAP. (2011). *Control Points and Compliance Criteria: All Farm Base. Code ref: IFA V4.0 March11; Edition AF 4.0-1; English Version*. Retrieved from http://www.globalgap.org/export/sites/default/.content/.galleries/documents/130621_gg_ifa_cpcc_af_ab_coc_v4_0-2_en.pdf

GLOBEFISH. (2013). European Price Report. *GLOBEFISH*, (04), 12–20. Retrieved from http://www.globefish.org/upl/Publications/EPR-04-2013.pdf

Glover, D., & Kusterer, K. (1990). *Small farmers, big business: contract farming and rural development* (p. 175). London: UK: MACMILLAN. Retrieved from http://www.cabdirect.org/abstracts/19916710935.html

Gómez Tovar, L., Martin, L., Gómez Cruz, M. A., & Mutersbaugh, T. (2005). Certified organic agriculture in Mexico: Market connections and certification practices in large and small producers. *Journal of Rural Studies*, *21*(4), 461–474.

González, A. A., & Nigh, R. (2005). Smallholder participation and certification of organic farm products in Mexico. *Journal of Rural Studies*, *21*(4), 449–460.

GOV. (1986). *Doi moi policy reforms. Government of Vietnam (in Vietnamese)*. Ha Noi.

GOV. (2009). *Decision No.2033/QD-TTg: Approval of master plan for the Striped catfish sector development until 2020. Government of Vietnam (in Vietnamese)* (p. 3). Ha Noi.

GOV. (2013). *Decision No.1445/QD-TTg: Approval of overal planning master plan for the Vietnamese fisheries sector development until 2020 and torwards to 2030. Government of Vietnam (in Vietnamese)* (p. 17). Ha Noi.

GOV. (2014). *Decree 36/2014/ND-CD on conditions for catfish production, processing and exporting (in Vietnamese)* (p. 10). Ha Noi.

Gow, H. R., & Swinnen, J. F. M. (1998). Up- and downstream restructuring, foreign direct investment, and hold-up problems in agricultural transition. *European Review of Agricultural Economics*, *25*(3), 331–350.

Gräslund, S., & Bengtsson, B. E. (2001). Chemicals and biological products used in south-east Asian shrimp farming, and their potential impact on the environment--a review. *The Science of the Total Environment*, *280*(1-3), 93–131.

Grunert, K. G., Jeppesen, L. F., Jespersen, K. R., Sonne, A., Young, J. A., Hansen, K., & Trondsen, T. (2005). Market orientation of value chains: A conceptual framework based on four case studies from the food industry. *European Journal of Marketing*, *39*(5/6), 428–455.

Grunert, K. G., Trondsen, T., Campos, E. G., & Young, J. A. (2010). Market orientation in the mental models of decision makers: two cross-border value chains. *International Marketing Review*, *27*(1), 7–27.

GSO. (2012). *Annual statistics yearbook in Vietnam 2011*. (General Statistics Office, Ed.) (p. 125). Ha Noi: Statistical publishing house.

GSO. (2013). *Annual statistics yearbook in Vietnam 2012*. (General Statistics Office, Ed.) (p. 135). Ha Noi: Statistical publishing house.

Gupta, M. V, & Acosta, B. O. (2004). Tilapia farming: A global review. *NACA*, 1–14. Retrieved from http://www.enaca.org/modules/news/article.php?storyid=453

Ha, T. T. P., & van Dijk, H. (2013). Fishery livelihoods and (non-)compliance with fishery regulations—A case study in Ca Mau Province, Mekong Delta, Viet Nam. *Marine Policy*, *38*, 417–427.

Ha, T. T. T., & Bush, S. R. (2010). Transformations of Vietnamese shrimp aquaculture policy: empirical evidence from the Mekong Delta. *Environment and Planning C: Government and Policy*, *28*(6), 1101–1119.

Ha, T. T. T., Bush, S. R., Mol, A. P. J., & van Dijk, H. (2012). Organic coasts? Regulatory challenges of certifying integrated shrimp–mangrove production systems in Vietnam. *Journal of Rural Studies*, *28*(4), 631–639.

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

Ha, T. T. T., Dijk, H. Van, & Bush, S. R. (2012). Mangrove conservation or shrimp farmer ' s livelihood ? The devolution of forest management and bene fi t sharing in the Mekong Delta, Vietnam. *Ocean and Coastal Management*, *69*, 185–193.

Hall, A. (2014). Agriculture innovation systems: an introduction. Retrieved June 18, 2014, from http://www.slideshare.net/LINKInnovationStudies/agricultural-innovation-systems-an-introduction#

Hall, A., Sulaiman, V. R., & Clark, N. (2003). From measuring impact to learning institutional lessons: an innovation systems perspective on improving the management of international agricultural research. *Agricultural Systems*, *78*, 213–241.

Han, H., & Immink, A. (2013). A zonal approach for aquaculture sustainability. *INFOFISH International*. Retrieved from http://cmsdevelopment.sustainablefish.org.s3.amazonaws.com/2013/11/26/26 - 28 _ Han Han - A zonal approach for aquaculture-2-bdfaec03.pdf

Hansen, H., & Trifković, N. (2014). Food Standards are Good – For Middle-Class Farmers. *World Development*, *56*, 226–242.

Haque, M. M., Monira, M. S., Salam, M. A., Shinn, A. P., & Little, D. C. (2013). Use of pangasius pond sediment for roof top bag gardening: potential for rural-urban integrated aquaculture-horticulture. *Aquaculture Asia, NACA*, *XVIII*(4), 21–24.

Hardi, P., & Zdan, T. (1997). *Assessing Sustainable Development: Principles in Practice* (p. 161). Winnipeg. Retrieved from http://www.iisd.org/pdf/bellagio.pdf

Haugen, A. S., Bremer, S., & Kaiser, M. (2013). *Assessment of costs and benefits of mandatory and voluntary certification schemes applied to Asian producers. SEAT Deliverable 8.5,Centre for the Study of the Sciences and Humanities, University of Bergen* (p. 11). Bergen. Retrieved from http://www.extranet.seatglobal.eu/download.php?f=d85andd86costsandbenefitsofcertification_1385800978.pdf

Heijungs, R., Settanni, E., & Guinée, J. (2012). Toward a computational structure for life cycle sustainability analysis: unifying LCA and LCC. *The International Journal of Life Cycle Assessment*. doi:10.1007/s11367-012-0461-4

Henriksson, P. J. G., Zhang, W., Nahid, S. A. A., Newton, R., Phan, L. T., Hai, D. M., Little, D. C. (2014). *Results of LCA studies of Asian Aquaculture Systems for Tilapia, Catfish, Shrimp, and Freshwater prawn. SEAT Deliverable Ref: D 3.5* (p. 182). Stirling.

Henson, S., Jaffee, S., Cranfield, J., & Siegel, P. (2008). *Linking African smallholders to high-value markets: practitioner perspectives on benefits, constrains, and interventions. Policy research working paper, the World Bank*.

Hermans, F., Apeldoorn, D. Van, Stuiver, M., & Kok, K. (2013). Niches and networks: Explaining network evolution through niche formation processes. *Research Policy*, *42*(3), 613–623.

Hishamunda, N., Bueno, P., Menezes, A. M., Ridler, N., & Martone, E. (2014). *Improving governance of aquaculture employment: A global assessment. FAO Fisheries and Aquaculture Technical Paper 575* (p. 48). Roma.

Hishamunda, N., & Ridler, N. B. (2008). Sustainable commercial aquaculture: A survey of administrative procedures and legal frameworks. *Aquaculture Economics & Management*, *7*(3-4), 167–178.

Hishamunda, N., Ridler, N. B., Bueno, P., & Yap, W. G. (2009). Commercial aquaculture in Southeast Asia: Some policy lessons. *Food Policy*, *34*(1), 102–107.

Hoa, T. T. T., Zwart, M. P., Thanh, N., Vlak, J. M., & Jong, M. C. M. De. (2011). Transmission of white spot syndrome virus in improved-extensive and semi-intensive shrimp production systems: A molecular epidemiology study. *Aquaculture*, *313*(1-4), 7–14.

Humphrey, J. (2006). Policy implications of trends in agribusiness value chains. *The European Journal of Development Research*, *18*(4), 572–592.

Humphrey, J., & Schmitz, H. (2002). *Developing country firms in the global economy: Governance and upgrading in global value chains. INEF-Report Nr. 61*. Duisburg.

Huysveld, S., Schaubroeck, T., Meester, S. De, Sorgeloos, P., Langenhove, H. Van, Van, V., & Dewulf, J. (2013). Resource use analysis of Pangasius aquaculture in the Mekong Delta in Vietnam using Exergetic Life Cycle Assessment. *Journal of Cleaner Production*, *51*, 225–233.

Irz, X., Stevenson, J. R., Tanoy, A., & Morissens, P. (2007). The Equity and Poverty Impacts of Aquaculture: Insights from the Philippines. *Development Policy Review*, *25*(April 2004), 495–516.

Irz1, X., & Stevenson, J. R. (2012). Efficiency and Farm Size in Philippine Aquaculture. Analysis in a Ray Production Frontier Framework. *Bio-Based and Applied Economics*, *1*(2), 175–198.

Islam, M. S. (2008). From pond to plate: Towards a twin-driven commodity chain in Bangladesh shrimp aquaculture. *Food Policy*, *33*(3), 209–223.

Jespersen, K. S., Kelling, I., Ponte, S., & Kruijssen, F. (2014). Institutional frameworks and the governance of aquaculture value chains: Lessons from Asia. *Food Policy*, *in press*.

Johnston, D., Trong, N. Van, Tien, D. Van, & Xuan, T. T. (2000). Shrimp yields and harvest characteristics of mixed shrimp–mangrove forestry farms in southern Vietnam: factors affecting production. *Aquaculture*, *188*(3-4), 263–284.

Jolly, C. M., Umali-Maceina, G., & Hishamunda, N. (2009). Small-scale aquaculture: a fantasy or economic opportunity. In M. Bondad-Reantaso M.G.; Prein (Ed.), *Measuring the contribution of small-scale aquaculture: an assessment. FAO Tecnical paper 534* (pp. 73–87). Rome: FAO.

Juma, C. (2011). Agricultural Innovation Systems. In C. Juma (Ed.), *The New Harvest: Agricultural Innovation in Africa* (pp. 50–83). New York: Oxford University Press.

