Doctoral Thesis

Developing Risk Management Framework for Small-scale Shrimp Farming
– A Case Study in East Java, Indonesia –

小規模エビ養殖業のためのリスク・マネージメントの発展
―インドネシア、東ジャワの事例―

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Abstract

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Aquaculture becomes the main contributor to Indonesian fisheries products to fulfill the fast growing of domestic and global demand. Ministry of Marine Affairs and Fisheries of Republic of Indonesia stated that total production of aquaculture reached 14.35 million tons compared to 6.48 million tons made up from capture fisheries production. Thus, the FAO ranks Indonesia as the second largest aquaculture producer in the world. Indonesian export commodities were dominated by seaweed, shrimp, tuna, crab, and pearl. Among those commodities, shrimp was the largest (49.42%) in term of value in a couple of years.

Indonesia exports two primary species of shrimp, consist of the giant black tiger (*Panaeus monodon*) and pacific white leg shrimp (*Panaeus vannamei*). Compare to the giant black tiger, *vannamei* contributes two third (1.5 million tons) of the total Indonesian shrimp production. In a couple of years, the production of *vannamei* increased consistently by an average of 13.82% per year. Such a fast growth of Indonesian shrimp production has caused many challenges. Shrimp diseases, environmental degradation, shrimp price fluctuation, and product rejection from importing countries were some of the few issues that affected Indonesian shrimp production in the last several years. Therefore, shrimp farming today is being increasingly exposed to risk and uncertainty in which those risks inherent to all activities in their business. All those risks are potential to damaging shrimp industry and need to be managed in a systematic way for sustainability of shrimp industry. Thus, a solid risk management framework is much needed for Indonesian shrimp industry, particularly in small-scale level.

The purpose of this study is to develop a risk management framework for Indonesian small-scale shrimp farming. Two specific objectives are proposed, consist of (1) to investigate the small-scale farmers' attitude and perception of risks and risk management strategies related to small-scale shrimp farming; (2) to develop a risk management framework through identifying the sources of risk and management strategies, as well as evaluate the effectiveness

of existing management strategies. This study was carried out in two areas of East Java, Indonesia. They are Lamongan (South coast of East Java) and Banyuwangi (North coast of East Java) district, which were selected purposively due to the main shrimp producing areas in East Java. Purposive random sampling using the Taro Yamane formula was conducted to select the sample of small-scale shrimp farmers in the study areas. A total of 166 small-scale shrimp farmers were selected. Before starting field surveys, in-depth interviews with the extension officers, academia, and head of shrimp farmer groups was conducted to avoid missing any relevant information.

This study used Exploratory Factor Analysis (EFA) and multiple linear regression to measure the impact of socioeconomic characteristics of farmers on their perception of risk and management strategies. Based on factor analysis, the results revealed that *input and pond preparation*, *finance and credit access*, *production*, *personal*, *harvesting and marketing*, *weather and environment, policy and institutional*, and *business environment* were major sources of risks in shrimp farming. The findings of regression indicate that the farmers' perceptions were influenced by various factors such as the age, experience, education level, availability of off-farm income, and location of a shrimp farm. Our results indicated that the farmers' perception of risk and risk management strategies are farm specific. The findings showed that the shrimp farmers develop a range of strategies and conversely, a risk management strategy can apply to mitigate different types of risk source.

Regarding developing the risk management framework for shrimp farming, this study used the AS/NZS ISO 31000:2009 standard as the foundation of the framework due to its appropriateness to the scale of Indonesian shrimp industry, which mainly at the small-scale level. The AS/NZS ISO 31000:2009 standard consist of seven-step risk management process, which are (1) Communication and consultation, (2) Establishing the context, (3) Risk identification, (4) Risk analysis, (5) Risk evaluation, (6) Risk treatment, and (7) Monitoring and review. Moreover, Business Process Model (BPM) method has been explicitly used in the third step to identify the sources of risk involved in small-scale shrimp farming. Based on the results, this study found that the farmers had six risk management options to deal with the risks in their shrimp farms. The framework allows the farmers to choose the optimal risk management strategies based on the degree of efficacy of management strategies. Specifically, the framework allows the shrimp farmers to measure, rank, analyses, and priorities the risk for treatment in their business.

Abbreviations

ALAAR : As Low as Acceptable Risk

AS/NZS : Australian Standards/New Zealand Standards

BPM : Business Process Model

CDF : Cumulative Probability Distribution Function

DGA : Directorate General of Aquaculture

EFA : Exploratory Factor Analysis

EMS : Early Mortality Syndrome

IMNV : Infectious Myonecrosis Virus

MMAF : Ministry of Marine Affairs and Fisheries - Republic of Indonesia

PDF : Probability Distribution Function

WFD : White feces disease

WSSV : White spot syndrome virus

Terms and Definitions

Risk	:	Effect of uncertainty on objectives.
Risk Management	:	Coordinated activities to direct and control an organization with regard to risk.
Risk Management Framework	:	Set of components that provide the foundations and organizational arrangements for designing, implementing, monitoring, reviewing and continually improving risk management throughout the organization.
Risk Management Process	:	Systematic application of management policies, procedures and practices to activities of communicating, consulting, establishing the context, and identifying, analyzing, evaluating, treating, monitoring and reviewing the risk.
Risk Consequence	:	Outcome of an event affecting objectives.
Risk Likelihood	:	Change of something happening.
Risk Level	:	Magnitude of a risk or combination of risks, expressed in terms of the combination of consequences and their likelihood.

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Chapter 1

Introduction

Chapter one presents a broad overview of the thesis. This thesis is divided into six chapters. This chapter begins with an overview of Indonesian fisheries, particularly aquaculture sector (sub-chapter 1.1). Sub-chapter 1.2 outlines the statement of problems that were identified, while sub-chapter 1.3 formulated the aims and objectives of the study. Then, the sub-chapter 1.4 describes the scope the study, and limitation of study defined on sub-chapter 1.5. Last, sub-chapter 1.6 presents the summary of the thesis.

1.1 Background

During the last several decades, fisheries products have always been the primary source of trade surplus for Indonesia with the major export destination being United States, Japan and European Union (FAO, 2016). Therefore, the Indonesian government has identified fisheries as one of the key sectors for supporting the economic growth (Azzura, 2017). The contribution of the fisheries sector to Indonesia GDP has increased almost every year, with an average 7.33% per year. Over five years from 2010 - 2014, volume and value of fisheries production have experienced a remarkable increase by an average 23.38%, especially for aquaculture (MMAF, 2015). Ministry of Marine Affairs and Fisheries of Republic of Indonesia mentioned that the contribution of aquaculture to the total production was 68.89%, compared to the capture fisheries of 31.11%. Among the aquaculture products, shrimp was the largest in terms of value in a couple of years (MMAF, 2015).

In spite of the fact that shrimp farming is the flagship of Indonesian fisheries product, the fast growth of shrimp production also brings some problems. The spread of diseases, environmental degradation, product rejection from importing countries, and price fluctuation were several issues that affected Indonesian shrimp farming in the last couple of years (Sustainable Fisheries Partnership, 2013; Undercurrent News, 2014; FAO, 2016). These sources of risks push the shrimp farmers to make risky decisions related to their farms. Unfortunately, there is no guidance or tools for them to manage their risks appropriately. On the other hand, risk management is a crucial part of shrimp farmers production decisions. Therefore, a solid risk management framework is definitely needed for mitigating the impact of risks in Indonesian shrimp farming.

1.2 Statement of Problems

Small-scale shrimp farmers in Indonesia face many risks in their shrimp cultivation. Sustainable Fisheries Partnership (2009) mentioned that farming suffered from Infectious Myonecrosis Virus (IMNV) during 2008-2009. Then, Indonesian shrimp industry has encountered a significant problem caused by White Spot Syndrome Virus in the mid-2011 (Kilawati et al., 2015). Indonesian shrimp production dropped in 2014 after White Feces Disease suffered in East Java and Lampung. Moreover, the risk and uncertainty in shrimp farming may increase due to dynamic markets, changes in consumer behavior, impacts of climate change, and aquaculture policy reforms (Theuvsen, 2013). Hence, the shrimp farming exposed to risk and uncertainty in which those risks inherent to all activities in their business.

Larcher, Schonhart, & Schmid (2016) revealed that risk management is the essential entrepreneurial activities in shrimp farming. The farmers are usually used to manage their risks like shrimp price volatility, unfavorable weather condition or availability inputs for production. In fact, the shrimp farmers do not have access to sufficient tools or guidance, such as risk management framework, which can help them to cope with the risks efficiently and systematically. Thus, this study intends to fill this knowledge gap.

1.3 Aims of Study and Objectives

This study is aimed to develop a framework to manage the risks in small-scale shrimp farming in East Java, Indonesia. In detail, this study seeks to identify the risk, analysis the risk, and evaluate the risk. Moreover, this study also proposes the appropriate risk management strategies based on the efficacy to mitigate the risks.

To develop the framework, this study used combination of a risk management process based on AS/NZS ISO 31000:2009 standard and Business Process Model (BPM). Specifically, this study aims to achieve the following objectives:

1. To investigate the small-scale farmers' attitude and perception of risks and risk management strategies related to small-scale shrimp farming. Moreover, the socio-economic characteristics of shrimp farmers also include into the analysis to measure the impact of those characteristics in the perception of risk and management strategies.
2. To develop a risk management framework through identifying the sources of risk and management strategies, as well as evaluating the effectiveness of existing management strategies. This study used the AS/NZS ISO 31000:2009 standard due to its

appropriateness to the scale of shrimp industry in Indonesia, which mainly at the small-scale level.

