Measuring Risk Levels and Efficacy of Risk Management Strategies in Vietnamese Catfish Farming

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***Abstract*—**Although the Vietnamese catfish farming has grown at very high rates in recent years, the industry has also faced many problems affecting its sustainability. This paper studies the perceptions of catfish farmers regarding risk and risk management strategies in their production activities. Specifically, the study aims to measure the consequences, likelihoods, and levels of risks as well as the efficacy of risk management in Vietnamese catfish farming. Data for the study were collected through a sample of 261 catfish farmers in the Mekong Delta, Vietnam using a questionnaire survey in 2008. Results show that, in general, price and production risks were perceived as the most important risks. Farm management and technical measures were perceived more effective than other kinds of risk management strategies in risk reduction. Although price risks were rated as important risks, price risk management strategies were not perceived as important measures for risk mitigation. The results of the study are discussed to provide implications for various industry stakeholders, including policy makers, processors, advisors, and developers of new risk management strategies.

***Keywords*—**Aquaculture, catfish farming, sources of risk, risk management, risk strategies, risk mitigation.

I. Introduction

CATFISH farming in Vietnam has grown at an impressive rate in the last few years; farming area has increased from about 560 ha in 2000 to 6000 ha in 2008, a 10-fold increase and production jumped from about 264 thousand tons in 2004 to a total output of 1.128 million tons in 2007 [1-3]. In 2008, earnings from catfish export reached $ 1.48 billion and for the first time, the catfish product became Vietnam's largest single foreign exchange earning aquacultural product passing shrimp, and according to some projections, this fast growing trend will continue in the future due to increasing demand both domestically and internationally, following the admission of Vietnam into the World Trade Organization (WTO) [4].

The fast growing catfish industry is troubled by many problems, challenges and uncertainties such as: environmental and edaphic issues, losses due to disease, strict quality and safety regulations, export-import restrictions, increasing production costs, sustainability, oversupply and other global and regional socio-economical problems. All these uncertainties are potentially detrimental risks to the catfish industry and they need to be managed in a systematic way for the sustainable development of the industry.

Highly intensive catfish farming brings high revenue, and thus profit for producers, but it also brings more risks to the farms. Price fluctuations due to oversupply and marketing difficulties and yield losses due to disease and environmental deterioration, both happened very frequently in recent years. As a result, catfish farmers are facing serious risks of severe financial losses, or even bankruptcy [5], i.e. at the end of 2008, about 30 - 40 % of catfish farmers stopped rearing catfish due to serious financial losses in 2008 [6]. These factors suggest that the fast growth of the catfish industry might not be sustainable. To enhance the ability of risk tolerance, a risk management system that can protect farmers against financial losses as well as maintain the sustainability of the business is a valuable tool for catfish farming in Vietnam.

The objective of this paper is: (1) to provide empirical insight into Vietnamese catfish farmers' perceptions of risk and risk management strategies, and (2) to calculate the levels of risk of the various sources of risk included in the study as a cornerstone for the development a risk management framework for Vietnamese catfish farming.

II. Literature Review

Risk is the possibility of adversity or loss, and refers to the "uncertainty that matters". Consequently, risk management involves choosing among alternatives to reduce the effects of risks. Understanding risk is a starting point to help producers make good management choices in situations where adversity and loss are possibilities [7]. In a report on risk management in US farming, risks in farming are classified into five main categories: (1) production or yield risk, (2) price or market risk, (3) institutional risk, (4) human or personal risk, and (5) financial risk. The results from the Agricultural Resource Management Survey (ARMS) done by the US Department of Agriculture (USDA) indicated that the degree of producers' concern (on a scale from 1 to 4, with 1 for "not concerned" and 4 for "very concerned") varies across groups of commodities. More specifically, farmers of wheat, corn,

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soybean, tobacco, cotton, and certain other crops were more concerned with price and yield risks than any other factors. The degree of concern of farmers of more specific crops, such as greenhouse crops and livestock producers was greatest regarding factors including changes in laws and regulations (with a score of 3.02), decreases in crop yields or livestock production (with a score of 2.95) and uncertain regarding commodity prices (with a score of 2.91). The study also found out that in general, producers of major field crops tend to be more concerned with price and yield risks, while producers of livestock and specialty crops are relatively more concerned with changes in law and regulations [7]. This may imply that different crops are subject to different marketing conditions and government policies controlling the market for these commodities. In the case of aquacultural products, food safety requirements might put an even stronger constraint on the aquacultural production and this issue will be reviewed in more details later in this paper.

The USDA report also provides a review of risk management strategies used by US farmers for risk reduction. The major strategies for risk management in US farming are: marketing contracting (including hedging, forwards, and futures and options), production contracting, enterprise diversification, vertical integration, and crop insurance. The study shows a mixed result regarding the effectiveness of enterprise diversification as a strategy for risk mitigation. While enterprise diversification can be an efficient strategy for risk reduction for smaller farms (measured by cropped acreages) and younger operators, it is not necessarily the case for large scale farms and wealthier operators. The degree of diversification in farming also varies significantly across regions and farm sizes. The reasons that could account for this situation are: differences and limitations in farm resources, expertise, market outlets, weather conditions and farmers' risk aversion [7].