Kagawa, M., & Bailey, C. (2006). Trade Linkages in Shrimp Exports: Japan, Thailand and Vietnam. *Development Policy Review*, *24*(3), 303–319.

Kai, S. (2006). *Facilitation of the market for Business Development Services to overcome difficulties of the Pangasius fish farmers in An Giang province, Vietnam*. *Fisheries (Bethesda)*. GTZ Vietnam, An Giang. Retrieved from http://www.sme-gtz.org.vn/Portals/0/AnPham/Pangasius-BDS Report_Vietnam.pdf

Kambewa, E. V. (2007). *Balancing the people, profit and planet dimensions in international marketing channels - A study on coordinating mechanisms in the Nile perch channel from Lake Victoria*. Wageningen University, the Netherlands.

Kariuki, L. . (2006). Participation of smallholders in international trade. *Agro-Food Chains and Network for Development*, *14*, 41–48.

Karunasagar, I. (2013). *Report on ICT/MIS capacity building methods and outcommes for targeted end users. SEAT Deliverable D 10.3. The University of Stirling* (p. 15). Stirling.

Kassam, L., Subasinghe, R., & Phillips, M. (2011). *Aquaculture farmer organizations and cluster management: concepts and experiences. FAO Fisheries and Aquaculture Technical Paper No.563, FAO* (p. 90). Rome.

Kelling, I. (2012). *Knowledge is Power? A market orientation approach to the global value chain analysis of aquaculture: Two cases linking Southeast Asia and the EU*. The University of Stirling. Retrieved from https://dspace.stir.ac.uk/bitstream/1893/12941/1/KELLING Ingrid_Knowledge is Power%3F_PhD Thesis_2012.pdf

Kelling, I., Kruijssen, F., & Li, C. O. (2010). *Review of trade, regulation and certification issues related to farmed aquatic animals. SEAT Deliverable 2.7, The WorldFish Center* (p. 30). Penang.

Key, N., & Runsten, D. (1999). Contract farming, smallholders, and rural development in Latin America: The organization of Agro-processing firms and the scale of out grower production. *World Development*, *27*(2), 381–401.

Khiem, N. T., Bush, S. R., Nguyen, C. M., & Vo, L. T. T. (2010). *Upgrading small-holders in the Vietnamese Pangasius value chain*. *Training* (p. 158). Final Report, ODI grant number RO334, An Giang. Retrieved from http://www.fao.org/uploads/media/UpgradingPangasiusFINAL.pdf

Khoa, N. A. (2014). The small-scale coffee farmers lack of operational cost for re-investment. *Gia Lai online*. Retrieved March 04, 2014, from http://baogialai.com.vn/channel/722/201402/nien-vu-ca-phe-2014-nong-dan-san-xuat-quy-mo-nho-thieu-kinh-phi-tai-dau-tu-2293574/

Khoi, L. D. N. (2007). *Description of the Pangasius value chain in Vietnam. CAS Discussion paper No 56, Centre for ASEAN Studies and Department, Can Tho* (No. 56). *Business* (p. 49). CAS Discussion paper No 56, Centre for ASEAN Studies and Department, Can Tho. Retrieved from http://webh01.ua.ac.be/cas/PDF/CAS56.pdf

Khoi, L. D. N. (2011). *Quality Management in the Pangasius Export Supply Chain in Vietnam: The Case of Small-Scale Pangasius Farming in the Mekong River Delta*. University of Groningen. Retrieved from http://irs.ub.rug.nl/ppn/333152026

Khoi, L. N. D., Son, N. P., Stewart, M. A., & Coclanis, P. A. (2011). Relationship quality in fish value chains: buyer-supplier management in the Pangasius industry, Vietnam.

In M. A. Stewart & P. A. Coclanis (Eds.), *Environmental Change and Agricultural Sustainability in the Mekong Delta* (Vol. 45, pp. 287–301). Dordrecht: Springer Netherlands.

Kilelu, C. W., Klerkx, L., & Leeuwis, C. (2013). Agricultural Systems Unravelling the role of innovation platforms in supporting co-evolution of innovation: Contributions and tensions in a smallholder dairy development programme. *Agricultural Systems*, *118*, 65–77.

Klerkx, L., Aarts, N., & Leeuwis, C. (2010). Adaptive management in agricultural innovation systems: The interactions between innovation networks and their environment. *Agricultural Systems*, *103*(6), 390–400.

Kluts, I. N., Potting, J., Bosma, R. H., Phong, L. T., & Udo, H. M. J. (2012). Environmental comparison of intensive and integrated agriculture-aquaculture systems for striped catfish production in the Mekong Delta, Vietnam, based on two existing case studies using life cycle assessment. *Reviews in Aquaculture*, *4*(4), 195–208.

Konefal, J., & Hatanaka, M. (2011). Enacting third-party certification: A case study of science and politics in organic shrimp certification. *Journal of Rural Studies*, *27*(2), 125–133.

Kongkeo, H. (1997). Comparison of intensive shrimp farming systems. *Aquaculture Research*, *28*, 789–796.

Kongkeo, H., & Davy, F. B. (2009). Backyard hatcheries and small scale shrimp and prawn farming in Thailand. In S. S. De Silva & F. B. Davy (Eds.), *Success Stories in Asian Aquaculture* (pp. 67–83). Springer and IDRC, Canada, Drodecht, The Netherlands.

Kruijssen, F., Hong, M. C., & Qasim, M. (2013). *Livelihood implications of global seafood trade. Deliverable report 5.8 of the Sustaining Ethical Aquaculture Trade (SEAT) project* (p. 65). WorldFish, Penang.

Krugman, P., Wells, R., & Graddy, K. (2010). Essentials of Economics. In P. Krugman, R. Wells, & K. Graddy (Eds.), *Business & Economics* (Second Edi., pp. 84–110). Business & Economics.

Kutty, M. N. (1995). Aquaculture Development and Sustainability in Southeast Asia. In T. U. Bagarinao & E. E. C. Flores (Eds.), *Towards Sustainable Aquaculture in Southeast Asia and Japan* (pp. 91–108). lloilo: SEAFDEC Aquaculture Department.

Kvaløy, O., & Tveterås, R. (2008). Cost structure and vertical integration between farming and processing. *Journal of Agricultural Economics*, *59*(2), 296–311.

Lam, X. T., & Truong, M. H. (2010). *Current status of best aquaculture practices (BAP) certification apply for the black tiger shrimp (Penaeus monodon) culture in the Mekong River Delta* (p. 11). College of Aquaculture & Fisheries, Can Tho University, Can Tho.

Lambert, D. M., & Cooper, M. C. (2000). Issues in Supply Chain Management. *Industrial Marketing Management*, *29*, 65–83.

Lazard, J., Baruthio, A., Mathé, S., Rey-valette, H., Chia, E., Clément, O., René, F. (2010). Aquaculture system diversity and sustainable development: fish farms and their representation. *Aquatic Living Resources*, *23*, 187–198.

Le, C. T. (2011). *A Risk Management Framework for Aquaculture: The Case of Vietnamese Catfish Farming*. RMIT University. Retrieved from http://researchbank.rmit.edu.au/eserv/rmit:160178/le.pdf

Le, S. X. (2009). Social impacts of coastal aquaculture in the Mekong Delta. In M. Bondad-Reantaso M.G.; Prein (Ed.), *Measuring the contribution of small-scale aquaculture: an assessment. FAO Tecnical paper 534* (pp. 95–107). Rome: FAO.

Le, S. X. (2010). *Lecture on Fisheries Economics*. Can Tho University Publisher, Can Tho.

Le, S. X. (2011). Value chain of catfish (Pangasianodon hypophthalmus) in the Mekong Delta. *Vietnam Journal of Agriculture and Rural Development*, (ISSN 0866-7020), 67–73.

Le, S. X., & Le, H. L. (2010). Supply and use of catfi sh (Pangasianodon hypophthalmus) seed in the Mekong Delta of Vietnam. *Aquacuture Asia Magazine*, *XV*(1), 26–33.

Le, S. X., Nguyen, T. T., & Nguyen, Q. K. T. (2011). Value chain of black tiger shrimp in the Mekong Delta. In *Prceedings of the 4th Aquaculture and Fisheries Conference* (pp. 524–535). Can Tho: Agriculture publisher.

Le, T. C., & Cheong, F. (2010). Peceptions of risk and risk management in Vietnames catfish farming: an empirical study. *Aquaculture Economics & Management*, *14*(4), 282–314.

Lebel, L., Garden, P., Luers, A., Manuel-Navarrete, D., & Giap, D. H. (2009). Knowledge and innovation relationships in the shrimp industry in Thailand and Mexico. In *Proceedings of the National Academy of Sciences of the United States of America* (p. 6). doi:10.1073/pnas.0900555106

Lebel, L., Lebel, P., Garden, P., Giap, D. H., Khrutmuang, S., & Nakayama, S. (2008). Places, Chains, and Plates: Governing Transitions in the Shrimp Aquaculture Production-Consumption System. *Globalizations*, *5*(2), 211–226.

Lebel, L., Mungkung, R., Gheewala, S. H., & Lebel, P. (2010). Innovation cycles, niches and sustainability in the shrimp aquaculture industry in Thailand. *Environmental Science & Policy*, *13*(4), 291–302.

Lebel, L., Tri, N. H., Saengnoree, A., Pasong, S., Buatama, U., & Thoa, L. K. (2002). Industrial transformation and shrimp aquaculture in Thailand and Vietnam: pathways to ecological, social, and economic sustainability? *Ambio*, *31*(4), 311–23.

Lehtonen, M. (2004). The environmental–social interface of sustainable development: capabilities, social capital, institutions. *Ecological Economics*, *49*(2), 199–214.

Lin, C. K., & Yi, Y. (2003). Minimizing environmental impacts of freshwater aquaculture and reuse of pond effluents and mud. *Aquaculture*, *226*(1-4), 57–68.

Lin, K., & Ren, H. (2006). The Function Defects of "Company Plus Farmers" Model and Food Safety (In Chinese). *Science-Economic-Society*, *24*(2), 69–72.

Little, D. C., Bush, S. R., Belton, B., Thanh Phuong, N., Young, J. A., & Murray, F. J. (2012). Whitefish wars: Pangasius, politics and consumer confusion in Europe. *Marine Policy*, *36*(3), 738–745.

Little, D. C., & Edwards, P. (2003). *Integrated Livestock-fish Farming Systems* (p. 161). Rome: FAO.