1.4 Scope of Study

Shrimp industries consist of many related business activities, including hatchery, shrimp farming (growing out), formulated feed, processing factory, trading company, etc. Among these related industries, this study focused on the farming activity of the small-scale shrimp farmers. Small-scale shrimp farmers define as the farmers with land holding less than five hectares. At small-scale level, there is three type of shrimp cultivation systems exist in Indonesia, consist of extensive, semi-intensive, and intensive systems. Naylor et al., (2000); Martins et al., (2010); Rice & Garcia, (2011) mentioned that implemented the intensive system implies increasing the density of individual in the shrimp pond, which requires higher use and management of inputs. Thus, the degree of risk and uncertainty is highest compared to other systems. Based on those reasons, this study focused on small-scale farmers with an intensive system in their shrimp cultivation

1.5 Limitation of Study

Besides the contribution to developing the risk management framework for small-scale shrimp farming in Indonesia, this study has several limitations regarding the data and methodology used to answer the objectives. These limitations were unavoidable, even though they do not invalidate the findings of the study.

To evaluate the farmers' perception of risks and risk management strategies, this study only used data from the shrimp farmers in the North and South coast of East Java, Indonesia. Regarding representations of shrimp farmers population, this limitation was acceptable due to the areas of study represented the main shrimp producing area in East Java. Due to time and cost constraints, this study does not include economic-based analysis, such as benefit-cost, to measure the degree of efficacy of risk management strategies. However, this study employed the descriptive approach to measuring the degree of efficacy of risk management strategies. Thus, the limit was acceptable regarding achieving the research objective.

1.6 Summary of Thesis

The summary of thesis will be described as follows:

Chapter 1 is the introductory part of this thesis. This chapter has laid the foundations for the rest of the thesis. This chapter begins with general information about Indonesian fisheries sector and some related issues that gave rise to the statement of problems. Then, the aims of the study have been formulated, and objective of study have been briefly described. Last, this chapter concludes with the scope and limitations of the study.

Chapter 2 presents the broad review of aquaculture development in Indonesia. This review is provided information about current status of Indonesian aquaculture industries, particularly shrimp industry. During the last 15 years, Indonesian shrimp production has grown at a significant rate, from around one million tons to two million tons. In 2015, Ministry of Marine and Fisheries Affairs of the Republic of Indonesia stated that shrimp is one of the flagships of Indonesian fisheries export commodities from aquaculture sector (MMAF, 2015). However, the primary constraint shrimp farming in Indonesia encountered was the diseases outbreaks since the 2000s (Taukhid & Nur'aini, 2009). Besides diseases problems, several problems such as environmental degradation, shrimp price fluctuation, and product rejections due to food safety and food security issues from importing countries occurred in the shrimp industry. Thus, the farmers have to work in an environment with numerous types of risk and uncertainty.

This chapter also presents the concepts of risk and risk management strategies in aquaculture. The last part of this chapter intensely discussed the risk management standard and risk management process. Recently, there exist two types of risk management standards in the world. The first type is developed or adopted by national or international standardization bodies, while the second type is designed by professional organizations which focus or interest in risk management. In general, these standards provide guidelines for risk management in businesses and organizations. However, all those standards are different regarding the scope, activities, and size of businesses. Considering a tiny scale of Indonesian shrimp farming, this study used the AS/NZS ISO 31000:2009 standard to develop the risk management framework. Therefore, a part of this chapter focused on the seven steps of risk management process based on AS/NZS ISO 31000:2009 standard. Last, the conceptual framework of this study was presented in the last section of this chapter.

Chapter 3 describes the methodology of this study, including study areas, population and sample, research tools and justification of research tools. Data analysis is divided into two

stages to address the research objectives. The first stage is to analyze the shrimp farmers' perception of risk and risk management strategies in small-scale shrimp farming. Understanding the shrimp farmers' perception is crucial information and foundation for developing risk management framework. In the first stage, this study analyzed the shrimp farmers' perception of risk and risk management strategies in small-scale shrimp farming using field survey data of 166 farmers. Two regression models are developed to measure the impact of socioeconomic characteristics of shrimp farmers on their perception of risk and management strategies to deal with the risk. The first regression model analyzes the effect of farm and farmer characteristics on the perception of risk sources. Last, the second model measures the impact of farm and farmer characteristics and their perception of risk on the perception of risk management strategies.

In the second stage, the methods used for developing risk management framework are presented in detail. Refers to AS/NZS ISO 31000:2009 standard, there are seven steps for risk management process which are related to each other. These steps consist of 1) communication and consultation, 2) establishing the context, 3) risk identification, 4) risk analysis, 5) risk evaluation, 6) risk treatment, and 7) monitoring and review. Specifically, this study used Business Process Model (BMP) to identify all the possibility of risks and risk management strategies involved in the shrimp production in the third step.

Chapter 4 examined the perceptions of sources of risk and risk management strategies in Indonesian shrimp farming. Exploratory Factor Analysis (EFA) and multiple linear regression used to answer the objective. The 32 sources of risk found from field survey data were grouped into eight factors through exploratory factor analysis. Regarding risk management, 35 strategies from field survey data were reduced to ten factors through the same method. The scores for each factor are saved for subsequent regression analysis. Also, Jointed Varimax Rotated Extraction method used to maximize the independency of the factor. Exploratory factor analysis identified *input and pond preparation*, *finance and credit access*, *production, personal*, *harvesting and marketing*, *weather and environment*, *policy and institutional*, *and business environment* as major of risk factors. The findings of regression indicate that the farmers' perceptions were influenced by various factors such as the age, experience, education level, availability of off-farm income, and location of a shrimp farm. Our results indicated that the farmers' perception of risk and risk management strategies are farm specific. The findings showed that the shrimp farmers develop a range of strategies and conversely, a risk management strategy can apply to mitigate different types of risk source.

Chapter 5 describes in detail the steps to develop the risk management framework based on the AS/NZS ISO 31000:2009 standard. In the first step, communicates and consults were done through the in-depth interview and focus group discussion with the expertise in shrimp farming. The context of the risk management framework was established in the second step, consist of (1) the objective of shrimp farms was to maximize profit; (2) the economic criteria were used to measure the consequence of risks; (3) the higher degree of efficacy of risk management strategies considers as a higher priority risk management strategy to be used. In the third step, this study used Business Process Model (BMP) to identify all the possibility of risks and risk management strategies involved in the shrimp production.

The fourth step is risk analysis. This study used the concept of the level of risk to measure the risk in Indonesian small-scale shrimp farming. The result showed that two sources of risk, *shrimp price volatility* and *high mortality due to diseases*, were classified as a very high risk with the potential of having the most severe impact on shrimp farmers' income. In the fifth step, this study used the "As Low As Acceptable Risk" (ALAAR) criteria to evaluate the sources of risk. Based on this the ALAAR criteria, the risk with rating 1 on a 5-point Likert scale, either the risk consequence or risk likelihood, will be accepted and no treatment needed. The results revealed that, there are no sources of risk located in the low-level cell, either the risk consequence or risk likelihood

In the sixth step, each risk source matched with all risk management strategies for that risks. As a result, a complete list of risks and risk management strategies with six risk management options. Based on this result, the shrimp farmers could make their own decision on choosing the management strategies that best meet their risk mitigation objectives. The last step is monitoring and review. However, since the risk management framework in this study still on developing process, the monitoring and review cannot be done.

Chapter 6 provides the conclusions and recommendations of this study. The study found that the relationships between the perceptions of risks significantly impact on shrimp farmers' perception of risk management strategies. However, these relationships are multidimensional and represent characteristics of farm and shrimp farmers. Based on the findings, this study concludes that there is no particular risk management strategy for the specific type of risk source. The results showed that the shrimp farmers develop a range of strategies to deal with the risk. Conversely, a risk management strategy can apply to mitigate diverse types of risk sources. Moreover, the farmers had six risk management options to deal with the risks in their

shrimp farms. The framework allows them to choose the optimal risk management strategies based on the degree of efficacy of management strategies.

In addition, most of the shrimp farmers are risk-seeking. To maintain sustainability in their business, policies that enhance access to ensuring shrimp farms activities should be put in place, such as encouraged the off-farm income, enhance the credit access, and improve the insurance scheme for shrimp farms business.

Chapter 2

Background and Literature Reviews

2.1 Introduction

During the last decade, Indonesian aquaculture production continued in a positive trend that resulted in a 36.6% growth. Among aquaculture products in Indonesia, shrimp was the leading fisheries export in value for couple years. However, Indonesia also faces several problems in its aquaculture productions. Thus, this chapter aims to give a broad review of Indonesian aquaculture, including relevant issues in shrimp industry, which consist of four sub-chapters.

The Chapter 2 begins with the development of aquaculture, particularly Indonesian shrimp industry and its contribution to economic growth in sub-chapter 2.2. High-risk and uncertainty are the two factors that characterize small-scale shrimp farming. Hence, the concepts of risk and risk management strategies in aquaculture are discussed in sub-chapter 2.3 to 2.7. Due to the fact that risk management framework is the essential tools to manage the risk, reviewing the existing risk management standards is provided in sub-chapter 2.8. In general, the existing risk management standards provide guidelines for process of risk management. However, these standards were different in term of scope and size of business. In this study, we use the Australian and New Zealand (AS/NZS ISO 31000:2009) standard as foundation for development of risk management framework for small-scale shrimp farming in Indonesia due to its appropriateness of the Indonesian shrimp farming, which are mostly at small-scale farms. Hence, the risk management framework for Indonesian small-scale shrimp farming based on AS/NZS ISO 31000:2009 is presented in sub-chapter 2.9.

2.2 Broad view of Indonesian Aquaculture and Shrimp Industry

To provide a depth insight into Indonesian shrimp industry, this sub-chapter will give a review of the role and development of the shrimp farming in terms of production, supporting equipment of shrimp farming, and export market. Moreover, the relevant issues regarding shrimp farming are also identified.

2.2.1 The role of Aquaculture on Indonesian Economic Growth

As archipelago country with the fourth longest coastline in the world, Indonesian fisheries sector, both capture, and aquaculture have the potential to become a major fisheries

producer in the global market. Seaweed, milkfish, shrimp, and tuna were the primary commodities in Indonesia during the 2011 – 2015 period. The contribution of the fisheries sector to Indonesia GDP has increased almost every year, with an average 7.33% per year in the last five years. Despite the slower growth of Indonesian economy in 2015, the contribution the fisheries sector to national GDP increased from 7.55% to 8.36%, which is almost double compared to the GDP growth of 4.79% in 2015 (Figure 1). The main growth for Indonesian fisheries is a strong demand in both domestic and international market, respectively (IPSOS Business Consulting, 2016).