A study on risk perceptions and management responses of 149 crop and livestock producers in 12 states in the US found that farmers' perception of sources of risk and management responses were significantly different across farm categories and product types. For crop producers, in general, weather conditions, crop price and government program were the most important sources of risk, however, a small group of ranchers considered variability in price as relatively unimportant. Mixed farming and small grain producers considered diseases and pests to be an important source of variability. Cotton producers were less concerned with diseases and pests than other farmers, they gave the greatest importance to the cost of operating inputs. Midwest corn, soybean, and hogs producers place greater importance on credit availability and the cost of credit than any other group. A similar pattern for risk perceptions was also found in livestock production and risk management responses. The findings suggest that risks and management responses vary across geographical regions and farm types. As a result, risk modeling should be adapted to the unique conditions of the domain being investigated and go beyond price and yield risks. As a minimum requirement, production (including inputs), marketing, and financial considerations must be integrated into a realistic decision-making framework [8].

In a study on risk and risk management of Dutch livestock farmers [9], it was found that meat price, epidemic diseases and milk price were the most important perceived risks and the most relevant risk management strategies were to produce at the lowest possible cost and buy business and personal insurance (in this order). The study also pointed out that although price risks were perceived as a major source of risk, risk management strategies to deal with price risks, such as price contracts, futures and options market, were not perceived as important.

Beef producers in the Texas and Nebraska states of the US rated drought and price variability as the greatest two concerns, with average responses of 4.4 and 4.3 on a 5-point Likert scale, respectively. The next cluster of the sources of risk between a scale of 2.5 and 3.0 included extremely cold weather and disease. Finally, four sources of risk that were rated between 2.0 and 2.5 included: land price variability, variation in rented pasture availability, labor availability, and labor price. In terms of risk management strategies, maintaining animal health was viewed as the most effective strategy (mean score of 4.2). This finding is somewhat paradoxical because disease was ranked relatively low as a source of risk. Being a low-cost producer, maintaining financial or credit reserves, and off-farm investments were also considered important strategies (mean of 3.8, 3.6, and 3.6, respectively). Forward contracting and use of futures and options market were considered as least effective in risk mitigation. Again, this was a paradoxical finding, considering the beef producers' perception of the high potential of price variability to affect ranch or farm income [10].

In comparing risk and risk management perceptions of organic and conventional dairy farming in Norway, organic dairy farmers had the least risk aversion perceptions. Both groups of dairy farmers rated institutional and production risks as major sources of risk, with farm support payments at the top. In contrast, organic farmers put more weight on institutional factors than production systems, in comparison to their conventional colleagues. Conventional farmers are more concerned with the cost of purchased inputs and animal welfare policies. However, both groups had similar responses on the efficacy of risk management strategies. Financial measures such as: liquidity and cost of production, disease prevention, and insurance were perceived as important ways to handle risks [11].

In aquaculture, besides other risks similar to agriculture, yield risk and quality risk are the most important issues due to the sensitivity of aquaculture to the environment. The success of aquaculture is greatly dependent on the quality of the cultivating environment. To meet the increasing demand of aquacultural products on the world market, semi-intensive and highly-intensive aquacultural farms are common in the world, especially, in Asia, where approximately 90 percent of the global aquacultural production is based [12]. These models of cultivation use a large amount of artificial feed as the main source of food for the fish stock. Consequently, a large amount of effluent from fish ponds or fish cages is dumped into natural water resources [13]. This causes serious problems for both the environment itself and the fish quality and yield due to disease spread out and contamination of toxic substances in the product that might be harmful for human health. Research on risk management in aquaculture emphasizes the importance of the sustainability of the industry and the environment and call for the application of good aquacultural practices.

Fish grown in large quantities are a major source of environmental disturbance. Wasted fish feed and fish faeces settle at the bottom and lead to a heavy accumulation of both beneficial and deleterious bacteria, and finer particles increase the turbidity in the water column and perhaps affect fish respiration [14]. The enrichment of nutrition causes a reduction in farm holding capacity and adverse biological and chemical conditions for fish growth. Many studies have aimed to reduce the impacts of fish effluents on environment and at the same time improve the economic efficiency of fish farming. Most previous work on effluents of fishponds were largely related to channel catfish in the USA [15-17]. Tucker and Lloyd (1985) recognized that effluents from channel catfish ponds were an important source of pollution, particularly for total nitrogen (TN) and chemical oxygen demand (COD) (cited in [18]).

The effect of agricultural animals on water pollution is a growing concern for policy makers in all countries around the world. For a sustainable growth of the industry, the adoption of “win-win” best management practices (BMP) is a common strategy in today’s aquaculture. An innovative aspect of many BMPs is their focus on pollution prevention by reducing the quantity of inputs used that cause run-off and emissions. Such cost-saving strategies should be profitable or profit-neutral to businesses [19]. The following six best management practices could reduce marine culture water effluents while maintaining farm profitability [20, 21]: (1) on-farm intake of pollution or effluent treatment plants (settling basins or constructed wetlands); (2) sludge removal, (3) co-production schemes, (4) improved feed and fertilizer management; (5) lower stocking rates, and (6) reduced water exchange or even closed recycling systems. The first three options are “structural BMPs” which require substantial fixed investment and significant capital outlay while the last three are “managerial” BMPs requiring changes in the variable inputs used. Better feed management lowers costs while reducing pollution. For example, feeding trays are a small investment likely to lower feed conversion ratios [19].