Loc, T., Nunan, L., Redman, R. M., Mohney, L. L., Pantoja, C. R., Fitzsimmons, K., & Lightner, D. V. (2013). Determination of the infectious nature of the agent of acute hepatopancreatic necrosis syndrome affecting penaeid shrimp. *Diseases of Aquatic Organisms*, *105*(1), 45–55.

Luning, P. A., Devlieghere, F., & Verhé, R. (2006). *Safety in the Agri-Food Chain* (p. 684 (249–301)). Wageningen: Wageningen Academic Publishers.

Lyon, S. (2006). Evaluating fair trade consumption: politics, defetishization and producer participation. *International Journal of Consumer Studies*, *30*(5), 452–464.

Maertens, M., & Swinnen, J. F. M. (2009). Trade, Standards, and Poverty: Evidence from Senegal. *World Development*, *37*(1), 161–178.

Mantingh, I., & Dung, V. N. (2008). *Pre-Assessment of the Pangasius Sector: Towards Sustainability.* Dutch Ministry of Agriculture, Nature and Food Quality.

MARD. (2009a). *Circular No. 15/2009/TT-BNN dated 17 April 2009 of Head of the MARD on "promulgating regulations on drug, chemicals and antibiotics banned/or limitedly using for manufacturing and trading in aquaculture" (in Vietnamese). Ministry of Agriculture & Rural D*. Ha Noi.

MARD. (2009b). *Project on aquaculture development of Vietnam up to 2020 (in Vietnamese). Ministry of Agriculture & Rural Developemnt* (p. 38). Ha Noi.

MARD. (2009c). *Strategies for fisheries development of Vietnam up to 2020 (in Vietnamese). Ministry of Agriculture & Rural Developemnt* (p. 83). Ha Noi.

MARD. (2010). *Project on development planning for Tilapia production and consumption of Vietnam up to 2015 and strategic planning to 2020 (in Vietnamese). Ministry of Agriculture & Rural Developemnt* (p. 160). Ha Noi.

MARD. (2014). *Restucture of fisheries sector torwards sustainable development and increasing of value added products. Mistritry of Agriculture & Rural Development (in Vietnamese)* (p. 42). Ha Noi.

Markelova, H., & Mwangi, E. (2010). Collective Action for Smallholder Market Access: Evidence and Implications for Africa. *Review of Policy Research*, *27*(5), 621–640.

Martinez-Cordero, F. J., & Leung, P. (2003). Sustainable aquaculture and producer performance: measurement of environmentally adjusted productivity and efficiency of a sample of shrimp farms in Mexico. *Aquaculture*, *241*(1-4), 249–268.

Melba G. Bondad-Reantaso, P. B. B., Demaine, H., & Tipparat, O. (2009). Development of an indicator system for measuring the contribution of small-scale aquaculture to sustainable rural development. In M. Bondad-Reantaso M.G.; Prein (Ed.), *Measuring the contribution of small-scale aquaculture: an assessment. FAO Tecnical paper 534* (pp. 161–179). Rome: FAO.

Minten, B., Randrianarison, L., & Swinnen, J. F. M. (2009). Global Retail Chains and Poor Farmers: Evidence from Madagascar. *World Development*, *37*(11), 1728–1741.

Miyata, S., Minot, N., & Hu, D. (2009). Impact of Contract Farming on Income: Linking Small Farmers, Packers, and Supermarkets in China. *World Development*, *37*(11), 1781–1790.

Moctezuma-Malagón, A., González-Esquivel, C. E., De la Lanza-Espino, G., & González-Rebeles Islas, C. (2008). A methodology for evaluating the sustainability of inland wetland systems. *Aquaculture International*, *16*, 525–537.

MOFI. (2006). *Evaluate results of "Decree 09/2000/NQ-CP" implementing on aquaculture sector during 2000 - 2005 (in Vietnamese). Ministry of Fisheries* (p. 45). Ha Noi.

Mohan, C. V. (2013). Aquaculture Certification: Producer Compliance Constraints. In *VIETFISH 2013: Trade Show and Conference in Vietnam, Vietnam Association of Seafood Exporters and Producers*. Ho Chi Minh.

Muir, J. (2005). Managing to harvest? Perspectives on the potential of aquaculture Managing to harvest? Perspectives on the potential of aquaculture. *Phil. Trans. R. Soc. B*, *360*, 191–218.

Mungkung, R., Udo de Haes, H., & Clift, R. (2006). Potentials and Limitations of Life Cycle Assessment in Setting Ecolabelling Criteria: A Case Study of Thai Shrimp Aquaculture Product (5 pp). *The International Journal of Life Cycle Assessment*, *11*(1), 55–59.

Murray, F. J., Zhang, W., Arlene, N. S., Phan, L. T., Haque, M. M., Henriksson, P., & Little, D. C. (2011). *Report on Boundary Issues. SEAT Deliverable 2.8.* (p. 83). SEAT project, Institute of Aquaculture, The University of Stirling, Stirling.

Murshed-E-Jahan, K., & Pemsl, D. E. (2011). The impact of integrated aquaculture–agriculture on small-scale farm sustainability and farmers' livelihoods: Experience from Bangladesh. *Agricultural Systems*, *104*(5), 392–402.

NACA. (2011). *Evaluation of the impact of the Indian Ocean tsunami and US antidumping duties on the shrimp farming sector of South and South-East Asia. Shrimp Price Study, Phase III-NACA* (p. 157). Bangkok.

Naturland. (2012). *Naturland Standards for Organic Aquaculture. Naturland - Association for Organic Agriculture, Registered Association.* (pp. 1–28). Gräfelfing, Germany.

Retrieved from http://www.naturland.de/fileadmin/MDB/documents/Richtlinien_englisch/Naturland-Standards_Aquaculture.pdf

Neiland, A. E., Soley, N., Varley, J. B., & Whitmarsh, D. J. (2001). Shrimp aquaculture: economic perspectives for policy development. *Marine Policy*, *25*(4), 265–279.

Neilson, J. (2008). Global Private Regulation and Value-Chain Restructuring in Indonesian Smallholder Coffee Systems. *World Development*, *36*(9), 1607–1622.

Nguyen, A. L., Dang, V. H., Bosma, R. H., Verreth, J. a J., Leemans, R., & De Silva, S. S. (2014). Simulated Impacts of Climate Change on Current Farming Locations of Striped Catfish (*Pangasianodon hypophthalmu*s; Sauvage) in the Mekong Delta, Vietnam. *Ambio*.

Nguyen, D. M. (2009). *Marketing challanges in Vietnamese striped catfish globalization* (p. 13). Department of Fisheries Management and Development, Nong Lam University, Ho Chi Minh.

Nguyen, D. M. (2010). Application of econometric models for price impact assessment of antidumping measures and labelling laws on global markets: a case study of Vietnamese striped catfish. *Reviews in Aquaculture*, *2*, 86–101.

Nguyen, H. D., Luu, D. D., Nguyen, H. V., Truong, T. T., Nguyen, T. V., Doan, B., Nguyen, P. V. (2013). *Evaluation of environmetal carrying capacity of Mekong and Bassac rivers related to planning of suatinable catfish farming (Pangasianodon hypophthalmus) (in Vietnamese). Ministry of Agriculture & Rural Development* (p. 325). Ho Chi Minh.

Nguyen, N. H. (2012). Aquaculture Certification. In *Aquaculture certification systems*. WWF Vietnam Forum, Can Tho.

Nguyen, P. T., & Dang, O. T. H. (2009). Striped catfish aquaculture in Viet Nam: A decade of unprecedented development. In S. S. De Silva & F. B. Davy (Eds.), *Success*

Stories in Asian Aquaculture (pp. 133–150). Springer and IDRC, Canada, Drodecht, The Netherlands.

Nguyen, P. T., Nguyen, T. T., Nguyen, A. T., Tran, H. T. T., Tran, H. N., Wilder, M., Maeno, Y. (2003). *Development of Freshwater Prawn (Macrobrachium rosenbergii) Seed Production and Culture Technology in the Mekong Delta Region of Viet Nam: A Review of the JIRCAS Project at Cantho University*. *Aquaculture* (p. 8). Can Tho. Retrieved from http://www.researchgate.net/publication/242221163_Development_of_Freshwater_Prawn_(Macrobrachium_rosenbergii)_Seed_Production_and_Culture_Technology_in_the_Mekong_Delta_Region_of_Viet_Nam_A_Review_of_the_JIRCAS_Project_at_Cantho_University

Nguyen, P. T., Tran, H. N., Tran, H. T. T., Tran, B. V., Do, H. T. T., Vo, S. N., Wilder, M. N. (2006). Current status of freshwater prawn culture in Vietnam and the development and transfer of seed production technology. *Fisheries Science*, *72*(1), 1–12.

Nguyen, P. T., Vu, S. N., Tran, B. V., Nguyen, T. A., & Wilder, M. N. (2003). *Research, Development and Economics of Giant Freshwater Prawn (Macrobrachium rosenbergii) Culture in the Mekong River Delta, Vietnam: A Review*. *Aquaculture* (pp. 1–12). College of Aquaculture & Fisheries, Can Tho University, Can Tho.

Nguyen, T. T., Le, L. T., Tran, D. T., Cao, Q. L., Nguyen, H. T., Phan, D. N., & Tran, T. X. (2009). *Project on development planning for aquaculture sector in the Mekong Delta up to 2015 and strategic planning up to 2020 (in Vietnamese). Ministry of Agriculrue & Rural Development* (p. 124). Ho Chi Minh.

Nguyen, T. T., Nguyen, T. V., & Phillips, M. J. M. (2004). *Policy Research–Implications of Liberalization of Fish Trade for Developing Countries—A Case Study of Vietnam*. *Policy* (p. 71). FAO, Roma.

Nguyen, D. V. (2008). *Achieving a Sustainable Future for Vietnamese Seafood Industry. Presentation in IIFET 2008 Vietnam: "Achieving a Sustainable Future: Managing Aquaculture, Fishing, Trade and Development* (p. 15). Nha Trang.

Nhuong, T. V., Dinh, T. V., Bui, H. T. T., Trinh, T. Q., Tuong, L. P., & Le, K. V. (2003). *The Shrimp Industry in Vietnam: Status, Opportunities and Challenges*. *Delta* (p. 18). Research Institute for Aquaculture No.1, Ha Noi.