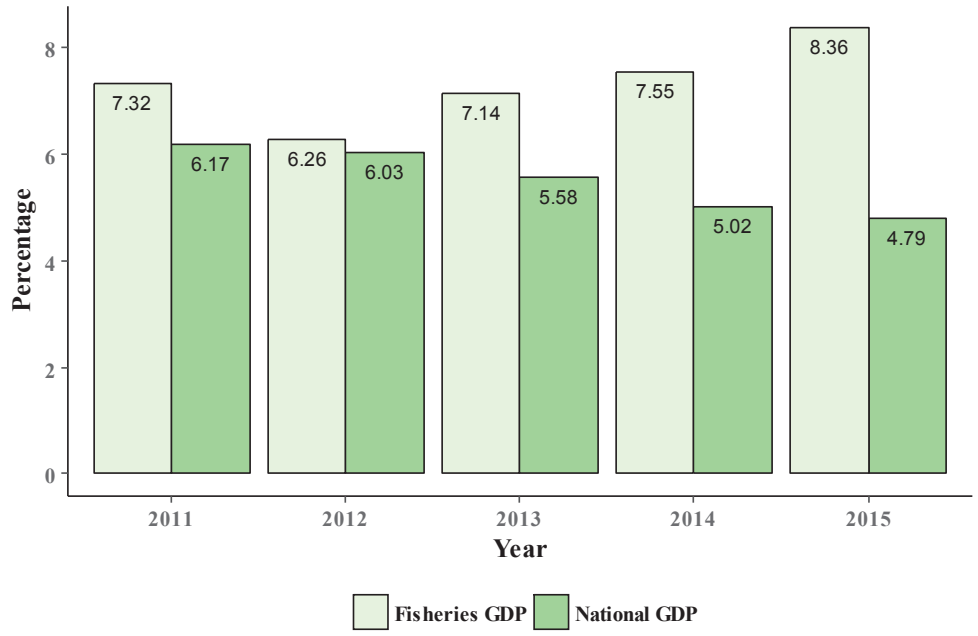

Figure 1. Indonesia's Growth of Fisheries and National GDP

In general, fishing activities are divided into two sub-activities, consist of aquaculture and capture fisheries. Because of IUU fishing practices and overfishing in Java and Sumatera islands, capture fisheries have experienced stagnant growth during 2010 to 2014. However, aquaculture becomes the main contributor to Indonesian fisheries products to fulfill the fast growing of domestic and global demand. As a result, Indonesian fisheries production has a continuous positive trend over 15% during 2010 – 2014 (Figure 2). In 2014, the contribution of aquaculture to the total production was 68.89%, compared to the capture fisheries of 31.11%.

Over five years from 2010 - 2014, volume and value of fisheries production have experienced a remarkable increase by an average 23.38%, especially for aquaculture. In 2014, total fisheries production reached 20.84 million tons, which increased 7.35% compared to the previous year (MMAF, 2015). As Figure 2 shows, total production of aquaculture reached

14.35 million tons compared to 6.48 million tons made up from capture fisheries production. Thus, the FAO ranks Indonesia as the second largest aquaculture producer in the world (FAO, 2016). Moreover, the value of fisheries production has also exhibited the most rapid growth overall, growing at 15.80% in the last five years.

The impressive growth of fisheries production was supported by the expansion area for aquaculture. During 2012 to 2013, aquaculture was expanded by 154.421 hectares (Central Bureau of Statistics, 2015). Recently, the total area of aquaculture in Indonesia has reached to 1.253.773 hectare (Central Bureau of Statistics, 2016). Ministry of Marine and Fisheries Affairs (MMFA) of the Republic of Indonesia stated that there are 16.6 million hectares untapped potential area for fish cultivation, consist of 11.8 million hectares of seawater, 2.3 million hectares of brackish water, and 2.5 million hectares of freshwater (MMAF, 2016).

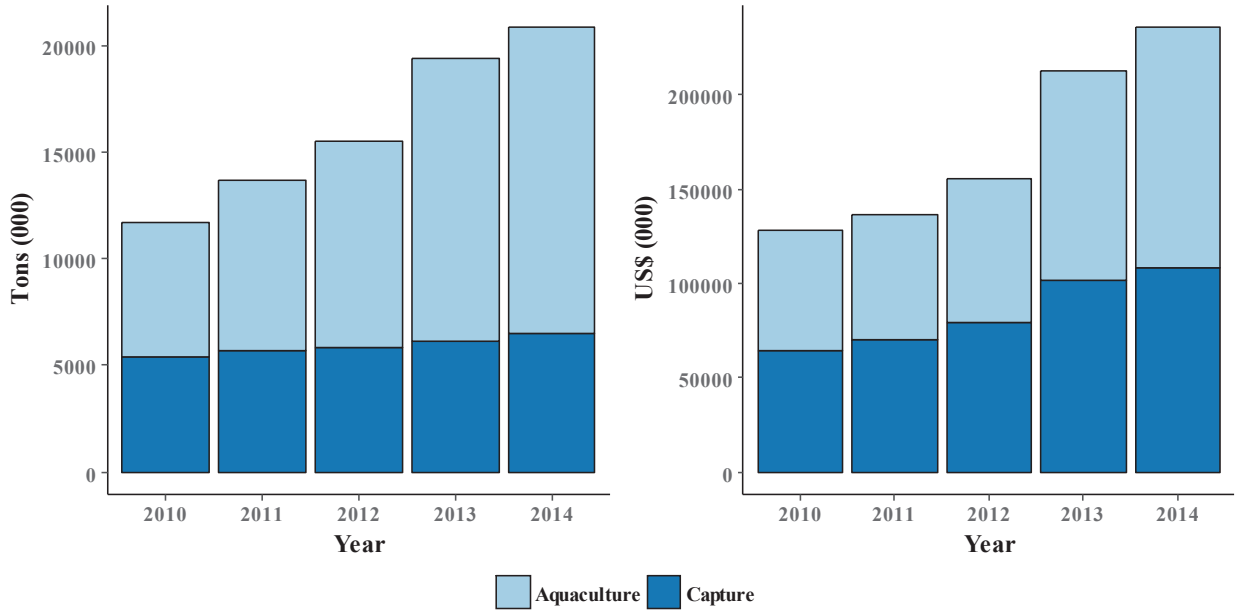

Figure 2. Indonesian Fisheries Production and Value

The fast growth of fisheries production has also followed by a rise in exports. As figure 3 shows, the total volume of fisheries export grew smoothly with an average of 8% during the period from 2010 to 2014. Regarding the value of export commodities, total earnings from fisheries export rose from UD$ 2.8 million in 2010 to US$ 4.6 in 2014 with the average growth of 17.6% per year.

MMAF (2015) reported that seaweed, shrimp, tuna, crab, and pearl were the main Indonesian export commodities. Among those commodities, shrimp was the largest in term of value in a couple of years. In 2014, shrimp contributed 49.42% to the total value of fisheries

product, following with tuna (16.04%), crab (9.56%), seaweed (6.46%), and pearl (0.72%), respectively.

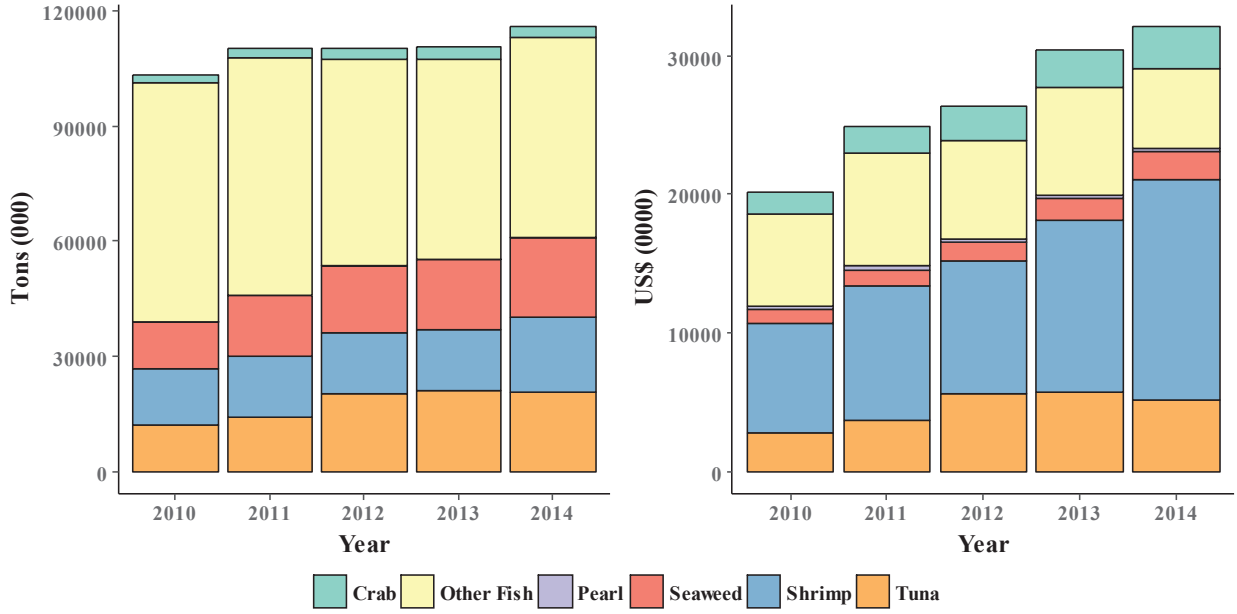

Figure 3. Indonesian Fisheries Export

2.2.2 Development of Indonesian Shrimp Industry

Indonesian aquaculture has a long history, starting with milkfish (*Chanos chanos*) farming in Java island. Before the 1960s, the brackish water ponds is used only for the cultivation of milkfish. Subsequently, the wild shrimp larvae were introduced into brackish water ponds and grown extensively. In the mid-1960s, extensive shrimp farming was initiated in South Sulawesi and spread rapidly to other islands in a few years later (Poernomo, 2004). In addition, the first shrimp hatchery was commissioned in the early 1970s in South Sulawesi followed by Jepara, Central Java Province. So far, three species of shrimp cultivated consist of black tiger shrimp (*Panaeus monodon*), white leg shrimp (*Panaeus vannamei*), and rostris shrimp (*Litopenaeus stylirostris*).