Another concern in aquacultural production is the food safety problem and one of the methods for controlling food safety and quality is the application of the Hazards Analysis and Critical Control Points (HACCP) system. While the implementation of HACCP-based safety assurance programs are well advanced in the fish processing sector, the application of such programs at fish farms, to enhance food safety is still in its infancy. There are few examples of applying HACCP principles in animal husbandry because of the lack of scientific data regarding the appropriateness of on-farm control of pathogenic micro-organisms. However, national and international agencies continue to recommend and promote the HACCP-based approach for all stages of the food chain, including the farm [22, 23]. The central goal of the HACCP rule is to stimulate improvement in food-safety practices by setting public-health oriented targets or standards that all food establishments must meet. The system establishes targets or standards to reduce risk from all sources of food-borne hazards—biological, chemical, and physical—while simultaneously providing a tool for holding establishments accountable for achieving acceptable levels of food-safety performance [24].

Reilly and Kaferstein (1997) suggested a generalized model for the application of HACCP to aquacultural production. In this model, a flow diagram describes all the steps included in the production process, and through that diagram, critical control points (CCPs) are identified. At each CCP, the application of HACCP based on seven principles tries to clearly identify the following issues: hazards, control measures, critical limits, monitoring procedure, and corrective action. Although this is a generalized model for applying HACCP in aquaculture production, it must be substantially modified to meet specific fish farm conditions. However, it provides a useful guideline for application in practice.

III. Methodology

A. Data Collection

Data for this study were collected using a questionnaire survey. Prior to designing the survey, a focus group workshop consisting of major stakeholders (catfish farmers, government staff, extension workers, aquacultural specialists and university researchers) in catfish farming was organized in An Giang province, a major catfish production area in the Mekong delta to collect comments, opinions, and suggestions about sources of risk and risk management strategies in Vietnamese catfish farming. Together with information from a literature review, a survey questionnaire was developed to include questions for gathering information on: (1) farm and farmers socio-economic characteristics, (2) catfish farmers’ perception on risk, and (3) catfish farmers’ perception on risk management strategies. The questionnaire was pre-tested through a pilot survey of 10 catfish farmers classified into three categories of farm size, more specifically, small (<5,000 m^2), medium (5,000-20,000 m^2), and large (>20,000 m^2) for checking the relevance of questions and for detecting possible ambiguous and missing questions. The questionnaire was revised and improved based on the comments and suggestions from farmers for the final version. The actual survey was conducted by direct (person-to-person) interviews with farmers and the questionnaire was used for recording information. A sample of 270 catfish farmers spread over three provinces of An Giang, Dong Thap, and Can Tho was interviewed and data collected. After screening for completeness, the questionnaires of 261 farmers were available for statistical analysis, i.e. the effective response rate was 96.66 percent). Most of the questions regarding the perceptions of risks and risk management strategies in the questionnaire are close-ended questions and measured by a 5-point Likert scale.

B. Data Analysis

Farmer's perceptions of risk and risk management were analyzed using descriptive analyses. All statistical analyses were conducted using SPSS for Windows (v16.0) and Microsoft Excel 2003.

IV. Results and Analysis

A. Level of Risk

This study used the concept of level of risk to measure the potential impact of a source risk on the income/profit of catfish farmers. According to the Australian Standard on Risk Management (AS/NZS 4360:2004), the level of risk is defined as the product of the consequence (severity) and the likelihood (probability) of risk, i.e. *Level of Risk = Consequence*Likelihood* [25]. The next three sections will consecutively present the consequence, likelihood, and level of risk of all sources of risk included in the survey questionnaire.

1) Consequence (Severity) of Risk

In total, 40 sources of risk were presented to the respondents. To measure the catfish farmers' perception about the potential impacts of the sources of risk, catfish farmers were asked to rate (on a 5-point Likert scale) the potential of the risk to affect their income/profit on each of the 40 risk factors. The consequence of risk was rated on a scale of 1 to 5, with, 1 representing very low or minor impact, and 5 representing very significant or severe impact.

Table I shows the mean scores, standard deviations, and rank of all 40 sources of risks. The risks are ranked in descending order in terms of risk consequences. Sources of risk such as *variability in prices, usage of prohibited medicines and chemicals, and inaccessibility to the market* were ranked as the top three most important sources of risk, reflecting catfish farmers' greatest concerns about risk factors, with average scores of 4.49, 4.06, and 4.04 respectively. The second cluster consists of the next 24 sources of risk (ranked from 4 to 27), with average scores varying from 3 to 4. The third cluster consists of the next ten risk factors rated from 2.5 to 3 (ranked from 28 to 37). Finally, three sources of risk were rated between 2.0 and 2.5 belonging to the fourth cluster which included *technical failure, flood, and drought*.