Nhuong, T. V., Le, L. T., Trinh, T. Q., Pham, T. M. T., & Thi, A. N. (2002). *Vietnam shrimp farming review. Individual Partner Report for the Project (EC INCO-DEV Project PORESSFA No.IC4-2001-10042): Policy research for sustainable shrimp farming in Asia* (p. 19). Research Institute for Aquaculture No.1, Bac Ninh. Retrieved from http://www.port.ac.uk/research/cemare/publications/pdffiles/sustainableshrimpfarminginasia/filetodownload,28779,en.pdf

Nhuong, T. Van. (2011). *Three Essays on Market and Non-Market Factors Affecting International Seafood Trade*. Auburn University.

Nietes-Satapornvanit, A. (2014). *Sustainable development of export-orientated farmed seafood in Thailand*. The University of Stirling.

Nietes-Satapornvanit, A., Kriengkrai, S., Murray, J. M., & Little, D. C. (2011). *Development trends and local sustainability perceptions for the international trade in seafood farmed in Thailand. SEAT Deliverable 2.1, The University of Stirling* (p. 64). Stirling. Retrieved from http://www.extranet.seatglobal.eu/download.php?f=draftthailandscopingandsustainabilityreportall_1341394618.pdf

Nussbaum, R. (2002). *Group certification for forests: a practical guide* (p. 59). Oxford.

Oanh, D. T. H., & Phuong, N. T. (2012). Serious diseases in marine shrimp and freshwater prawn farming in the Mekong river delta. *Science Journal of Can Tho University*, *22c*, 106–118.

OECD. (2001). *The DAC Guidelines Strategies for Sustainable Development: Guidance for Development Co-operation*. Paris: OECD Publications.

Olesen, I., Myhr, A. I., & Rosendal, G. K. (2010). Sustainable Aquaculture: Are We Getting There? Ethical Perspectives on Salmon Farming. *Journal of Agricultural and Environmental Ethics*, *24*(4), 381–408.

Ommani, A. R., & Chizari, M. (2010). *Strategies for Sustainable Aquaculture: Designing for the future. College of Agriculture, Tarbiat Modaress University* (p. 11). Tehran. Retrieved from http://www.freewebs.com/ommani/a35.pdf

Omoto, R. (2012). *Small-scale producers and the governance of certified organic seafood production in Vietnam's Mekong Delta*. The University of Waterloo. Retrieved from https://uwspace.uwaterloo.ca/bitstream/handle/10012/7078/Omoto_Reiko.pdf

Oosterveer, P. (2006). Globalization and sustainable consumption of shrimp: consumers and governance in the global space of flows. *International Journal of Consumer Studies*, (September), 465–476.

Page, S., & Slater, R. (2003). Small Producer Participation in Global Food Systems: Policy Opportunities and Constraints. *Development Policy Review*, *21*(5-6), 641–654.

Palin, C., Gaudin, C., Espejo-hermes, J., & Nicolaides, L. (2013). *Compliance of imports of fishery and aquaculture products with EU legislation*. Policy Department Structural and Cohesion Policies, European Parliament, EU. Retrieved from http://www.europarl.europa.eu/RegData/etudes/etudes/join/2013/513968/IPOL-PECH_ET(2013)513968_EN.pdf

Parliament, C., Lerman, Z., & Fulton, J. (1990). Performance of cooperatives and investor-owned firms in the dairy industry. *Journal of Agricultural Cooperation*, *5*, 1–16.

Paul, B. G., & Vogl, C. R. (2011). Impacts of shrimp farming in Bangladesh: Challenges and alternatives. *Ocean & Coastal Management*, *54*(3), 201–211.

Paul, B. G., & Vogl, C. R. (2013). Organic shrimp aquaculture for sustainable household livelihoods in Bangladesh. *Ocean and Coastal Management*, *71*, 1–12.

Pham, A. T., Bus, S. R., Mol, A. P. J., & Kroeze, C. (2011). The Multi-level Environmental Governance of Vietnamese Aquaculture: Global Certification , National Standards , Local Cooperatives. *Journal of Environmental Policy & Planning*, *13*(4), 373–397.

Pham, L. T. (2010). Current practices of tilapia broodstocks and quality improved measurements in Vietnam. *UV Company Limited, Ho Chi Minh*. Retrieved from http://uv-vietnam.com.vn/NewsDetail.aspx?newsId=739

Pham, O. T. K., & Truong, M. H. (2011). The status of Striped catfish (*Pangasianodon hypophthalamus* Sauvage, 1878) farming integration and non-integration in the Mekong Delta. *Science Journal of Can Tho University*, *20b*, 48–58.

Pham, P. T. L., Nguyen, T. T., Donna, B., Sally, M., & Bui, N. H. (2010). *SEMs in the livestock feed sector in Vietnam. Volume I: Livestock feed production* (p. 89). CARD Project 030/06 VIE, Institute of Policy & Strategy for Agriculture and Rural development, Ha Noi. Retrieved from http://www.docstoc.com/docs/128280425/SMALL-MEDIUM-ENTERPRISES-IN-THE-LIVESTOCK-FEED---CARD

Phan, L. T., Bui, T. M., Nguyen, T. T. T., Gooley, G. J., Ingram, B. A., Nguyen, H. V., De Silva, S. S. (2009). Current status of farming practices of striped catfish, Pangasianodon hypophthalmus in the Mekong Delta, Vietnam. *Aquaculture*, *296*(3-4), 227–236.

Phan, L. T., Nguyen, P. T., Murray, F. J., & Little, D. C. (2011). *Development trends and local sustainability perceptions for the international trade in seafood farmed in Vietnam. SEAT Deliverable 2.1, The University of Stirling* (p. 62). Stirling. Retrieved from http://www.extranet.seatglobal.eu/download.php?f=d21bvietnamscopingreport_1341597368.pdf

Phan, T. L., Anh, N. D., Hai, D. M., Son, V. N., Dien, N. T., & Phuong, N. T. (2013). Nutrient characteristics and utilization of striped catfish pond sediment (Pangasiandon hypophthalus) in the Mekong Delta, Viet Nam. In *International Fisheries Symposium 2013*. Pattaya.

Phan, T. M., & Populus, J. (2007). Status and changes of mangrove forest in Mekong Delta: Case study in Tra Vinh, Vietnam. *Estuarine, Coastal and Shelf Science*, *71*(1-2), 98–109.

Phi, T. T. (2010). Resutl on the improvement of black tiger shrimp broodstock. *VASEP*. Retrieved May 16, 2014, from http://vietfish.org/2010080503289818p48c63/viet-nam-gia-hoa-thanh-cong-tom-su-bo-me-sach-benh.htm

Phuong, N. T., Hao, N. Van, Tam, B. M., Lam, P. T., Son, V. M., Nhut, N., Silva, S. S. De. (2011). *Better Management Practices for Striped Catfish Farming in the Mekong Delta-Viet Nam. Collaboration for Agriculture and Rural Development (CARD) project (001/07VIE)*. *Aquaculture* (p. 92). Bangkok. Retrieved from http://library.enaca.org/inland/catfishbmps/catfish_bmp_version3_final.pdf

Phuong, N. T., Vu, U. N., Vuong, T. T., Nguyen, H. T. T., & Ernesto, M. J. (2009). *Water quality monitoring in striped catfish (Pangasianodon hypophthalmus) farms in the Mekong Delta, Vietnam - phase 2* (p. 53). College of Aquaculture & Fisheries, Can Tho University, Can Tho.

Phuong, N. T., Vu, U. N., Vuong, T. T., Nguyen, H. T. T., Nguyen, L. T. K., Duong, O. T. H., Do, H. T. T. (2008). *Water quality monitoring in striped catfish (Pangasianodon hypophthalmus) farms in the Mekong Delta, Vietnam - phase 1* (p. 53). College of Aquaculture & Fisheries, Can Tho University, Can Tho.

Pietrobelli, C., & Rabellotti, R. (2011). Global Value Chains Meet Innovation Systems: Are There Learning Opportunities for Developing Countries? *World Development*, *39*(7), 1261–1269.

Pongthanapanich, T., & Eva, R. (2006). *Toward Environmental Responsibility of Thai Shrimp Farming through a Voluntary Management Scheme* (p. 44). IME working paper 70/06. Department of Environmental and Business Economics, University of Southern Denmark. Retrieved from http://busieco.samnet.sdu.dk/ime/PDF/pongthanapanich70.pdf

Ponte, S. (2002). The “Latte Revolution ”? Regulation, Markets and Consumption in the Global Coffee Chain. *World Development*, *30*(7), 1099–1122.

Ponte, S., Corsin, F., Jespersen, K. S., & Young, J. A. (2011). *Review of aquaculture certification schemes. SEAT Deliverable 8.4, The University of Stirling* (p. 73). Stirling. Retrieved from http://www.extranet.seatglobal.eu/download.php?f=d84reviewofcertificationschemesfinal_1300269325.pdf

Ponte, S., & Ewert, J. (2009). Which Way is “Up” in Upgrading? Trajectories of Change in the Value Chain for South African Wine. *World Development*, *37*(10), 1637–1650.

Ponte, S., & Gibbon, P. (2006). Quality standards, conventions and the governance of global value chains. *Economy and Society*, *34*(1), 1–31.

Ponte, S., Kelling, I., Jespersen, K. S., & Kruijssen, F. (2014). The Blue Revolution in Asia: Upgrading and Governance in Aquaculture Value Chains. *World Development*, *64*, 52–64.

Porter, M. E. (1985). *Competitive advantage: creating and sustaining superior performance*. New York: Free Press.

Prein, M. (2013). Aquaculture certification: Global Sustainable Seafood Initiative (GSSI). In *VIETFISH 2013: Trade Show and Conference in Vietnam, Vietnam Association of Seafood Exporters and Producers*. Ho Chi Minh.

Preißel, S., & Reckling, M. (2010). Smallholder group certification in Uganda – Analysis of internal control systems in two organic export companies. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, *111*(1), 13–22.

Prell, C., Hubacek, K., & Reed, M. (2007). Stakeholder Analysis and Social Network Analysis in Natural Resource Management. *SRI Papers*, *22*(6), 501–518.

Primavera, J. H. (1998). *Tropical shrimp farming and its sustainability* (p. 33). Tigbauan. Retrieved from http://repository.seafdec.org.ph/handle/10862/426

Pullin, R. S. V., Froese, R., & Pauly, D. (2007). Indicators for the Sustainability of Aquaculture. In T. M. Bert (Ed.), *Ecological and Genetic Implications of Aquaculture Activities* (pp. 53–72). Springer.