During the 1980s to 2000s, most of the shrimp farmers cultivated species of black tiger (*Panaeus monodon*). However, the production of black tiger stagnated at around 90,000 tons during 1997 to 2001 due to outbreaks of *White Spot Syndrom Virus* (FAO, 2003). Then, the Indonesian government imported the broodstock of *Panaeus vannamei* from Hawai in 2000 to support shrimp farming development. In July 2001, the government declared that vannamei has a better quality of shrimp. It has higher resistance to diseases, faster growth (1.37 gram per week), can be cultured in high density (more than 70 head per m^2), and more tolerance of

environmental fluctuation (FAO, 2003). As a result, the farmers shifted from the traditionally farmed black tiger shrimp to *vannamei* (Ablaza, 2003; Rimmer *et al*., 2013). Since then, shrimp farming has become the alternative solutions to support national shrimp production, especially after prevailing of Presidential Decree No. 39/1980, which banned trawls in shrimp capture (Dyspriani, 2007). The following section below will describe the driving force of Indonesian shrimp industry during the last five years in more detail.

2.2.2.1 Shrimp Farming System and Management

Indonesian shrimp farming was characterized by small-scale farms, low capital, and local ownership (Hanafi & Ahmad, 1999; Dyspriani, 2007). Based on management and input factors, shrimp farming classified into three types; small, medium, and large scales farming. The small-scale farms are typically less than five hectares in the total shrimp pond areas, usually operated by family members, simple facilities, low level of management, and sometimes hire labor for special activities, such as pond preparation and harvesting. Medium-scale farms have a total shrimp pond areas about 5 to 40 hectares. It has seasonal hire labor, medium facilities, and improved the level of management. Large-scale characterized by high tech technology and facilities along with controlled management level. They also required hiring labor and technicians to support their facilities.

Table 1. Classification of Shrimp Farming in Indonesia*

System	Size of Shrimp Pond (hectare)	Stocking Density (fry / ha / crop)	Expected Yield (kg / hectare / crop)
Extensive	1 – 4	10.000 – 30.000	150 – 240
Semi-intensive	1 – 2	30.000 – 100.000	600 – 1.200
Intensive	0.2 – 0.1	100.000 – 150.000	2.000 – 3.000

* : Recommended by the Directorate General of Aquaculture, MMAF.

Regarding cultivation system, shrimp farming in Indonesia is divided into three systems, consist of extensive, semi-intensive, and intensive ones (Table 1). The farming systems depend on the size of cultivation area, presence or absence of the management of brackish water exchange, fertilization, monitoring brackish water quality and biomass, aeration system, feeding management, and stocking density.

The extensive system is characterized by using little of fertilizer to stimulate plankton bloom as a source of shrimp feed, sometimes supported by supplementary feeding, and water pumping with stocking density between 10.000 – 30.000 per hectare (10 – 30 fry per m^2). Semi-intensive use regularly inputs of production, such as formulated feed and supplementary feed

with stocking density between 30.000 – 100.000 per hectare (30 – 100 fry per m^2). The intensive system uses more regular inputs, consist of formulated feed, supplementary feed, water pumping, and aerators. The stocking density for the intensive system is much higher (100 – 150 fry per m^2), and production costs are high (± US$ 4 per kg live shrimp) (Dyspriani, 2007). Moreover, Naylor *et al*., (2000); Martins *et al*., (2010); Rice & Garcia, (2011) mentioned that implemented the intensive system implies increasing the density of individual in the shrimp pond, which requires higher use and management of inputs and produces greater of waste products.

Recently, a new shrimp farming system has been developed in Indonesia. This is called the super intensive farming system and will replace the current intensive farming technique (Sangadji, 2014). The stocking density for the super intensive farming system is up to 1250 fry per m^2 (Mo, 2017). The system could boost production to up 153 tons per hectare (Aqua Culture Asia Pacific, 2013). However, the system is not suitable for small-scale shrimp farming due to capital-intensive and required modern facilities.

2.2.2.2 Shrimp Production

The total Indonesian shrimp production has grown at a significant rate during 2005 - 2015. Figure 4 depicts the development of the total volume of Indonesian shrimp farming. Within this 15 years period, shrimp production increased from around one million tons to two million tons, a two-fold increase. In 2015, Ministry of Marine and Fisheries affairs of the Republic of Indonesia stated that shrimp is one of the flagships of Indonesian fisheries export commodities from aquaculture sector (MMAF, 2015).

Based on geographical conditions, Indonesia had warm and stable brackish water temperatures. Those conditions provide the best conditions for shrimp cultivation throughout the year (EU Indonesia Business Network, 2017). Due to the great potential of shrimp to the Indonesian trade balance, the Directorate General of Aquaculture (DGA) has increased the target of production of 934 thousand tons in 2016 (MMAF, 2016). Furthermore, to achieve the goal to increase production, DGA stated that it is available of 1.2 million hectares of manufacturing areas could potentially be used as breeding of shrimp broodstock (Global Business Guide Indonesia, 2016)

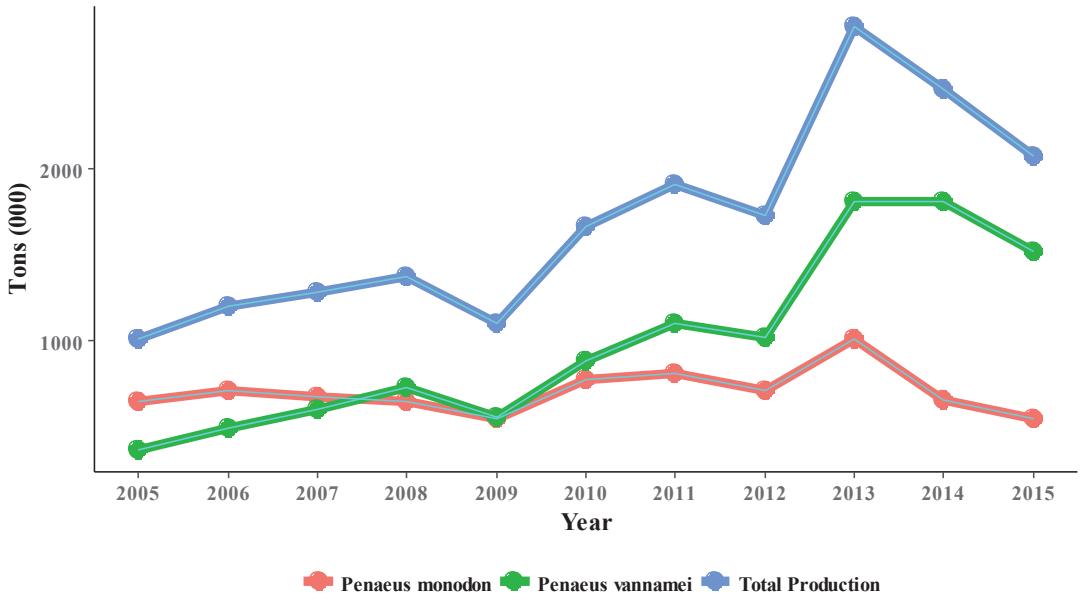

Figure 4. Indonesian Shrimp Production

Indonesia exports two primary species of shrimp commodities, consist of the giant black tiger (*Panaeus monodon*) and pacific white leg shrimp (*Panaeus vannamei*). During 2005 – 2015, the volume of production for *Panaeus vannamei* has experienced a significant increase, while *Panaeus monodon* remains stagnant. Compare to giant black tiger, *vannamei* contributes two third of the total Indonesian shrimp production, accounting for around 1.5 million tons in 2015. Refers to Figure 4, the production of *vannamei* increased consistently by an average of 13.82% per year.

2.2.2.3 Market and Segmentation

Shrimp industry in Indonesia has continued to enjoy higher demand in both international and domestic markets, respectively. During the 2011 to 2015 periods, the international market grew at 6.9% compared to 5% for the domestic market. However, the domestic demand for shrimp is relatively lower compared to fish since most of the Indonesian households still consider shrimp as an expensive source of protein. Because of the weaker domestic demand, Indonesian shrimp industry is sensitive to global shrimp production. In 2012, several shrimp producer countries suffered from production losses due to Early Mortality Syndrome (EMS), include China, Thailand, and Vietnam (Sustainable Fisheries Partnership, 2016). As a result, Indonesian shrimp industry enjoyed increasing profit margin around 30% - 60% for shrimp farming with the intensive system during that time.