For the top three most important sources of risk, concern about the *variability of price* reflects the fact that catfish farmers are producing their product without any guarantee of sale price and are always facing a high price risk. Variations in catfish sale prices in the last few years have caused big losses for farmers, especially in 2008. Most of the farmers had to sell their catfish at a 10 to 15% lower price than production cost. It is important to understand the underlying reasons for this phenomenon as well as the perceptions of farmers about risk management strategies they use to mitigate the price risk.

Usage of prohibited medicines and chemicals was ranked second in the list. This shows that this risk factor can have a severe impact on the income and profits of farms. One possible reason for this finding is that the bulk of the Vietnamese catfish is produced for export markets, where standards and regulations for food hygiene and safety are very strict. In these markets, there is almost zero tolerance for residues of prohibited medicines and chemicals in the imported food. As a result, if the fish is infected by prohibited medicines and chemicals, catfish processors will refuse to buy infected fish for processing. This causes a serious impact on catfish farmers' income, causing big losses, or even bankruptcies.

The third important risk factor affecting catfish farmers' income was the inaccessibility to the market. This source of risk causes a similar problem to the catfish farmer like the use of prohibited medicines and chemicals. However, the reason comes from the imbalance in market supply and demand, i.e. the over-supply problem. In recent years, the total catfish output has increased rapidly, far exceeding the growth in demand and processing capacities, and as a result, catfish processors could not buy all the catfish produced in that period of time. This created a cost to catfish producers because they cannot stop feeding the fish, and it also caused a reduction in selling price of the fish due to oversize of fish and reduction in quality.

2) Likelihood of Risk

Similarly to the consequences of risk factors, the likelihood of risk factors' occurrences were measured on a 5-point Likert scale, 1 representing very rare occurrence to 5 representing almost certain occurrence within a catfish crop. The mean scores, standard deviations, and rank of the likelihoods of 40 sources of risk are presented in Table II and sorted by in descending order of the likelihood of occurrence.

The first cluster of the sources of risk that have average scores of likelihood above 4 (out of 5) consists of three risk factors, namely, (1) *fish price variability,* (2) *high cost of operating inputs, and* (3) *epidemic checking for fingerlings not conducted*, with average scores of 3.35, 3.19, and 3.08, respectively.

The second cluster of risks factor that had the probability of occurrence in the range of 2.5 to 3.0 were: (1) *farm have no reserved area for water and mud treatment,* (2) *under financing by own capital for the whole crop cycle,* (3) *pond located outside of planned area,* (4) *pond dose not have the waste treatment system, and* (5) *weak enforcement in conducting sale contract with processor.* Their average scores of probability were 2.97, 2.76, 2.67, 2.63, and 2.53, respectively. These factors are considered as having the potential to occur with relatively high probability, and hence need careful monitoring.

TABLE I
MEAN SCORES AND RANK OF SOURCES OF RISKS

Risk ID	Sources of risk	N	Mean	Std. Deviation	Rank by mean
27	Fish price variability	261	4.49	0.807	**1**
19	Use of prohibited chemicals and medicines	233	4.06	1.26	**2**
28	Inaccessibility to the market	255	4.04	1.237	**3**
15	High death rate due to disease	257	3.96	0.926	**4**
31	Costs of operating inputs	255	3.95	0.886	**5**
7	Fingerlings infected by diseases	244	3.9	1.023	**6**
5	Low quality fingerlings	260	3.85	0.943	**7**
4	Pond not treated before stocking	248	3.83	1.034	**8**
32	Under financing by own capital for the whole crop cycle	256	3.75	0.991	**9**
22	Pond water is under-managed	258	3.74	0.978	**10**
14	Overfeeding cause pollution and waste accumulation	246	3.7	1.065	**11**
12	Low quality of feed	242	3.62	1.005	**12**
33	Under financing by credits from banks/credit institutions	245	3.62	1.063	**13**
34	High interest rate for loans	247	3.57	1.041	**14**
16	Inability to control diseases from environmental sources	259	3.54	1.054	**15**
10	Over (density) stocking fingerlings	251	3.49	0.948	**16**
29	Weak enforcement in conducting sale contract with processors	251	3.47	1.063	**17**
13	Uncontrolled/unstable home-made feed quality	250	3.45	1.13	**18**
18	Limited knowledge about usage of chemical and medicines	258	3.34	1.134	**19**
8	Fingerlings treated by anti-biotic during fingerling production process	201	3.32	1.054	**20**
6	Fingerlings with unknown origin	237	3.27	1.147	**21**
26	Inappropriate method of harvesting causing reduction of fish quality and weight	257	3.19	1.302	**22**
17	Low awareness of disease prevention by farmers	242	3.18	1.167	**23**
36	Changes in environmental policy	236	3.1	1.089	**24**
20	Applying chemical and medicines improperly	230	3.07	1.218	**25**
21	Farm have no reserved area for waste water and mud treatment	255	3.06	1.145	**26**
3	Pond doesn't have waste treatment system	252	3	1.154	**27**
24	Unawareness about community environmental protection	222	2.94	1.242	**28**
30	High technical barriers from importing countries	234	2.91	1.061	**29**
25	Inappropriate size of harvested fish	261	2.88	1.298	**30**
1	Pond outside planning area	247	2.87	1.466	**31**
2	Pond nearby residency	241	2.86	1.318	**32**
35	Changes in government policy on product development strategy	236	2.83	1.148	**33**
9	Epidemic checking for fingerlings not conducted	209	2.8	1.116	**34**
11	Use undersize/oversize fingerlings	247	2.8	1.139	**35**
23	Waste water treatment system is under-invested	219	2.74	1.085	**36**
39	Lack of water supply	234	2.62	1.46	**37**
40	Technical failure	236	2.28	1.178	**38**
38	Flood	221	2.17	1.343	**39**
37	Drought	219	2.11	1.257	**40**