Rahman, M., & Yakupitiyage, A. (2004). Agricultural Use of Fishpond Sediment for Environ mental Amelioration. *Thammasat Int.J.Sc.Tech., Vol.9, No.4*, *9*(4), 10.

Rametsteiner, E., Pülzl, H., Alkan-Olsson, J., & Frederiksen, P. (2011). Sustainability indicator development-Science or political negotiation? *Ecological Indicators*, *11*(1), 61–70.

Reardon, T., Barrett, C. B., Berdegué, J. A., & Swinnen, J. F. M. (2009). Agrifood Industry Transformation and Small Farmers in Developing Countries. *World Development*, *37*(11), 1717–1727.

Reardon, T., & Timmer, C. P. (2006). Transformation of Markets for Agricultural Output in Developing Countries Since 1950: How Has Thinking Changed? In T. Reardon & C. P. Timmer (Eds.), *Handbook of Agricultural Economics*. Elsevier.

Reed, M., Fraser, E., & Dougill, A. (2006). An adaptive learning process for developing and applying sustainability indicators with local communities. *Ecological Economics*, *59*(4), 406–418.

Reed, M. S. (2008). Stakeholder participation for environmental management: A literature review. *Biological Conservation*, *141*(10), 2417–2431.

Reilly, A. (2007). From farm to fork – new European food hygiene regulations. In W. Einarsson, H.; Emerson (Ed.), *International seafood trade: challenges and opportunities* (pp. 47–57). Akureyri, Iceland: FAO Fisheries & Aquaculture proceeding 13. FAO.

Reisch, L., Eberle, U., & Lorek, S. (2013). Sustainable food consumption: an overview of contemporary issues and policies. *Sustainability: Science, Practice, & Policy*, *9*(2), 7–25.

RIA2. (2009). *Fisheries comanagement: A case study in rice-shrimp rotation in Soc Trang province* (p. 25). Research Institute for Aquaculture No.2, Ho Chi Minh.

Rice, R. A. (2001). Noble goals and challenging terrain: organic and fair trade coffee movements in the global marketplace. *Journal of Agricultural and Environmental Ethics*, *14*, 39–66.

Rico, A., Phu, T. M., Satapornvanit, K., Min, J., Shahabuddin, a. M., Henriksson, P. J. G., Van den Brink, P. J. (2013). Use of veterinary medicines, feed additives and probiotics in four major internationally traded aquaculture species farmed in Asia. *Aquaculture*, *412-413*, 231–243.

Rico, A., Satapornvanit, K., Haque, M. M., Min, J., Nguyen, P. T., Telfer, T. C., & van den Brink, P. J. (2012). Use of chemicals and biological products in Asian aquaculture and their potential environmental risks: a critical review. *Reviews in Aquaculture*, *4*(2), 75–93.

Riisgaard, L., Bolwig, S., du Toit, A., Matose, F., Halberg, N., & Ponte, S. (2008). *Tools for action research with small producers in global value chains. Danish Institute for International Studies*. Copenhagen.

Rigg, J. (2012). *Unplanned Development: Tracking Change in South-East Asia*. (J. Rigg, Ed.) (p. 239). London: Zed Books.

Rivera, W. M., Alex, G., Hanson, J., & Birner, R. (2006). Enabling Agriculture: The Evolution and Promise of Agricultural Knowledge Frameworks. In *Association for International Agricultural and Extension Education (AIAEE) 22nd Annual Conference Proceedings*. Clearwater Beach.

Roth, E. (2002). Does globalization of markets influence the Aquaculture challenge in Asia? In *Proceedings of the ASEM Workshop AQUACHALLENGE* (pp. 27–30). Retrieved from http://www.aseanbiotechnology.info/Abstract/22003464.pdf

Ruben, R., & Fort, R. (2012). The Impact of Fair Trade Certification for Coffee Farmers in Peru. *World Development*, *40*(3), 570–582.

Ruben, R., Fort, R., & Zúñiga-Arias, G. (2009). Measuring the impact of fair trade on development. *Development in Practice*, *19*(6), 777–788.

Ruben, R., Tilburg, A. V., Trinekens, J., & Boekel, M. V. (2007). Linking market integration, supply chain governance, quality and value added. In *In Tropical Food Chains: Governance Regimes for Quality Management*. Wageningen, the Netherlands: Wageningen Academic Publishers.

Ruddle, K., & Gongfu, Z. (1988). *Integrated Agriculture-aquaculture in South China: The Dike-pond System of the Zhujiang Delta* (p. 173). Cambridge University Press.

Saleetid, N., Little, D. C., Murray, F., & Green, D. (2013). *Evaluating risk factors associated with prevalence and incidence. MSc thesis*. Institute of Aquaculture, The University of Stirling.

Samuel-Fitwi, B., Wuertz, S., Schroeder, J. P., & Schulz, C. (2012). Sustainability assessment tools to support aquaculture development. *Journal of Cleaner Production*, *32*, 183–192.

Sang, N. V. (2010). *Genetic studies on improvement of striped catfish (Pangasianodon hypophthalmus) for economically important traits*. *Life Sciences*. Norwegian University of Life Sciences.

Schulze, B., Wocken, C., & Spiller, A. (2006). Relationship quality in agrifood chains: Supplier management in the German pork and dairy sector. *Journal on Chain and Network Science*, *6*(1), 55–68.

SEAT. (2009). *Sustaining Ethical Aquaculture Trade: Description of Work* (p. 149). SEAT project, Institute of Aquaculture, The University of Stirling, Stirling.

Sebesvari, Z., Thi, H., Le, T., Toan, P. Van, Arnold, U., & Renaud, F. G. (2012). *Agriculture and Water Quality in the Vietnamese Mekong Delta*. (F. G. Renaud & C. Kuenzer, Eds.)*The Mekong Delta System* (pp. 331–361). Dordrecht: Springer Netherlands.

Segura, S. F. (2006). *Contract Farming in Costa Rica. Opportunities for smallholders?* Wageningen University, the Netherlands.

Setthasakko, W. (2007). Determinants of corporate sustainability: Thai frozen seafood processors. *British Food Journal*, *109*(2), 155–168.

SFP. (2013). Vietnamese Pangasius Aquaculture Improvement Project. *Sustainable Fisheries Partnership*. Retrieved February 16, 2014, from http://www.sustainablefish.org/aquaculture-improvement/pangasius/pangasius-aquaculture-improvement-partnership

Shang, Y. C., Leung, P., & Ling, B.-H. (1998). Comparative economics of shrimp farming in Asia. *Aquaculture*, *164*(1-4), 183–200.

Shen, L.-Y., Jorge Ochoa, J., Shah, M. N., & Zhang, X. (2011). The application of urban sustainability indicators - A comparison between various practices. *Habitat International*, *35*(1), 17–29.

Sheriff, N. (2004). *Fisher Livelihoods in Southern Thailand : Sustainability and the Role of Grouper Culture*. The University of Stirling. Retrieved from http://hdl.handle.net/1893/72

Siar, S. V., & Sajise, P. E. (2009). Access rights for sustainable small-scale aquaculture and rural development. In M. Bondad-Reantaso M.G.; Prein (Ed.), *Measuring the contribution of small-scale aquaculture: an assessment. FAO Tecnical paper 534* (pp. 87–95). Rome: FAO.

Simard, F., Ojeda, J., & Haroun, R. (2008). The sustainable development of Mediterranean aquaculture: Problems and perspectives. *Options Méditerranéennes*, *Series B*(62), 113–124.

Smeets, E., & Weterings, R. (1999). *Environmental indicators: Typology and overview* (p. Technical report No 25, 19). Copenhagen. Retrieved from http://www.brahmatwinn.unijena.de/fileadmin/Geoinformatik/projekte/brahmatwinn/Workshops/FEEM/EEA_tech_rep_25_Env_Ind.pdf

Smith, M. D., Roheim, C. A., Crowder, L. B., Halpern, B. S., Turnipseed, M., Anderson, J. L., Selkoe, K. A. (2010). Sustainability and Global Seafood. *Science*, *327*(February), 784–786.

Spaargaren, G., Oosterveer, P., & Loeber, A. (2012). Sustainability transitions in food consumption, retail and production. In and A. L. Gert Spaargaren, Peter Oosterveer (Ed.), *Food practices in Transition: changing food consumption, retail and production in the Age of reflexive modernity* (pp. 1–31). New York: Routledge.

Spielman, D. J., Ekboir, J., & Davis, K. (2009). The art and science of innovation systems inquiry: Applications to Sub-Saharan African agriculture. *Technology in Society*, *31*(4), 399–405.

Spielman, D. J., Ekboir, J., Davis, K., & Ochieng, C. M. O. (2008). An innovation systems perspective on strengthening agricultural education and training in sub-Saharan Africa. *Agricultural Systems*, *98*(1), 1–9.

Srinath, K., Sridhar, M., Kartha, P. N. R., & Mohanan, A. N. (2000). Group farming for sustainable aquaculture. *Ocean & Coastal Management*, *43*, 557–571.

Sriwichailamphan, T. (2007). *Global Food Chains and Environment: Agro-Food Production and Processing in Thailand*. Wageningen University, the Netherlands.

Stanton Emms & Sia. (2009). Characteristics of Vietnam's Market for Animal Feed. Regional Agri-Food Trade Commissioner, Singapore. Retrieved March 11, 2013, from http://www.vietnamoverseas.com/?p=971

Steinfeld, H., Gerber, P., & Wassenaar, T. (2006). *Livestock's long shadow: environmental issues and options*. Rome. Retrieved from http://www.fao.org/docrep/010/a0701e/a0701e00.HTM

Stentiford, G. D., Neil, D. M., Peeler, E. J., Shields, J. D., Small, H. J., Flegel, T. W., Lightner, D. V. (2012). Disease will limit future food supply from the global crustacean fishery and aquaculture sectors. *Journal of Invertebrate Pathology*, *110*(2), 141–157.

Stockbridge, M., Dorward, A., & Kydd, J. (2003). Farmer organizations for market access. In *Stakeholders Meeting on Farmer Organisations in Malawi, 18–19 June 2003*. Lilongwe.

Sturgeon, T. J. (2002). Modular production networks: a new American model of industrial organization. *Industrial and Corporate Change*, *11*(3), 451–496.