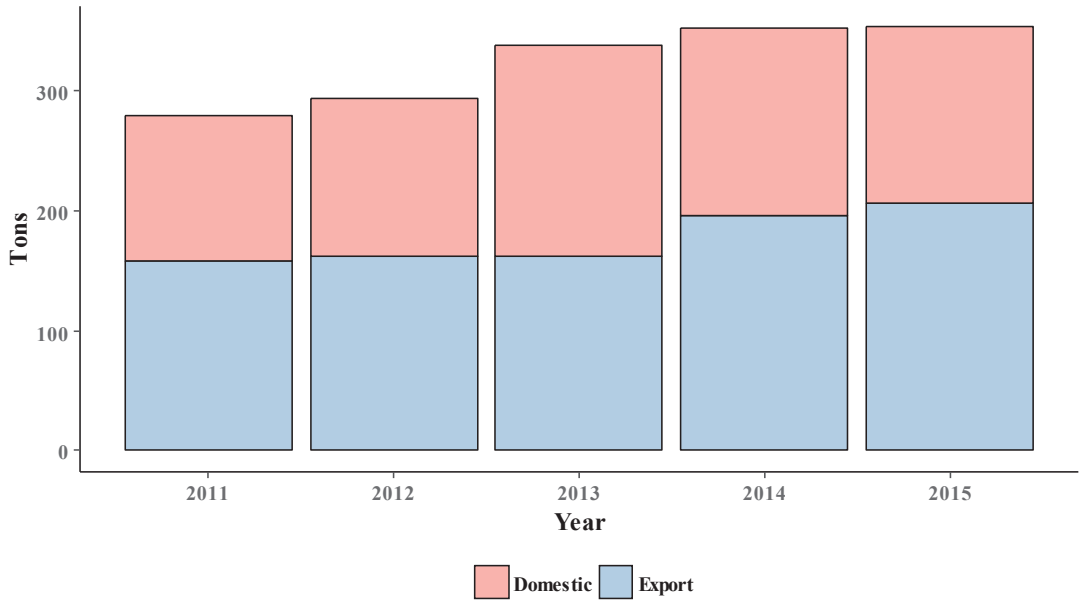

Figure 5. Market Segmentation of Shrimp in Indonesia

2.2.2.4 Shrimp Export and Export Destinations

Figure 5 depicts the Indonesian shrimp export during 2010 to 2014. In 2010, the export volume reached 145.092 tons with export earnings of US$ 1.056 Million. Based on the latest data, the total Indonesian shrimp production reached to 196.623 tons with the export value of US$ 2.140 Million for the year 2014.

Indonesian shrimp industry has continued to see higher demand from the international market (Figure 6). By the end of 2014, the USA become the largest export market for Indonesian shrimp, accounting for 55.28% of the total Indonesian shrimp export and being equivalent to 107.427 tons. The second primary market was Japan, with 17.29% of the total export value and equal to 33.608 tons, following with ASEAN and Middle East Market with 16.01% (31.100 tons). Spreading shrimp diseases in several ASEAN countries, such as Thailand, Vietnam, and Malaysia triggered increasing demand from processing factories in those countries due to lack of supply in the last several years (Pratruangkrai, 2013; Towers, 2016).

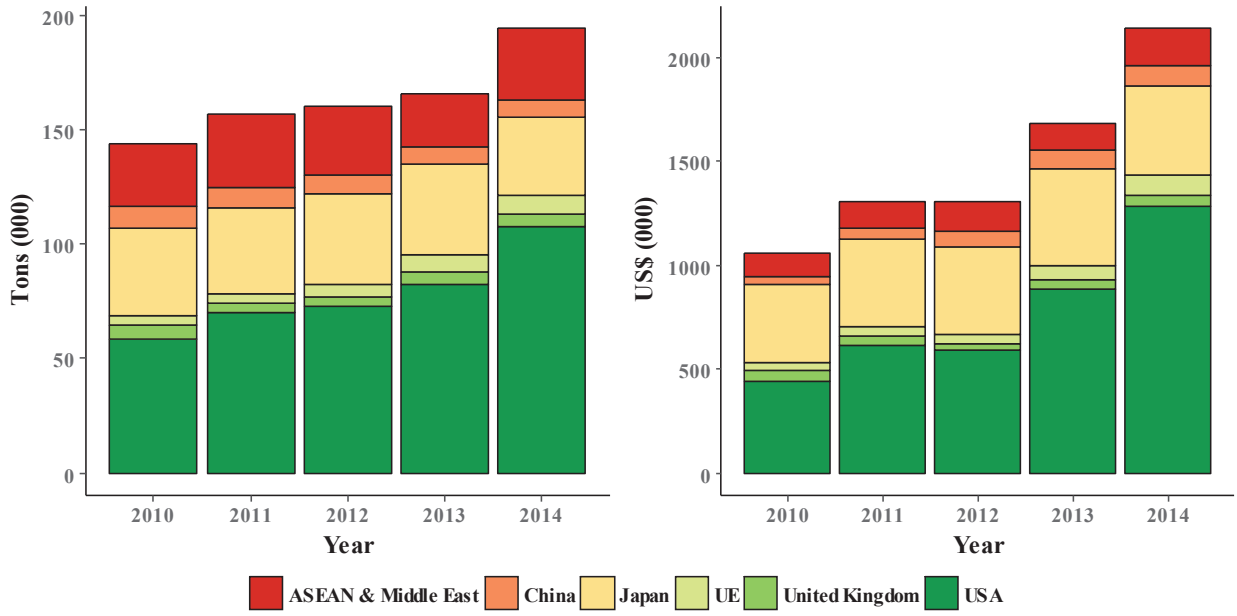

Figure 6. Indonesian Shrimp Export

Moreover, several experts in the shrimp industry estimate that the export market of Indonesian shrimp commodity will continue to exhibit a strong growth of 6% per annum for the 2016 – 2020 periods (IPSOS Business Consulting, 2016).

2.2.2.3 The Relevant Issues to the Indonesian Shrimp Industry

a. Shrimp Diseases

Since the 2000s, the main constraint *vannamei* farming in Indonesia encountered was the diseases outbreaks (Taukhid & Nur'aini, 2009). Anderson, Valderrama, & Jory, (2017) mentioned that shrimp diseases were the main issue for the global shrimp industries. Diseases outbreaks could reduce the survival rate of shrimp below 30%. As the one of the major aquaculture producers, Indonesia also experienced with several problems caused by diseases. During the 2008 to 2009 periods, *vannamei* farming suffered from Infectious Myonecrosis Virus (Sustainable Fisheries Partnership, 2009; Utari, Senapin, Jaengsanong, Flegel, & Kruatrachue, 2012). Taukhid & Nur'aini (2009) mentioned that three provinces, such as East Java, Bali, and West Nusa Tenggara, have experienced with Infectious Myonecrosis Virus. As a result, Indonesian shrimp production dropped by 31.52% during 2008 – 2009 (FAO, 2016).

Afterward, Indonesian shrimp industry encountered a serious problem caused by White Spot Syndrome Virus in the mid-2011 (Kilawati *et al*., 2015). The first occurrence of this diseases was reported in the northern coast of Central and West Java, then spread to many shrimp farms across the country (Ferasyi *et al*., 2015). Due to this diseases, shrimp farming

areas in Central Java decreased from 7.500 hectare to 1.000 hectares, and national shrimp production throws down by 7.77% (Arafani, Ghazali, & Ali, 2016; FAO, 2016).

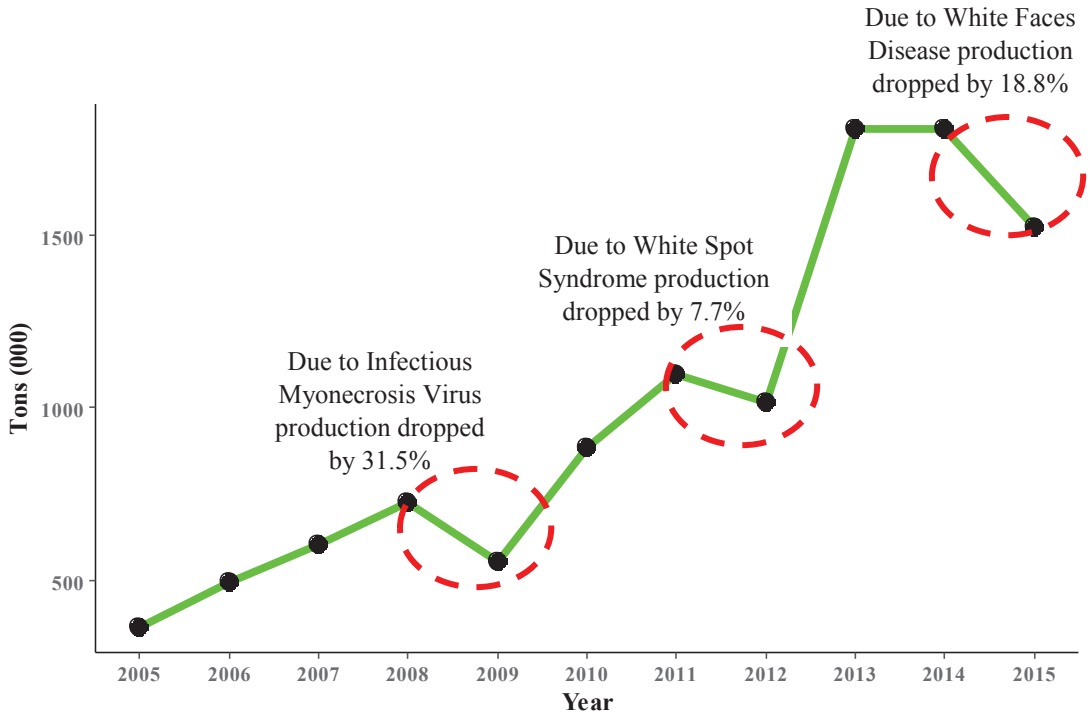

Figure 7. Impact of Diseases on Indonesian Shrimp Production

Vannamei production dropped during 2014 to 2015 after *White Faces Disease* suffered in East Java and Lampung. This disease decreased shrimp growth and the survival rate of *vannamei* (Thitamadee *et al*., 2016). As a result, the farmers harvest in large quantities of small shrimp and the shrimp price fell down due to oversupply in the market (Seaman, 2014). Moreover, national shrimp production dropped by 18.87% due to *White Faces Disease* (FAO, 2016).

b. Demand for Shrimp Feed

The fast growth of Indonesian shrimp industry bolstered the growth of supporting industries, such as shrimp feed, as well. Indonesian shrimp feed production has increased from 120 thousand tons in 2011 to 366 thousand tons in 2015, a threefold increase. However, Indonesia is highly reliant on import raw material for shrimp feed, especially fish meal, corn meal, and soybean meal. Tacon (2016) stated that Indonesian shrimp feed producers depended on world commodity prices and currency exchange due to around 50% - 80% raw materials being imported. Currently, the domestic price of shrimp feed was around US$ 1.04 per kg, which was about 15% higher than that of the international market.