TABLE II
MEAN SCORES AND RANK OF RISK LIKELIHOODS

Risk ID	Sources of risk	N	Mean	Std. Deviation	Rank by mean
27	Fish price variability	239	3.35	1.135	**1**
31	Costs of operating inputs	231	3.19	1.084	**2**
9	Epidemic checking for fingerlings not conducted	188	3.08	1.336	**3**
21	Farm have no reserved area for waste water and mud treatment	224	2.97	1.387	**4**
32	Under financing by own capital for the whole crop cycle	234	2.76	1.214	**5**
1	Pond outside planning area	206	2.67	1.504	**6**
3	Pond doesn't have waste treatment system	227	2.63	1.268	**7**
29	Weak enforcement in conducting sale contract with processors	228	2.53	1	**8**
34	High interest rate for loans	223	2.45	1.165	**9**
6	Fingerlings with unknown origin	214	2.41	1.17	**10**
8	Fingerlings treated by anti-biotic during fingerling production process	179	2.4	1.163	**11**
33	Under financing by credits from banks/credit institutions	221	2.37	1.103	**12**
5	Low quality fingerlings	236	2.27	1.028	**13**
13	Uncontrolled/unstable home-made feed quality	224	2.27	1.088	**14**
15	High dead rate due to disease	233	2.18	1.103	**15**
7	Fingerlings infected by diseases	221	2.16	1.112	**16**
10	Over (density) stocking fingerlings	226	2.14	0.992	**17**
23	Waste water treatment system is under-invested	195	2.14	1.089	**18**
14	Overfeeding cause pollution and waste accumulation	219	2.11	1.152	**19**
28	Inaccessibility to the market	224	2.11	1.113	**20**
16	Inability to control diseases from environmental sources	234	2.09	1.067	**21**
4	Do not treat the pond before stocking	228	2.05	1.377	**22**
30	High technical barriers from importing countries	206	2.05	0.925	**23**
2	Pond nearby residency	215	1.99	1.172	**24**
12	Low quality of feed	217	1.98	0.935	**25**
22	Pond water is under-managed	232	1.98	0.953	**26**
11	Use undersize/oversize fingerlings	221	1.93	0.826	**27**
17	Low awareness of disease prevention by farmers	217	1.88	1.025	**28**
18	Limited knowledge about usage of chemical and medicines	233	1.87	0.915	**29**
24	Unawareness about community environmental protection	197	1.79	0.972	**30**
25	Inappropriate size of harvested fish	235	1.78	0.868	**31**
35	Changes in government policy on product development strategy	212	1.75	0.885	**32**
36	Changes in environmental policy	212	1.75	0.842	**33**
39	Lack of water supply	210	1.7	0.938	**34**
26	Inappropriate method of harvesting causes reduction of fish quality and weight	233	1.68	0.762	**35**
20	Applying chemical and medicines improperly	208	1.67	0.839	**36**
40	Technical failure	211	1.63	0.722	**37**
38	Flood	195	1.51	0.846	**38**
19	Use of prohibited chemical and medicines	203	1.46	1.035	**39**
37	Drought	195	1.35	0.619	**40**

The third cluster includes 15 risk factors that have an average score between 2.0 to 2.5 on the 5-point scale. The next 15 risk factors belong to the fourth cluster which has average scores from 1.5 to 2.0, and were considered as having relatively low likelihood of occurrence. The fifth cluster, in which the sources of risk have the lowest likelihood with average scores of probability of occurrence between 1.0 and 1.5, consists of two risk factors, namely (1) *use of prohibited medicines and chemicals, and* (2) *drought problem*, with the scores of 1.46 and 1.35 respectively.

Among the top three risk factors which have the highest likelihoods of occurrences, two of them relate to marketing risks, more specifically, (1) *price of catfish and* (2) *price of operating inputs.* These two risks are beyond the control of catfish farmers and are set by catfish processors and feed producers. The markets for catfish output and feed are obviously imperfect markets in terms of pricing mechanism. As the results, catfish farmers often have to face variations in output and input prices that go beyond the control of catfish farmers.

3) Level of Risk

According to the AS/NZS 4360: 2004, the level of risk is defined as the product of the consequence and the likelihood of risk. Using this formula, the levels of risk of the 40 sources of risk in Vietnamese catfish farming were calculated and presented in Table III. The level of risk of all 40 sources of risk is presented in the fifth column of Table III. The consequence and likelihood of risk factors are reproduced and presented in the third and fourth columns, respectively, for convenience of reference. Values presenting the levels of risk are simply used for ranking purposes only and do not represent the loss value due to risk.