Sturgeon, T. J., Biesebroeck, J. Van, & Gereffi, G. (2009). The North American automotive value chain: Canada's role and prospects. *International Journal of Technological Learning, Innovation and Development*, *2*(1-2), 25–52.

Subasinghe, R., Soto, D., & Jia, J. (2009). Global aquaculture and its role in sustainable development. *Reviews in Aquaculture*, *1*(1), 2–9.

Sumberg, J. (2005). Systems of innovation theory and the changing architecture of agricultural research in Africa. *Food Policy*, *30*(1), 21–41.

SustainAqua. (2009). *A handbook for Sustainable aquaculture* (p. 111). SustainAqua Collective Research project (Project no: COLL-CT-2006-0300384), EC/FP6, Wageninigen. Retrieved from http://www.haki.hu/tartalom/SUSTAIN0906/SustainAqua handbook_EN.pdf

Tacon, A. G. J., Metian, M., Turchini, G. M., & De Silva, S. S. (2009). Responsible Aquaculture and Trophic Level Implications to Global Fish Supply. *Reviews in Fisheries Science*, *18*(1), 94–105.

Tain, F. H., & Diana, J. S. (2007). Impacts of Extension Practice: Lessons From Small Farm-Based Aquaculture of Nile Tilapia in Northeastern Thailand. *Society & Natural Resources*, *20*(7), 583–595.

Taylor, P. L. (2005). In the Market But Not of It: Fair Trade Coffee and Forest Stewardship Council Certification as Market-Based Social Change. *World Development*, *33*(1), 129–147.

Temel, T., Janssen, W., & Karimov, F. (2003). Systems analysis by graph theoretical techniques: assessment of the agricultural innovation system of Azerbaijan. *Agricultural Systems*, *77*(2), 91–116.

Thao, N. P., Campbell, J., Bowman, J. E., & Chau, N. M. (2006). *Good Agricultural Practices and EUREPGAP Certification for Vietnam's Small Farmer - Based Dragon Fruit Industry* (p. 11). Ho Chi Minh.

Tran, H. T. T., Nguyen, P. T., Truong, M. H., & Wilder, M. N. (1998). *Current status of freshwater prawn culture in the Mekong River Delta of Vietnam*. *JIRCAS J. 1998; 6: 89–100* (Vol. 6, pp. 89–100). College of Aquaculture & Fisheries, Can Tho University, Can Tho.

Tran, N., Bailey, C., Wilson, N., & Phillips, M. (2013). Governance of Global Value Chains in Response to Food Safety and Certification Standards: The Case of Shrimp from Vietnam. *World Development*, *45*(202374), 325–336.

Trifković, N. (2013). *The Role of Food Standards in Development: An Empirical Perspective*. University of Copenhagen. Retrieved from http://www.ifro.ku.dk/english/research/past_phd_defences/phd20june2013/

Truc, L. T. T. (2013). *Investigation into Jaundice in farmed catfish (Pangasianodon hypophthalmus, Sauvage) in the Mekong Delta, Vietnam*. The University of Stirling. Retrieved from https://dspace.stir.ac.uk/bitstream/1893/13060/1/INVESTIGATION INTO JAUNDICE IN FARMED CATFISH (Pangasianodon hypophthalmus, Sauvage) IN THE MEKONG DELTA, VIETNAM.pdf

Truong, P. Q., Le, B. V., To, T. C., & Tran, T. K. (2011). *Study on Nutritional, chemical contaminants and micro-organism composition analysis of catfish sludge and re-use for agriculture sector* (p. 147). College of Aquaculture & Fisheries, Can Tho University, Can Tho.

Tuan, P. A., Dung, T. T., Luan, T. D., Mieng, T. T., Phuc, N. K., Thi, D. Van, Vinh, N. D. (2013). *50 years of Vietnam Fisheries development (in Vietnamese)*. (P. A. Tuan, Ed.) (p. 252). Ha Noi: Agriculture publisher.

Tuan, T. H. (2013). *Assessemnt of production efficiency of catfish farming certified by ASC and GlobalGAP in the Mekong Delta. MSC thesis*. College of Aquaculture & Fisheries, Can Tho University.

Tung, L. T. (2011). *Assessment of technical and financial efficiency in the production linkages or collaboration of different intensive shrimp (Penaeus monodon) farming models in Ben Tre and Soc Trang provinces. MSC thesis*. College of Aquaculture & Fisheries, Can Tho University.

Umesh, N. R. (2007). Development and adoption of BMPs by self-help farmer groups. *Aquaculture Asia Magazine*, *XII*, 8–10.

Umesh, N. R., Chandra Mohan, A. B., Ravi Babu, G., Padiyar, P. A., Phillips, M. J., Mohan, C. V., & Bhat, B. V. (2009). Shrimp farmer in India: Empowering small scale farmer through a cluster-based approach. In S. S. De Silva & F. B. Davy (Eds.), *Success Stories in Asian Aquaculture* (pp. 43–65). Springer and IDRC, Canada, Drodecht, The Netherlands.

USAID. (2013). *Sustainable fisheries responsibility aquaculture: A guide for USAID staff and partners* (p. 160). Washington, DC. Retrieved from http://www.crc.uri.edu/download/FishAquaGuide14Jun13Final.pdf

Utting, K. (2008). Assessing the Impact of Fair Trade Coffee: Towards an Integrative Framework. *Journal of Business Ethics*, *86*(S1), 127–149.

Valdimarsson, G. (2007). Fish in the global food chain: challenges and opportunities. In W. Einarsson, H.; Emerson (Ed.), *International seafood trade: challenges and opportunities* (pp. 17–27). Akureyri, Iceland: FAO Fisheries & Aquaculture proceeding 13. FAO.

Valenti, W. C., Kimpara, J. M., & Preto, B. de L. (2011). Measuring aquaculture sustainability. *World Aquaculture*, *42*(3), 26–30.

Valkila, J. (2009). Fair Trade organic coffee production in Nicaragua - Sustainable development or a poverty trap? *Ecological Economics*, *68*(12), 3018–3025.

Valkila, J., & Nygren, A. (2009). Impacts of Fair Trade certification on coffee farmers, cooperatives, and laborers in Nicaragua. *Agriculture and Human Values*, *27*(3), 321–333.

Van Zalinge, N., Degen, P., Pongsri, C., Nuov, S., Jensen, J. G., Nguyen, V. H., & Choulamany, X. (2004). The Mekong River system. In R. L. Welcome & T. Petr (Eds.), *The Mekong River system* (pp. 335–357). RAP Publication 2004⁄16, Vol. 1, pp. 335-357. FAO Regional Office for Asia and the Pacific, Bangkok: Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries. Retrieved from http://www.fao.org/docrep/007/ad525e/ad525e0l.htm#bm21

VASEP. (2010). *Seafood export statistics, period 1998-2010. Vietnam Association of Seafood Exporters and Producers*. *2009 IEEE International Symposium on Industrial Electronics* (p. 100). Ha Noi: Ieee.

VASEP. (2011). *Report on Vietnam seafood export in 2011 (in Vietnamese). Vietnam Association of Seafood Exporters and Producers* (p. 58). Ha Noi.

VASEP. (2012). *Report on the shrimp production and conumption in 2012 and plan of 2013 (in Vietnamese). Vietnam Association of Seafood Exporters and Producers* (p. 15). Ha Noi.

VASEP. (2013). *VASEP 15 years (1998-2013)* (p. 114). Ha Noi. Retrieved from http://www.vasep.com.vn/vasep15nam.htm

VASEP. (2014a). *Report on Vietnam seafood export in 2013 (in Vietnamese). Vietnam Association of Seafood Exporters and Producers* (p. 78). Ha Noi.

VASEP. (2014b). Vietnam seafood exports in 2013 surpassed US$6.5 billion. Retrieved February 11, 2014, from http://www.vasep.com.vn/Tin-Tuc/785_34182/Xuat-khau-thuy-san-Viet-Nam-2013-vuot-xa-muc-tieu-65-ty-USD.htm

VIFEP. (2009a). *Project on development planning for catfish production and consumption in the Mekong Delta up to 2015 and strategic planning up to 2020(in Vietnamese). Vietnam Institute of Fisheries & Economic plan* (p. 135). Ha Noi.

VIFEP. (2009b). *Project on development planning for crustacean production and consumption of Vietnam upto 2020 (in Vietnamese). Vietnam Institute of Fisheries & Economic plan*. Ha Noi.

Vinh Long DoF. (2012). *Annual statistics on the aquaculture sector in Vinh Long province (in Vietnamese). Vinh Long Department of Fisheries* (p. 27). Vinh Long.

Vo, L. T. T. (2003). *Quality management in shrimp supply chain in the Mekong Delta, Vietnam: problems and measures. CAS Discussion paper No 43, Centre for ASEAN Studies and Department* (No. 43). *Quality Assurance*. Can Tho. Retrieved from http://webhost.ua.ac.be/cas/PDF/CAS43.pdf

Vo, L. T. T., Bush, S. R., & Le, S. X. (2009a). Assessment of value chains for promoting sustainable fisheries development in the Mekong Basin: Cases of Pangasius in Vietnam and Cambodia. *Vietnam Economic Management Review*, *26*(5-6), 32–42.

Vo, L. T. T., Bush, S. R., & Le, S. X. (2009b). *Value chains for sustainable Mekong fisheries: the case of Pangasius hypopthalmus and Henicorhynchus/Labiobarbus spp. in Vietnam and Cambodia*. *Policy* (p. 55). Can Tho. Retrieved from http://www.sumernet.org/old_sumernet/2009Learning_Forum/Mekong_fisheries_value_chain.pdf

Vo, L. T. T., Bush, S. R., Le, S. X., & Nguyen, K. T. (2010). High and low value fish chains in the Mekong Delta: challenges for livelihoods and governance. *Environment, Development and Sustainability*, *12*(6), 889–980.

Volden, C. (2002). The Politics of Competitive Federalism: A Race to the Bottom in Welfare Benefits? *American Journal of Political Science*, *46*(2), 352–363.

Vu, T. A., Phan, L. T., Do, H. V., Ngo, T. T. N., Nguyen, K. D., Phan, V. Q., & Nguyen, H. T. (2013). *Status of small-scale environmentall friendly shrimp production in the Ca Mau province, the Mekong Delta, Vietnam* (p. 111). GIZ Vietnam, Ca Mau.