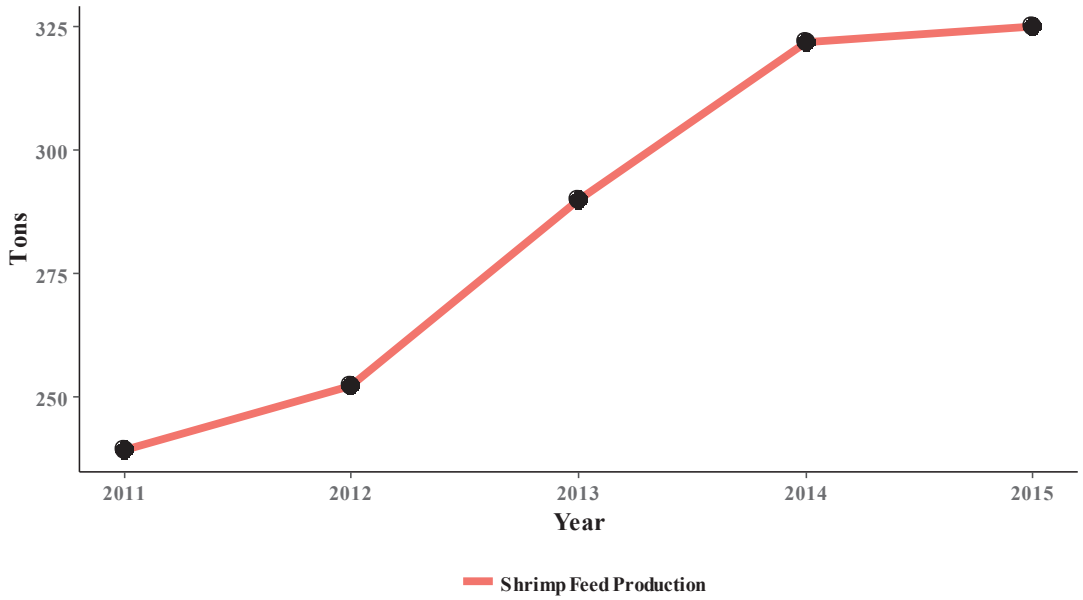

Figure 8. Indonesian Shrimp Feed Production

c. Environment Degradation and Natural Disaster

The fast growth of shrimp industry in Indonesia brings not only benefits for the farmers and country but also changes the nature gradually. In the last twenty years, Indonesia mangrove forest has been lost around 1.1 million hectares due to the expansion of shrimp farming (Sigit, 2013). Moreover, Sidik (2010), mentioned that development of shrimp industry in East Kalimantan province had been occupied 57.912 hectares equal with 54% of total area of Delta Mahakam river, and still growing up due to mangrove deforestation. The similar cases are also reported in several areas in Indonesia. The Environmental Impact Agency (BAPEDAL) stated that the mangrove forest in South Sulawesi province had been converted to shrimp ponds up to 80% during 2012 (Mayudin, 2012). National Geographic reported that the main cause of mangrove destruction along the Lampung coast was the expansion of fishery cultivation areas, mainly shrimp farming (Widodo, 2016). In addition, wastewater from shrimp ponds, which contained organic wastewater, antibiotics, and chemicals could pollute groundwater or coastal estuaries (WWF, 2017).

Furthermore, the most shrimp farmers in Indonesia use open water system as the source of brackish water. This system receives brackish water from ground water or sea water, in which the quality of water usually depends on the environmental condition and pollution from other sectors, such as agriculture, animal husbandry, and industry. During 2016 – 2017, the shrimp farmers in eight provinces in Indonesia have experienced a crop failure and loss profit due to brackish water sources quality (Adji, 2016; Chandra, 2016; Widiyanto, 2017). The

shrimp farming in Indonesia also vulnerable related to the natural disaster. In a couple of years, natural disaster problems has been damage the ponds in some shrimp production areas, such as extreme weather in Rembang, flooding in Pekalongan, Sumenep, Indramayu (Hadiyan, 2017; Temmy, 2017; Widiyanto, 2017)

2.3 Uncertainty and Risk

Since the 1920s, the differences and common features between uncertainty and risk have been a major debate. Frank H. Knight was the first scholar to distinguish risk from uncertainty. He differentiates uncertainty into two terms, consists of (1) measurable uncertainty and (2) unmeasurable uncertainty. The first term refers to the "risk," while the "uncertainty" related to the second terms (Knight, 1921).

Recently, the clear terminology is given by several scholars to distinguish between risk and uncertainty. Jaeger, Renn, Rosa, & Webler (2013); Rachev, Stoyanov, & Fabozzi (2011) defined the risk as exposure to uncertain unfavorable economic consequences, while the uncertainty as imperfect knowledge. The uncertainty arises from the lack of perfect knowledge of decision makers.

Thompson (2002) argue that uncertainty implies the situation which the decision makers might make non-optimal choices because insufficient of their knowledge. Moreover, Kochenderfer (2015) stated that the uncertainty covers all things that can happen, but the decision maker will never expect to happen. In some case, the uncertainty can reduce by obtaining related information, but this may not always be possible.

Regarding risk, it is a complex concept, which does not apply smoothly to in one line definition. Although there is no universal definition of risk, several definitions are commonly used. Even (2010); Andersen & Schrøder (2010) defined risk as a situation in which the action to face the uncertainty would affect the well-being of decision maker due to involves the change of gain and loss. According to Si & Thi (2015), the risk is defined as probabilities of events causing any positive and negative impact that give impact on business performance. Also, the risk is used by scholars to describe the situation in which the decision maker knew the objective probability distribution of outcomes (Nguyen, Wegener, & Russell, 2016; Just, Wolf, & Zilberman, 2003). Briefly, the risk is considered as uncertainty with consequences (Jaeger, Renn, Rosa, & Webler, 2013; Australian and New Zeland standard, 2009; Cross, 2000).

2.3.1 Perception of Risk

The risk perception is focused on the psychological factors that have been shown to have a significant impact on decision-making behavior. Sjöberg, Moen, & Rundmo (2004) explained that the risk perception refers to the subjective assessment of the probability of a specified type of accident happening and measure how far the decision maker concerned about the consequences. The best way to analyze the farmers' decision under risk and the uncertain condition is by taking into consideration their risk perception and attitude toward risk (Ullah et al., 2015; Lucas and Pabuayon, 2011; Ahsan, 2010).

Based on Thaler (2000), the economist has a theory of risky choice with both normative and descriptive approaches. The normative approach focuses on the question of how people should make decisions in various types of conditions if they wish to be regarded as rational. On the contrary, the descriptive approach reflects how people make decisions in different circumstances (Rapoport, 2013). Regarding descriptive approach, van Raiij (1981); de Wolff, Pieter, & Thierry (1998); Stensland (2013) developed the framework on decision making behavior (Figure 8). This framework is useful to explore the relationship between farmer and farm characteristics, the perception of risk, and risk management strategies (Flaten et al. 2005; Ahsan, 2010; Ullah et al. 2015).

According to Figure 9, the relationship between $\boldsymbol{P \rightarrow E/P}$ describes how personal characteristics and farm status (*P*), such as age, experience in shrimp farming, education level, off-farm income, land holding, and the number of shrimp ponds affect the shrimp farmers' risk perception (*E/P*). Then, the relationship $\boldsymbol{E/P \rightarrow B}$ reflect how shrimp farmers' characteristics influence their economic behavior (*B*) i.e. they risk management strategies, planning, and investment decision. This model is useful in understanding how various variable influence the shrimp farmers' economic behavior.

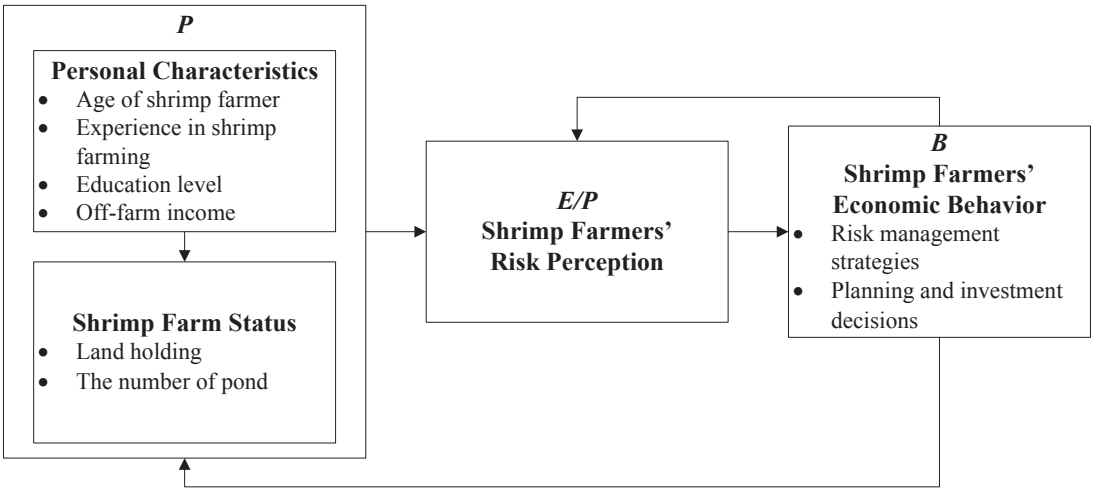

Figure 9. Shrimp Farmers Decision Making Behavior Model

(Modified of van Raaij, 1981; de Wolff, Pieter, & Thierry, 1998; and Stensland, 2013)

2.3.2 Farmers Risk Attitudes Toward Risk

The farmer's attitudes toward risk often could be used to describe the reason why seemingly similar farmers make entirely different decisions. Understanding the farmer's attitudes toward risk is important in analyzing their economic behavior. Hence, the risky attitude has been studied in detail, usually as an individual characteristic (Gloede, Menkhoff, & Waibel, 2015). In economics, the farmers' risk attitudes could be divided into three general types, consist of (1) risk-averse, (2) risk-seeking, and (3) risk-neutral. These types divided based on the shape of the farmer's utility function (Rabin, 2013; Nguyen, 2007; Marchant, 2003). Figure 10 below shows the three differently shape of farmers' utility curves corresponding to the risk-averse, risk-seeking, and risk-neutral behaviors.