TABLE III
THE CONSEQUENCES, LIKELIHOODS, AND LEVELS OF RISKS

Risk ID	Sources of risk	Consequence	Likelihood	Level of Risk	Rank
27	Fish price variability	4.49	3.35	**15.04**	**1**
31	Costs of operating inputs	3.95	3.19	**12.60**	**2**
32	Under financing by own capital for the whole crop cycle	3.75	2.76	**10.35**	**3**
21	Farm have no reserved area for waste water and mud treatment	3.06	2.97	**9.08**	**4**
29	Weak enforcement in conducting sale contract with processors	3.47	2.53	**8.77**	**5**
34	High interest rate for loans	3.57	2.45	**8.74**	**6**
5	Low quality fingerlings	3.85	2.27	**8.73**	**7**
15	High dead rate due to disease	3.96	2.18	**8.63**	**8**
9	Epidemic checking for fingerlings not conducted	2.8	3.08	**8.62**	**9**
33	Under financing by credits from banks/credit institutions	3.62	2.37	**8.57**	**10**
28	Inaccessibility to the market	4.04	2.11	**8.52**	**11**
7	Fingerlings infected by diseases	3.9	2.16	**8.42**	**12**
8	Fingerlings treated by anti-biotic during fingerling production process	3.32	2.4	**7.96**	**13**
3	Pond doesn't have waste treatment system	3	2.63	**7.89**	**14**
6	Fingerlings with unknown origin	3.27	2.41	**7.88**	**15**
4	Do not treat the pond before stocking	3.83	2.05	**7.85**	**16**
13	Uncontrolled/unstable home-made feed quality	3.45	2.27	**7.83**	**17**
14	Overfeeding cause pollution and waste accumulation	3.7	2.11	**7.80**	**18**
1	Pond outside planning area	2.87	2.67	**7.66**	**19**
10	Over (density) stocking fingerlings	3.49	2.14	**7.46**	**20**
22	Pond water is under-managed	3.74	1.98	**7.40**	**21**
16	Inability to control diseases from environmental sources	3.54	2.09	**7.39**	**22**
12	Low quality of feed	3.62	1.98	**7.16**	**23**
18	Limited knowledge about usage of chemical and medicines	3.34	1.87	**6.24**	**24**
17	Low awareness of disease prevention by farmers	3.18	1.88	**5.97**	**25**
30	High technical barriers from importing countries	2.91	2.05	**5.96**	**26**
19	Use of prohibited chemical and medicines	4.06	1.46	**5.92**	**27**
23	Waste water treatment system is under-invested	2.74	2.14	**5.866**	**28**
2	Pond nearby residency	2.86	1.99	**5.69**	**29**
36	Changes in environmental policy	3.1	1.75	**5.42**	**30**
11	Use undersize/oversize fingerlings	2.8	1.93	**5.40**	**31**
26	Inappropriate method of harvesting causes reduction of fish quality and weight	3.19	1.68	**5.35**	**32**
24	Unawareness about community environmental protection	2.94	1.79	**5.26**	**33**
20	Applying chemical and medicines improperly	3.07	1.67	**5.12**	**34**

25	Inappropriate size of harvested fish	2.88	1.78	**5.12**	**35**
35	Changes in government policy on product development strategy	2.83	1.75	**4.95**	**36**
39	Lack of water supply	2.62	1.7	**4.45**	**37**
40	Technical failure	2.28	1.63	**3.71**	**38**
38	Flood	2.17	1.51	**3.27**	**39**
37	Drought	2.11	1.35	**2.84**	**40**

4) Locating risks in a two-dimensional matrix

A two dimensional matrix, with consequence on one dimension (horizontal) and likelihood on the other (vertical), is used to described the level of risk of all sources of risk in study. On each dimension, a scale was assigned to measure the magnitude of the consequence and the likelihood of all sources of risk. Specifically, the scale for the consequence consists of I, II, II, III, IV, and V, representing the following degrees or levels of severity respectively: negligible, minor, moderate, major, and severe. Similarly, the scale for the likelihood of sources of risk includes A, B, C, D, and E, representing the following likelihoods of occurrence: almost certain, likely, possible, unlikely, and rare [26]. Table IV locates each source of risk in this two dimensional matrix, based on a 5-point scale for both risk consequence and probability. The interpretation of the levels of risk of the factors is as follows: (1) factors with very high risk levels are listed in cells AIV, AV, BV, (2) factors with high risk levels are listed in cells AII, AIII, BIII, BIV, CIII, CIV, CV, and DV, (3) factors with moderate levels are listed in cells AI, BI, BII, CII, DIII, and DIV and (4) factors with low levels are listed in cells CI, DI, and DII.

Only the risk factor of *fish price variability* is classified as very high risk level with the potential of having the most severe impact on catfish farmers' income and profit. Therefore, it definitely needs a serious attention for risk mitigating strategies. A large number of risk factors (23 factors) are classified as very high risk level according to AS/NZS 4360:2004 and they also need special attention from management. The remaining 16 risk factors are classified as moderate risks. None of the risks identified is classified as low level risks with negligible impact.