Vu, T. D., & Don, G. (2008). *Shrimp GAP and BMPs in Vietnam: Policy, current status and future direction. SUDA project, FSPSII, Ministry of Agriculture & Rural Developemnt* (p. 21). Ha Noi.

Vu, A. V., & Phan, L. T. (2008). *Inland Fisheries and Aquaculture in the Mekong Delta: A Review.* (p. 75). Research Institute for Aquaculture No.2, Ho Chi Minh.

Wang, A. (2009). Historical Evlution and System Rethinking of Company Plus Farmer (In Chinese). *Journal of Anhui Agricultural Sciences*, *37*(10), 4819–4821.

Wang, X., He, X., Chen, B., & Xie, C. (2011). Rice field for the treatment of pond aquaculture effluents. *African Journal of Biotechnology*, *10*(1684-5315), 6456–6465.

Washington, S., & Ababouch, L. (2011). *Private standards and certification in fisheries and aquaculture: current practice and emerging issues* (p. 181). Food and Agriculture Organization, Rome.

Washington, S., & Ababouch, L. (2011). *Private standards and certification in fisheries and aquaculture: current practice and emerging issues* (FAO Fisher., p. 181). Rome: FAO.

WCED. (1987). *Our Common Future*. Oxford.

Weymann, V. (2013). Aquaculture certification: Benchmarking certification. In *VIETFISH 2013: Trade Show and Conference in Vietnam, Vietnam Association of Seafood Exporters and Producers*. Ho Chi Minh.

Whitmarsh, D. J., Cook, E. J., & Black, K. D. (2006). Searching for sustainability in aquaculture: An investigation into the economic prospects for an integrated salmon–mussel production system. *Marine Policy*, *30*(3), 293–298.

Wilder, M. N., Yang, W., Do, H. T. T., & Maeda, M. (1998). Reproductive mechanisms in the giant freshwater prawn, and cooperative research to improve seed production technology in the MKD. Retrieved September 05, 2011, from http://www.lib.noaa.gov/retiredsites/japan/aquaculture/proceedings/report28/Wilder.pdf

World Bank. (2006). *Enhancing Agricultural Innovation: How to Go Beyond the Strengthening of Research Systems. The International Bank for Reconstruction and Development, The World Bank* (p. 135). Washington.

World Bank. (2012). *Agricultural innovation systems: an investment sourcebook. International Bank for Reconstruction and Development, The World Bank* (p. 684). Washington.

Wurts, W. A. (2000). Sustainable Aquaculture in the Twenty-First Century. *Reviews in Fisheries Science*, *8*(2), 141–150.

WWF. (2011). *Draft stabdards for responsible shrimp aquaculture. Version 3.0 for Guidance Development and Field Testing, ShAD.* (p. 104). Retrieved from http://worldwildlife.org/publications/responsible-shrimp-aquaculture-standards-final

Yamprayoon, J., & Sukhumparnich, K. (2010). Thai Aquaculture: Achieving Quality and Safety through Management and Sustainability. *Journal of the World Aquaculture Society*, *41*(2), 274–280.

Young, J. A., Goulding, I., & Stirrat, R. L. (2011). *Post-harvest to consumer driver review of the aquatic supply chain. Driver Review-DR17/Foresight Project on Global Food and Farming Futures* (p. 62). London.

Zhang, W. (2014). *Sustaining export-oriented value chains of farmed seafood in China*. The University of Stirling.

Ziggers, G. W., & Trienekens, J. (1999). Quality assurance in food and agribusiness supply chains: developing successful partnerships. *Journal of Production Economics*, *60*(61), 271–279.

Zweig, R. D., Thong, H. X., Luu, T. L., Cook, J. R., & Phillips, M. (2005). *Vietnam: Aquaculture and Fisheries Sector Study. East-Asia Pacific Rural Development and Natural Resources Sector Unit, World Bank* (p. 141). Ha Noi. Retrieved from http://siteresources.worldbank.org/INTVIETNAM/Resources/vn_fisheries-report-final.pdf

APPENDICES

Appendix 1. Checklist questionnaires of the scoping survey

1. General information:

1.1. History information *[occupation before this business/operation, established year, other occupation outside this occupation/business?, income structure…]*

1.2. Infrastructure information *[land used, no.of farms/building/factories, water area, no.of ponds/processing lines/shop, infrastructure (houses for labours, pumps systems, storages, boat, lorry…, other facilities), code for traceability, capital sources, land ownership ….]*

1.3. Human resources *[family labours, hiring labours, labours sources and trends, educational/technical levels of labours….]*

1.4. Mode of business/operation management *[organization structure, role of labours/staff, mode of management: individual or co-operation with other sector (contacted farms with processors/suppliers, other households…)….]*

2. The information on current practices of operation/business activities:

2.1. Current practices of activities

a). Farmers/Nurseries/Hatcheries: *[culture area, no.of farms/nurseries/hatcheries, no.of ponds (i.e. grow-out; fry to juvenile; juvenile to fingerling; no.of pre-/broodstock ponds), yield and production, stocking density, seed sources, water resources, sediment pond….]. At the hatcheries [number of incubating tanks, hatching tanks, containing of water, fry/juvenile/fingerling production, hatching density, egg fertilisation rate, hatching rate of eggs, larvae to fry survival rate, fry to fingerling survival rate, brood-stock sources, water sources …]*

c) Seafood/Feed processors: *[no.of factories, processing lines, storages, transportation means (i.e. truck, lorry, boat…), aquaculture zone, quality control lab., network of traders/collectors, capital sources, land owners/lease, raw material sources (self-produce, contracted farms, other farms, traders networks), type of products, 5 main products (rank, % of total production), permanent labours, mode of selling products...]*

d). Feed/chemical traders: *[no.of shops, transportation means (i.e. truck, boat…), storages, network of customers, input products sources, type of trading products, yield (tons/day, or tons/year…), 5 main products (rank, % of total production), permanent labours, mode of selling products (main products, networks….]*

2.2. Input management

a). Farmers/Nurseries/Hatcheries: *[pond preparation, feed & chemical/drug use, seed/broodstocks sources (size, sources, quality…), labours (salary, training, working regulation ...), water management (monitoring, water treatment, water exchange, sediment treatment…), disease management (mortality rate, dead shrimp/fish disposal, type of disease and occurrence freq., prevent/treatment methods), information on prices of input materials, mode of buying/selling (payments, thought middle-men or directly contract with farmers, and/or suppliers/processors…)*

b) Wholesalers: *[storages/truck/boat preparation, pre-processing of product after buying, labours (salary, training, working regulation ...), information on prices of input materials, mode of buying/selling (payments, thought middle-men or directly contract with suppliers/processors, linkage of farming), network of regular customers …*

c) Seafood/Feed processors: *[processing stages management (raw material sources and quality control, processing stages?), storages management, labours (salary, training, working regulation ...), information on prices of input materials, mode of buying/selling (payments, thought middle-men or directly contract with suppliers/importers, activity linkages, …logbook, price decision ...)*

d). Feed/chemical traders: *[storages management (cross- contaminant management among products in the storage?), labours (salary, training, regulation ...), information on prices of input materials, mode of buying/selling (payments, thought middle-men or directly contract with suppliers/importers, activity linkages, …logbook, price decision ...)*

2.3. Output management

a). Farmers/Nurseries/Hatcheries: *[water exchange mechanism (freq., volume, sources…), waste water/sediment treatment (where is waste go?, methods' treatment), disease/seasons/harvesting, mode of selling production (via traders, direct to processors?, gate price decision (who decide the price)…?)].*

b) Wholesalers: *[trading seasons, dead fish/shrimp treatment, waste water treatment (where is waste go?, mode of selling production (via higher levels of traders, direct to processors?, logbook and price decision…?)].*

c) Seafood/Feed processors: *[type of products, seasons, by-product treatment, mode of selling products (via traders, importers?), quality control, waste water treatment, price decision, logbook, markets of 5 main products?.*

d). Feed/chemical traders: *[type of products, seasons, mode of selling products (via traders, suppliers?), quality control, waste treatment, price decision, logbook, markets of 5 main products?.*

2.4. Efficiency economics

a). Farmers/Nurseries/Hatcheries: *[production, cost/income/profit (i.e. per 1 kg harvested fish/shrimp, per 100,000 post lavae, per 1kg juvenile/fingerling or 1 PL), opportunities cost (delay payments of input materials, interest rate, investment structure?)]*

b) Wholesalers: *[profit of 2 main products: ….VND/product (tons), opportunities cost (delay payments of input materials, interest rate, investment structure and sources?)]*

c) Seafood/Feed processors: *[production, cost/income/profit of 5 main products (….VND/tons), opportunities cost (delay payments of input materials, interest rate, investment structure and sources?)]*

d). Feed/chemical traders: *[production, cost/income/profit of 5 main products (….VND/tons), opportunities cost (delay payments of input materials, interest rate, investment structure and sources?)]*

2.5. Problems faced? *[capital investment, seed quality, disease, techniques (mortality rate, disease), water resources, activities linkages, policy and regulation related ...].* How do you solve problems?

2.6. Development trend line assessment *[development trend line (i.e size in general, investment level, production, market trend, disease trend,….), the main reasons and ways to solve?. The planning for future].*

2.7. Assess sustainable scale indicator of current business/operation? *[classification business scale (small- , medium-, large-): based on culture area, production, capital investment, ownership,…]*

3. Environment and social issues:

3.1. Issues on certification/farming standardization *[certification application and standard related, training…, traceability (logbook, record keeping and management …?)].*

3.2. Issues on food safety *[awareness on regulation related (chemical/drug use and baned documents) from Government?, traceability systems running?...]*

3.3. Issues on social responsibility *[taxation of land/water use, ownership, local labours sources, programme support for local communities to compensate impacts from activities (waste water release to public canals..),….]*

3.4. Producing linkages issues *[aqua-association (functions, duties and mode of operations…), what are the linkages with famers, processors, suppliers, traders and hatcheries/nurseries farms? and mode of co-operation?...].*

***3.5. Animal welfare** [methods of disease prevent/treatment, feeding mechanism, harvesting and transferring methods, escape fish/shrimp management?...]*

***3.6. Labour welfare** [type of labour contract, salary, issuance, and facilities supports (uniforms, vocation, accommodation, waste treatment…)].*

***3.7. Social securities** [risk & conflicts management, supports from local authorities …]*

***3.8. Issues on policy and regulation** [type of policy and regulation, problems faced with policy/regulation during operating?. recommendations are requested to local government for future development?...]*

4. Information on trading and value chain

***4.1. Description of existing value chain?** [identify stakeholders involvement to your operation/business activities (directly and indirectly involvement…); pls plot vertical or horizontal value chain?]. In above value chain plotted who are kept the leading role and why? [rank for at least 3 main actors].*

***4.2. Assess of sustaining development issues** [your business is sustainable development? why?, if not yet, pls give main constraints and how to improve?]*

Date: ___/___/____	*- Respondent name:*	*Address/Tel:*

Appendix 2. SoS exercises and questionnaires

a. SoS exercise 1 – Individual task: Questions and answers

Full name ______________________________; Age: ______; Male [ ]/Female [ ],
Name of Institution: _________________ ; Position: ______
Address: Village: _________________; Commune: _____________; District:__________
Province: _______________; Tel: _________________; Email: ____________

Read the following question:

What factors do you foresee that could POSITIVELY or NEGATIVELY affect your business performance over next 1-2 years?