Risk-averse refers to the farmer who prefers less risky sources on income in their business. In this type, the farmers will sacrifice some amount of income to reduce the probability of losses. In other words, they will forego some possible gains to reduce the probability of losses (Just & Pope, 2013). In contrast, the risk-seeking farmers would not be willing to give up the possibility of gains to eliminate the possibility of losses. In short, the farmers prefer more risky business alternatives (Gloede, Menkhoff, & Waibel, 2015). Last, between risk-averse and risk-seeking are risk-neutral. Rabin (2013) mentioned that the risk-neutral farmers make decision based on the expected values of the distribution of consequences. The farmers choose the action with the highest expected value, regardless of the associated distribution outcomes. Moreover, the risk-neutral farmers are unresponsive to the

risk involved in their business. They are only concerned about the expected return on the investment in their business (Nguyen, 2007).

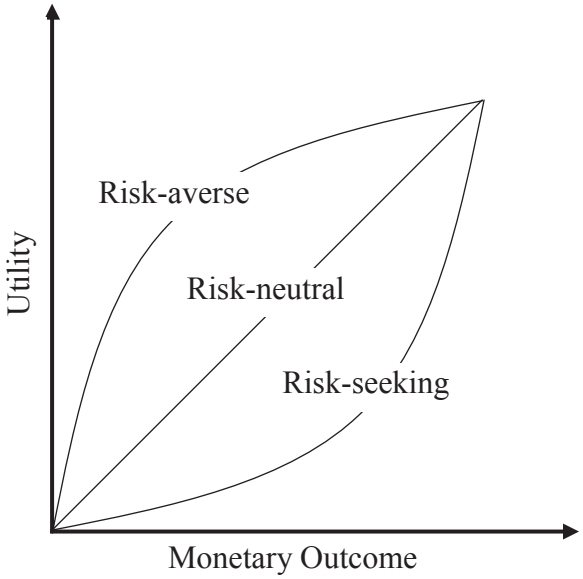

Figure 10. The Farmers' Utility Function of Risk Attitudes

(Modified of Vlahos, 2001)

Briefly, in all three cases above, the greater wealth corresponds to the higher utility. However, the curve of risk-averse is concave because to as wealth increase, the incremental attractiveness of the same amount of money becomes smaller. In the opposite side, the risk-neutral curve is a straight line, while the risk-seeking is a convex curve.

2.4 Risk Management

The farmer's response to the risk is diverse, same as the risks that affect their farms. Rabin (2013) stated that the risk management strategy is a form of farmer's respond to deal with the risk. There are two components of risks related to different aspects of farmers' decisions. The first is the possibility of unforeseeable future events. This component makes the farmers try to reduce future risks and their consequences. This is referred to as ex-ante risk management strategy. The second is the actual occurrence of shocks. This component pushes farmers to cope with the effects of shock when it occurs. This referred to as ex-post risk management strategy.

Ex-ante risk management and ex-post risk coping strategies could be defined as measures taken before and after experiencing shock, respectively (Lekprichakul, 2009). A shock is an unpredicted or unfavorable event that effects fluctuation in shrimp farmers' income. Ex-ante

risk management strategies that are undertaken before a shock occurs include risk avoidance, risk reduction and risk transfer (Chuku, 2009). These strategies are taken to minimize the impact of a shock when it occurs. Makoka (2008) said that the purpose of ex-ante risk management strategies is to reduce fluctuation in farmers' income. Furthermore, if the farmers fail to manage the shock ex-ante, they develop strategies to cope with the shock. This is called ex-post coping strategy which is aimed at reducing fluctuation in consumption and assets protection.

2.5 Risk Management Mechanisms

In exploring how to manage the risk in agriculture and aquaculture farms, it is useful to distinguish between strategies and mechanisms used by farmers in dealing with risk. The World Bank (2005) highlighted two mechanisms regarding risk management mechanisms in agriculture: informal and formal.

Informal mechanisms involve individuals, household or communities. Informal ex-ante strategies with informal mechanism are characterized by diversification of income sources and choice of production strategy. Informal ex-ante strategies are classified into two: on-farm and risk-sharing. Table 2 shows that on-farm ex-ante strategies include risk avoidance, crop diversification, diversification of income sources, buffer stock accumulation of crop or liquid assets and adoption of advanced technology (World Bank, 2005). Ex-ante strategies are classified as risk-sharing include sharecropping, sharing equipment, and informal risk pooling (Gunning, 2012). Informal ex-post mechanisms consist of sale of assets or reallocation of labor resources, reduced consumption pattern, and migration (Perdana, 2005).

Formal mechanisms are arrangements that include market-based activities and government support or publicly-provided strategies. Extension support from government, subsidy for on-farm inputs and infrastructure are publicly provided strategies that could be classified as formal on-farm ex-ante mechanism. Ex-ante risk sharing strategies include marketing contract, production contract and insurance. According to Gunning (2012) formal ex-post strategies consists market-based strategies in the form financial institutions and publicly-provided strategies in the form of social assistance and cash transfer from the government.

Table 2. Mechanisms in risk management strategies

		Informal Mechanism	Formal Mechanism	
			Market Based	*Government Support*
Ex-Ante Strategies	*On Farm*	• Risk avoidance • Risk Reduction • Diversification of income sources • Buffer stock accumulation • Adoption advanced technique	-	• Aquaculture extension • Subsidy or supply of quality seeds, inputs, etc.
	Sharing the Risk	• Sharecropping • Sharing equipment • Informal risk pooling	• Contract marketing • Insurance	-
Ex-Post Strategies	*Coping the Risk*	• Reduce consumption pattern • Sale of assets • Reallocation of labor • Mutual aid	• Credit	• Social assistance • Cash transfer

Soucer: World Bank (2005)

2.6 Risk and Risk Management in Aquaculture

In commercial aquaculture, the farmers should manage a various set of risks that treat the profitability of their farms. Besides other risks that are similar in agriculture and animal husbandry, aquaculture are also sensitive to the quality of the environment. Lebel, Whangchai, Chitmanat, & Lebel (2015) mentioned that the success of aquaculture production highly depends on the support of the environment.

Recently, several scholars give more attention to the impact of climate change on aquaculture. A study by Doubleday *et al*. (2011) on the effect of climate change to mariculture industries in south-east Australia revealed that oyster industry was suffered the highest potential risks due to increased temperature and heatwave-related mortalities. Across 11 mariculture industries, the result showed that the level of connectivity of growth to the environment, diseases, and pest management significantly influenced the level of risk. Similar study by Le Bihan, Pardo, & Guillotreau (2013) also found comparable results. Oyster farmers in Bay of Bourgneuf, France mentioned that the massive mortality of oyster juvenile has been increasing their sensitivity to environmental risks. Moreover, the oyster farmers rated spill-oil and zoo-sanitary problems were considered as a major risk in their business, while the price of input and output were ranked as minor risks. Regarding the oyster farmers' perception of risk management strategies, the result revealed that the farmers combined several risk management instrument to deal with the risk, such as shared storage capacity, taking out the insurance policies, and deductible payments. In addition, a comparative study of risk exposure in

agriculture and aquaculture done by Flatten, Lien, & Tveteras (2011) revealed that salmon farmings in Norway were riskier on the variability of yield, output price, and economics return compare to agriculture business, such as potatoes farms and livestock. However, salmon farming has the highest Return on Asset (ROA) with the average annual return of 9.6%, while all agriculture business showed a negative ROA. This result implied that salmon farming as the most risk-efficient in the long term.

In case of freshwater aquaculture, Lebel, Niwooti, Chanagun, & Lebel (2015) studied the impact of climate risks on river-based tilapia cage culture in Thailand. The result showed that drought, high feed price, and diseases outbreak were the top three of risks faced by tilapia farmers. In terms of management strategies, the farmers gave more attention to mixture several strategies, consist of technical, business, and social risk management strategies. In detail, choose good stock, keep a good relationship with neighbors, and keep a good relationship with fisheries staff were rate as the most effective strategy to mitigate welfare impact of risks in river-based tilapia cage farming. Those strategies are underlining the potential importance of collection action, best practices and decision support tools for strengthening risk management. In line with this study, the fish farmers in Northern Thailand managed the risks that they face by adjusting stocking calenders, take financial measures, seek new information, and maintaining good relations with other stakeholders and reservoir management (Lebel, Lebel, & Lebel, 2016). In another case, Pimolrat, Niwooti, Chanagun, Jongkon, & Lebel (2013) mentioned that the climate change phenomena, such as flood, drought, extreme hot and cold weather, were factors of high concern to tilapia pond farms in Thailand. The farmers respond those risks by reducing the amount of formulated feed supplied and considering non-farm occupations as adaptation strategies.

Besides affected by climate change risks, aquaculture sectors are also vulnerable to exposes by other risks. Le & Cheong (2010) stated that production and price risk were perceived as the most significant risks for Vietnamese catfish farming. Regarding management strategies, this study mentioned that there was no specific strategy to mitigate the impact of risk. Several strategies, such as financial, input quality, diseases prevention, and diversification, were perceived as relevant to reduce production risks in Vietnamese catfish farming. In case of Mussel farming in Greece, Theodorou, Tzovenis, Adams, Sorgeloos, & Viaene (2014) found that institutional risk, such as a licensing system for Mussel farm size, was a major risk factor faced by Mussel farmers and threaten the sustainability of their business. Thus, horizontal integration can be used as the effective strategy to scale up the Mussel production and brings

benefit from economies of scale for the Mussel farmers. In addition, Ngo, Azadi, Tran, & Lebaily (2017) mentioned that market risks were the primary risk factor for clam farming in Vietnam due to the rapid expansion of clam farming areas in the last several years. Regarding management strategies, the clam farmers applied several strategies, such as implementing technical innovations, diversifying livelihood activities, and accessing financial sources with no or lower interest rate, were the most effective for reducing loss as well as achieving fast recovery when the risks occur.