B. Measuring the Efficacy of Risk Management Strategies

In this study, 50 risk management strategies (RMS) were rated by catfish farmers in regards to their efficacy for mitigating each risk factor. The efficacy of the risk management strategies was rated on a 5-point Likert scale, with 1 as negligible effect, and 5 as very significant effect.

Average scores, standard deviations and rank of the efficacy of the strategies are presented in Table V in decreasing order of mean scores. Six strategies were rated as very highly significant in mitigating catfish farming risks. These are: (1) strictly treat the pond before stocking with a score of 4.34, (2) well manage water environment in pond with a score of 4.29, (3) select good fingerlings with a score of 4.14, (4) choose pond location nearby good water supply source with a score of 4.10, (5) choose good brand feed with a score of 4.06, and (6) buy the fingerlings from reliable sources with a score of 4.04.

The second cluster consisted of a large number (35 out of 50) of suggested strategies with average scores between 3.0 and 4.0 and considered as relatively good effective strategies. Next, there were 8 strategies rated as having moderate effects on risk mitigation, scoring from 2.0 to 3.0. Finally, off-farm work was rated as the least efficient strategy in the list, with a score of 1.97.

Although price risks were perceived as the most important sources of risk on average (refer to Table I), risk management strategies to deal with price risks (sale and production contract, vertical integration, enterprise diversification, cooperative marketing, and off-farm work) were not perceived as important strategies (refer to Table V). This finding is similar to the case of Dutch livestock farmers' perception of risk and risk management [9]. The highest-rated risk management strategies were the ones related to cultivation techniques, pond location selection, disease control, and water management.

V. Discussion

A. Perceptions of Risk Consequences, Likelihoods, and Levels of Risk

In measuring and interpreting the perceptions of risks and risk management strategies in catfish farming, we used the average scores of all catfish farmers included in the analyses. There were considerable variations in the answers given on risk sources, as indicated by the large standard deviations of most variables (refer to Table I and Table II). This suggests that perceptions on risk sources are very personal and specific across farmers. However, catfish farmers were relatively in agreement when evaluating the impacts of some sources of risks, such as: (1) *price variability*, (2) *cost of operating inputs*, (3) *high death rates due to diseases, and* (4) *low quality of fingerlings*. This fact is indicated by the rather low standard deviations of these variables, being 0.80, 0.88, 0.92, and 0.94 respectively. These are also the sources of risks that were rated with the highest scores in terms of their potential to affect the income or profits of catfish farmers. This might suggest that these sources of risk are obvious and important risks that all catfish farmers often face and perceive in their production activities.

TABLE IV
TWO DIMENSIONAL MATRIX OF LEVELS OF RISK

Likelihood	Consequence				
	Negligible (I)	**Minor (II)**	**Moderate (III)**	**Major (IV)**	**Severe (V)**
Almost Certain (A)					
Likely(B)			• Epidemic checking for fingerlings not conducted (8.6)	• High cost of operating inputs (12.60)	• Fish price variability (15.04)
Possible (C)			• High technical barriers from importing countries (5.96) • Pond located outside planned area (7.66) • Waste water treatment is under-invested (5.86)	• High dead rate due to diseases (8.63) • Fingerlings infected by diseases (8.42) • Low quality of fingerlings (8.73) • Do not treating the pond before stocking (7.85) • Under financing by own capital (10.35) • Overfeeding cause pollution problem (7.80) • Under financing by credits (8.57) • High interest rate for loans (8.7) • Inability to control disease sources from environment (7.39) • Over stocking fingerlings (7.46) • Weak enforcement of sale contract with processor (8.77) • Uncontrolled homemade feed (7.83) • Fingerlings treated by anti-biotics (7.96) • Fingerlings with unknown origin (7.88) • Farm has no reserved area for water/mud treatment (9.08) • Farm has no waste treatment system (7.89)	• Inaccessibility to the market (8.52)
Unlikely (D)			• Unawareness about community environment protection (5.26) • Harvest fish at inappropriate size (5.12) • Pond located nearby residency (5.69) • Change in Gov. policy on product development strategy (4.95) • Use small or undersize fingerlings (5.4) • Lack of water supply (4.45) • Technical failure of the live supporting system (3.71) • Flood (3.27) • Drought (2.84)	• Pond water is under managed (7.40) • Low quality of feed (8.74) • Limited knowledge about usage of chemicals and medicines (6.24) • Inappropriate method of harvesting (5.35) • Low awareness of disease prevention (5.97) • Change in Gov. environmental policy (5.42) • Applying chemicals and medicines improperly (5.12)	• Use of prohibited chemicals and medicines (5.92)
Rare (E)					

Note: Numbers in parentheses are Level of Risk, defined as the product of consequence and likelihood