Now complete the table below based on the following steps:

1. Identify **up to 5** factors into the below table;
2. Identify if they are **positive (+)** or **negative (-);**
3. **Rank** the results in order of importance where 1 is most important and 5 is least important

Note: you results might include all negative factors, all positive or a mix of both

	Sustainability Factor	**Positive (+) or negative (-)**	**Rank**
1			
2			
3			
4			
5			

b. SoS exercise 3 - Group discussion: Questions and answers

Rank	**Factor**	**Why and how to measure?**

Appendix 3. Questionnaires of telephone survey

1. Survey Details

1.1. SurveyCD		Date	
1.2. Interview Date			
1.3. Enumerator			
1.4. Respondent Full Name			
1.5. Farm RoleCD (manager, owner etc)			
1.6. Same Respondent? Yes/No *	Survey 1		Survey 2	
1.7. Telephone number(s)			

* Survey 1 = Integrated scoping Survey 2 = IFS

2. Farming transition status

Which of the following best describes any change in your situation since you were first interviewed (i.e. for the integrated survey)? – tick relevant box(es)

	Change Status	Tick	Month & Year
1	Farming as normal i.e. no significant change		
2	Farming as normal with some changes		
3	Temporarily stopped farming and already restarted		
4	Temporarily stopped farming with planned restart date		
5	Temporarily stopped with no planned restart date		
6	Permanently stopped farming		
7	Plan to stop temporarily in near future		
8	Plan to stop permanently in near future		

2.1. Are you planning to make any other changes to investment, production or marketing practices in the near future? Yes [ ] No [ ]

Details: ____

2.2. Why did you (or do you plan to) permanently of temporarily stop farming?

Stop cause	Give details
Stock loss disease	
Stock loss other	
Seed quality	
Low sales price	
Lack operational finance	
Lack capital finance	
New business	
Land access	
Water access	
Regulatory burden	

3. If you have (or plan) to stop farming temporarily, but plan to restart later i) why? & ii) when do you plan to restart?

____

Production change		**First survey**	**Now(or planned)**	**Mnth&Yr**	**Details & reason(s) for change**
Total culture area (ha)					
Total number of ponds					
pond lined/add greenhouse					
Avg pond depth (m)					
Avg No ponds stocked/ cycle					
Avg pond area stocked/ cycle					
Pond fallow period (wks)					
No. of crop/year					
Avg stocking density					
Size of stocked juveniles					
Supplier of feed inputs					
Type of feed inputs					
Level of feed inputs					
Sludge removal freq/cycle					
Species/life stage farmed (%area/pond No)	Grow-out				
	Juvenile				
	Other Spp.				

4. How do you finance your operational costs? (rank: where 1 = most important)

Code	Income Category	Rank (1st survey)	Rank (now)
1	Use savings/ profits		
2	Sell assets		
3	Sell livestock		
4	Sell land		
5	Sell other crops		
6	Borrow - moneylender		
7	Borrow - relatives		
8	Borrow - non-relatives		
9	Borrow - commercial bank		
10	Gift from relatives		

5. Rank current income generating activities for your own household

Code	Income Category	Rank (1st survey)	Rank (now)
1	**Aquaculture** farming		
2	Crop farming, livestock keeping, processing, marketing (own farm)		
3	Casual wage labour (farm and non-farm)		
4	Long-term agricultural employee		
5	Salaried employment		
6	Business , trade, manufacturing		
7	Service provision		
8	Fishing		
9	Owner of small business		
10	Collection / foraging		
11	Family member remittances		
12	Land lease		

7. How has your own role in the business changed since the first survey (or over the last 2 years)?

Details: ____

8. How has this affected you personally – inc. benefits and negative impacts?

Details: ____

9. Considering your previous responses, are you better or worse-off now than 2yrs ago?(tick one box): Much worse-off [ ] , Worse-off [ ]
No-different [ ] , Better-off [ ], Much better-off [ ]

Appendix 4. Checklist questionnaires of in-depth farm survey

1.1. SurveyCD		Date*		
1.2. Interview Date				
1.3. Enumerator				
1.4. Respondent Full Name				
1.5. Farm Role CD (manager, owner etc)				
1.6. Same Respondent? Yes/No *	Survey 1		Survey 2	
1.7. Telephone number(s)				

* Survey 1 = Integrated scoping   Survey 2 = IFS survey

Area 1 Time-line questions

- When did you come here, where were you living before or have you always lived here, what did you do before you started fish farming.
- When did you start fish farming here
- Did you/do you still do other crops as well. What are they, do you have any off-farm income
- Can you tell us about fish production in this village/your neighbours

Area 2 Reasons for starting to farm fish

- Why did you start fish farming?
- Please tell us about how you started (did you dig the ponds?) and flood conditions here at that time (were you inside an August dike or a high dike)
- Where and how did you learn fish farming (who taught you)
- When you began were many other people here doing the same thing.

Diversification

- Have you ever stopped or changed what you do, e.g. from growing out to fingerlings; from selling to a processor to selling to local market; change of variety; other change. Why did you make changes
- try to get cost benefit data for diversification strategies relative to catfish
- Mitigation strategies during low price periods: stopping farming, lower density, feeds, number of ponds stocked etc..

Area 3 Conditions for production

- What were conditions like when you began, including family conditions for production (labour), environment (e.g. water), economic conditions (the needs of your family; costs of food and price for sale)
- What are conditions like now, in what ways have conditions changed
- What price/kg of fish would make you stop/start production

- Feed details: on farm feeds v commercial diets and reasons (linked to this sludge-removal frequency – and fate)
- Production strategy: stocking density, fingerling size and timing of stocking and sequencing if more than one pond
- FCR and yield, mortality changes
- Loss, profit and breakeven years

Marketing

- Breakeven price v farm-gate price over last 2-3yrs
- Spot market v contracting (contract details)
- Marketing mix
- for grow-out (name processor and buying arrangements)
- and fingerlings (who buys large, med or small farms – why)
- Marketing changes why (price, timely payment, feed or other credit relations etc)
- Quality requirments of buyers

Operational and capital costs

- Credit requirement and availability
- Rank importance of operational costs: feed, energy (eg. Pumping), labour, chemicals (probiotics, disinfectants), drugs, sludge-removal, fingerlings etc
- Land buying leasing price (with and without ponds) and changes - reasons

Labour

- Labour requirements – part-time and FTE
- Origins of workers and reasons i.e. local v none-local
- Labour turnover rates and reasons
- Impacts of other observed farm changes (e.g. closure, or merger) on labour - what happened to staff

Area 4 Looking forward in time

- Do you expect to be able to continue farming, what might make you stop, or change production.
- What are your main problem at this time. Will one of them cause you to stop, which one, what effect.
- Have you been affected by the building of high dikes, how
- How is your supply of water – source – tidal variation – mix of pumping and gravity input/output – is water quantity or quality limiting?
- Do you expect your children to continue farming when you retire
- Will you sell your land use certificate in the future

Treating the farmer as a key informant

- Are you aware of any other farms in the village/ locale that have stopped catfish farming recently or in the past? – details / why?
- What happened to their ponds (filled in, leased, sold etc – to whom from where)?
- Awareness of other local catfish farmer diversification strategies (other aquatic species, fingerlings etc reasons?)
- Trends in changing size (area depth) of farms and ponds – where why who?

Mapping

- Locate of ponds along the same stretch of canal – assoc. houses, rice fields and other land marks
- Annotate pond size, year of construction, change in ownership/ farm stoppage, filled ponds, switched species etc.
- Try to get explanations of any emerging spatial patterns

Appendix 5. Checklist questionnaires of key informants

1.1. Survey CD		Date	
1.2. Interview Date			
1.3. Enumerator			
1.4. Respondent Full Name			
1.5. Role CD (manager, owner etc)			
1.6. Same Respondent? Yes/No	Scoping survey [ ]		
1.7. Telephone number(s)			

A. Begin by treating the respondents as key informants on general industry trends

- Perceptions on transitional change in the wider industry and drivers - numbers of enterprises etc.
- Check validity major secondary statistics on industry concentration (Govt, VASEP etc.) against their perceptions

B. Then move to reflection on their own business situation

- History of their business
    -- Trends in production capacity and actual operating capacity since inception
    -- Any mergers and acquisitions - historic or planned - along with reasons
- Value-chain relational trends
    -- e.g trends in contractual arrangements with raw material suppliers - reasons for change
    -- credit provision arrangements to or from input suppliers/ buyers
- Perceptions of the main problems and opportunities for the future of your business
- What are you adaption strategies to historic and future problems and opportunities - including competition strategy (e.g. value-addition versus lower-margin, high volume strategy)
- Profit and loss - history and reasons
- The respondents perceptions on personal security and their future in the sector (who you want your children to do the same job?)
- Attitudes towards and requirement for industry support (from Govt. producer organisations etc.)

C. Additional questions for respondents involved in credit provision

- What type of business (along the value-chain, scale etc) are most likely to request credit and for what purpose?
- How has demand changed over time and why?
- What are your main assessment criteria for loan provision? Who is most likely to be accepted/ rejected and why?
- How do you evaluate risk?

- What are the rates and terms of credit provision for different types of risk - and how have they changed over time and why?
- How important is the role of your type of business in credit-provision to different parts/ nodes of the value-chain?
- How do you think your service compares to informal credit - or credit from input suppliers etc. (check credit arrangement with all types of respondent)?
- What is the impact of government policy on credit provision.