TABLE V
MEAN SCORES AND RANK OF RISK MANAGEMENT STRATEGIES

RMS ID	Risk Management Strategies	N	Score	Std. Deviation	Rank
6	Strictly treat the pond before stocking	261	4.34	0.70	**1**
20	Well manage water environment in pond	259	4.29	0.72	**2**
8	Select good fingerlings	251	4.14	0.77	**3**
45	Choose location nearby good water supply sources	213	4.10	0.89	**4**
16	Choose good brand for feed	238	4.06	0.90	**5**
9	Buy fingerlings from reliable places	249	4.04	0.75	**6**
21	Prevent disease infection by regular checking and observation pond	244	3.94	0.92	**7**
48	Keep a good relationship with the community	232	3.94	0.78	**8**
33	Ask for government support	250	3.78	1.18	**9**
34	Apply quality management program (HACCP, Global-GAP…)	239	3.72	0.56	**10**
12	Strictly follow government regulations and technical guides	248	3.72	0.75	**11**
11	Careful checking fingerlings when buying	252	3.71	0.77	**12**
4	Regular checking of quality of supply water	246	3.70	0.88	**13**
19	Use only factory made (pallet) feed	231	3.68	1.14	**14**
18	Choosing good raw materials	242	3.65	1.11	**15**
13	Reduce density of fingerling stocking	244	3.63	0.72	**16**
35	Production at lowest possible cost/keep fixed cost low	236	3.62	0.93	**17**
14	Regularly update list of prohibited chemical and medicines	218	3.50	1.23	**18**
22	Develop aquacultural water treatment pond	231	3.48	1.21	**19**
28	Vertical integration	253	3.48	1.20	**20**
3	Develop a separated water supply system	238	3.46	0.82	**21**
42	Keep cash on hand for farming	214	3.46	1.15	**22**
15	Use large size fingerlings	252	3.45	0.90	**23**
47	Regular checking and maintaining of dyke	184	3.44	1.13	**24**
39	Make credit arrangement before cropping	224	3.43	0.79	**25**
10	Buy fingerlings only from certified producers	219	3.42	1.04	**26**
24	Consult people who have knowledge about aquacultural veterinary	227	3.41	0.97	**27**
43	Apply new technology in production	233	3.41	0.78	**28**
17	Self-processing to ensure feed quality and reduce cost	239	3.39	0.86	**29**
1	Locate pond in designated (planning) area	241	3.38	1.23	**30**
25	Sale and production contract with processor	255	3.37	1.07	**31**
23	Use labour with knowledge about aquacultural veterinary/advice	216	3.37	1.02	**32**
37	Increase solvency ratio	223	3.35	0.94	**33**
7	Attend extension workshop	233	3.31	0.66	**34**
44	Increase investment in environmental protection	225	3.25	0.96	**35**
50	Regular checking equipments	239	3.22	1.06	**36**
36	Reduce farm size to appropriate scale	247	3.15	1.18	**37**
27	Choose proper size of pond	226	3.13	1.03	**38**
49	Surplus machinery capacity	239	3.13	1.17	**39**
5	Apply farming system that minimize water replacement	229	3.03	0.79	**40**
30	Cooperative marketing	234	3.02	1.03	**41**
40	Solvency-debt management	214	2.80	0.93	**42**
32	Buying insurance for crop	224	2.75	1.27	**43**
26	Collect information about favourable size from processors	246	2.72	0.92	**44**
38	Co-operate with others for financing production	210	2.70	1.30	**45**
41	Use economic consultancy services	186	2.54	0.99	**46**
46	Spatial diversification	186	2.17	0.94	**47**
29	Enterprise diversification	232	2.04	1.05	**48**
2	Change to other activity	232	2.00	0.99	**49**
31	Off-farm work	209	1.97	1.07	**50**

Catfish farmers rated: (1) *fish price variability,* (2) *use of prohibited chemicals and medicines, and* (3) *inaccessibility to market* as the most important sources of risk in terms of their potential impacts on the income or profit of catfish farmers. However, the sources of risk that have highest levels of risk from our analysis are: (1) *fish price variability,* (2) *costs of operating inputs, and* (3) *under-financing by own capital for the whole crop cycle.* This is an important issue in identifying which sources of rich are in need for treatment and risk mitigation strategies.

B. Perceptions of the Efficacy of Risk Management Strategies

The standard deviations of risk management strategies showed much less variation in comparison to the sources of risk (refer to Table V). Most of them have a standard deviation of less than 1, and the highest standard deviation is for *collecting favorable size of fish at harvesting time from the processors*. Risk management strategies having the lowest standard deviations are: (1) *strictly follow government regulations,* (2) *attending extension workshop,* (3) *strictly treat the pond before stocking,* (4) *reducing the density of stocking, and* (5) *well managing pond water environment.* However, compare to previous studies, which also used a 5-point-Likert scale [9, 27, 28, 29], our study's standard deviations were found to be relatively low. This suggests that the catfish farmers included in our survey are fairly homogeneous in terms of risk management perceptions. Other aspects of risks and risk management perceptions are difficult to compare to previous studies because of the differences in the type of product, differences in questions, and differences in farming practices and the risk environment.

VI. Conclusion

The goal of this study is to provide empirical insights of Vietnamese catfish farmers' perceptions of risk and risk management strategies in their catfish farming. Our results suggest that, in general, price and production risks were perceived as the most important sources of risk. However, price risk reduction strategies such as sale contract, insurance, and diversification were not perceived as relevant strategies for price risk management. Instead, catfish farmers perceived farm management, disease prevention, and selecting good quality inputs (water source, feed, and fingerlings) as the most relevant risk management strategies.

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