2.7 Risk and Risk Management in the Context of Shrimp Farming

In many scientific disciplines, the risk is an important topic. Therefore, a variety of risk concepts exist (See Renn, 2008a; 2008b). This study refers the concept of risk to social science approach, which combines two components; 1) the real event of human action that cause an actual outcome, and 2) the identification of the impact of the outcome on the individual's welfare. Based on this approach, the study defines risk as a perceived potential of impact on something of value (i.e., shrimp farmer's income) that is caused by an event or action. Regarding management strategies, Dorfman (2008) and Sethi (2010) defined as the logical development and implementation of plans to deal with the potential losses. In this study, risk management strategies refer to the general process of (1) *identifying* the risk along the business process of shrimp production, (2) *characterizing* the risk by measured the consequences and the likelihood of each risk, (3) *reacting* to the risk as a form of shrimp farmers' strategy.

2.8 Risk Management Standard and Process

2.8.1 Risk Management Standard

Since the last decade, the interest of professional organizations and the national management standard bodies in several countries to improve methods in risk management has been a surge. Hence, development of tools, processes, technique, and methodologies has led. Those developments are typically classified under the label of risk management standards (Raz & Hillson, 2005). Crikette et al., (2011) defined risk management standard as a fixed requirement. These requirements are usually a formal document that established criteria, methods, processes, and practices under the jurisdiction of an international, regional or national standards body.

Table 3. Types of Risk Management Standard

National or international standardization bodies	Professional organizations which focus or interest in risk management
Australian and New Zealand standard (AS/NZS ISO 31000:2009)	Committee of Sponsoring Organizations of the Treadway Commission – Enterprise Risk Management (COSO ERM)
Japanese Standards Association (JIS Q2001: 2001(E))	The Institute of Risk Management (IRM), The Association of Insurance and Risk Managers (AIRMIC), The National Forum for Risk Management in Public Sector (ALARM) - UK
Canadian Standards Association (CAN/CSA-Q850-97)	Hazard Critical Control Point (HACCP)
	GLOBALG.A.P. Risk Assessment on Social Practice (GRASP)

Recently, there exist two types of risk management standards in the world. The first type is developed or adopted by national or international standardization bodies, such as Australian and New Zeland standard (AS/NZS ISO 31000:2009), Japanese Standards Association (JIS Q2001: 2001(E)), Canadian Standards Association (CAN/CSA-Q850-97), etc. The second type is developed by professional organizations which focus or interest in risk management. Examples are the Committee of Sponsoring Organizations of the Treadway Commission – Enterprise Risk Management (COSO ERM), The Institute of Risk Management (IRM), The Association of Insurance and Risk Managers (AIRMIC), Hazard Critical Control Point (HACCP), The National Forum for Risk Management in Public Sector (ALARM), etc. In general, these standards provide guidelines for risk management in businesses and organizations. However, all those standards are different regarding the scope, activities, and size of businesses. By considering the scale of shrimp farms in Indonesia, which are mainly at the small-scale level, this study used the AS/NZS ISO 31000:2009 as the foundation to develop risk management framework. The AS/NZS ISO 31000:2009 was chosen purposively due to provide guidelines for developing risk management framework across various sizes and types of organizations.

2.8.2 Risk Management Process

According to the AS/NZS ISO 31000:2009 standard, the risk management process defined as a series of steps, which enable continuous improvement in decision making when it undertook in sequence (SAI Global, 2009). The AS/NZS ISO 31000:2009 standard divided the process of risk management into seven steps that closely related to each other. These steps consist of 1) to communicate and consult, 2) to establish the context, 3) to identify the risk, 4)

to analyze the risk, 5) to evaluate the risk, 6) treat the risk, and 7) to monitor and review. Figure 1 below described the seven steps of risk management standard based on AS/NZS ISO 31000:2009. The following sections provide a brief description of each step of the risk management process.

Step 1. Communication and consultation

Communication and consultation are the earliest steps in the risk management process. Knight (2010) defined the risk communication and consultation as the two-way dialogue between or among stakeholders not only about the existence of risk but also the nature and form of risk, and severity of acceptability of risk. In this step, two factors should be identified to establish the remaining proses of risk management, which are (1) eliciting risk information and (2) managing stakeholder's perceptions for the management of risk.

Step 2. Establishing the context

Establishing the context of risk defines as the sets of scope and necessary parameters that give information within which risks must be managed for the rest of risk management process (Standards Australia & Standards New Zealand, 2005). This step aims to identify the boundaries within which the risk management should be applied to the business process. There are five points to assist with establishing the context, consist of (1) establish the internal context, (2) establish the external context, (3) establish the risk management context, (4) develop the risk criteria, and (5) define the structure for risk analysis.

Step 3. Risk identification

The risk cannot be managed unless it is identified. Once the context has been defined in the previous step, the next is to identify as many risks as possible. Comprehensive identification, using a well-structured, and systematic process to identify the risk are critical in this step (Kanona & Tawalbeh, 2007). In this step, the main purpose is to identify possible risks that may affect, either positive or negative.

Step 4. Risk analysis

The critical step in developing an understanding of the risk is risk analysis. Risk analysis aims to provide information on the level of risk and its nature. Based on AS/NZS ISO 31000:2009, the level of risk is defined by the relationship between consequence and likelihood applicable to the areas of risk (SAI Global, 2009).

The formula bellow shows the simple form of level of risk that represents the relationship between consequence and likelihood

$$The\ Level\ of\ Risk\ = Consequence\ x\ Likelihood$$

Alam (2016) mentioned that risk analysis provides information to decisions on whether the risk needs to be treated and the most risk management strategies. There are three types of analysis could be used to determine the level of risk, consist of qualitative, semi-quantitative, and quantitative analysis (Knight, 2010).

Step 5. Risk evaluation

The objective of risk evaluation is to create action or decision, based on the outcome of risk analysis in the previous step. This step includes a decision about which risk should be accepted or treat and the treated priorities (Standards Australia & Standards New Zealand, 2005). There are several reasons to accept the risk, consist of (1) the level of risk is low; (2) the degree of efficacy of risk management strategies is effective to mitigate the impact of risk; and (3) the cost of treating the risk outweighs the benefit (Kanona & Tawalbeh, 2007).

Step 6. Risk treatment

The risk treatment involves selecting one or more available options to face the risk which were not accepted at the previous step (SAI Global, 2009). In treating the risks, a combination of options may be appropriate. Following the AS/NZS ISO 31000:2009 standard, the several treatments that available should be identified, consist of avoiding the risk, reducing the risk, sharing the risk, and retention the risk (SAI Global, 2009).

Step 7. Monitoring and review

Monitoring and review is the crucial and integral step in the risk management process. Many factors may improve the consequences and likelihood of the risk source. Thus, the risk should be monitored periodically to confirm changing circumstances do not alter the risk environment (Knight, 2010). Based on AS/NZS ISO 31000:2009 standard, the risk management plan should be review periodically to ensure the effectiveness of risk management strategies plan and to capture the possibility arising from new risks (Standards Australia & Standards New Zealand, 2005).

2.9 Application of Risk Management Framework in Fisheries and Aquaculture

During the last decade, risk management framework has been applied widely across industries. However, the literature on implementation of risk management framework in fisheries and aquaculture is limited. Based on the previous studies, implementation of risk

management framework in fisheries and aquaculture was widely diversed in term of the scope of risk analysis, the scale of business, and specify on target of risk assessment, with focuss on environmental sustainability, food safety problems, and diseases prevention management. The following sections will provide several examples of risk management framework in fisheries and aquaculture sectors for different purposes.

McDaniels, Longstaff, & Dowlatabadi (2006) applied the value-based framework for risk management decisions in salmon aquaculture at British Columbia, Canada. The authors developed three principle steps to solve multiple levels of institutional and regulatory control risks in the salmon industry. These principle steps consist of (1) characterizing the multi-levels at which regulatory decisions arise, and linkages among them; (2) characterizing the objective of stakeholders at each level; and (3) assessment and evaluation. These steps tried to reach critical decisions that arise at each level and identify the relationship among them.

Murray & Peeler (2005) developed a framework for understanding the potential for emerging diseases in aquaculture. The authors combine risk analysis method and virulence theory to identify key diseases-emergence risk factors in salmon production. This study proposes a four-step model to identify diseases emergence, consist of (1) emergence the pathogen, (2) establishment in a farmed population, (3) establishment at the regional scale, and (4) development of diseases and its consequences. Moreover, the rate and extent of the emergence of diseases could be reduced by applied biosecurity programmes that designed to mitigate the risk factors for emergence of the diseases. Similar to this study, Bartley, Bondad-Reantaso, & Subasinghe (2006) developed a risk analysis framework for aquatic animal health management in marine stock enhancement programmes. The framework contains 10 aspects to be considered in marine stock enhancement programmes, consist of (1) the source of animal to be released, (2) the population to be managed, (3) hazard identification, (4) risk assessment, (5) risk management, (6) quarantine, (7) diagnostic and treatment procedure, (8) mitigation measure, (9) monitoring, and (10) reporting. The study highlight that to avoid incursions of diseases and pathogens as a result of a wild animal released, diseases control strategies should be an integral part of stock enhancement programmes.

In case of risk management in fisheries, Sethi (2010) applied two stages-framework for risks management in Alaska fisheries. These stages consist of (1) risk identification and (2) risk treatment. In the first stage, risks in Alaska fisheries are identified and analyzed. The strategies presented in this stages focus on decision analysis, including multicriteria decision-making tools, and the related concept of risk assessment. In the second stage, the identified

risks will be analyzed to determine the particular treatment for each risk, such as avoided, transferred, or retained. Also, the author mentioned several tools to manage risk in Alaska fisheries as the precautionary approach, consist of portfolio management, horizontal integration, and financial contract for manage price risk.

Williams, Dowdney, Smith, Hobday, & Fuller (2011) used the Ecological Risk Assessment for the Effect of Fishing (ERAEF) to evaluate the impact of fishing on habitats of benthic in Australia. The ERAEF framework is based on a hierarchy with a scoping stage and three analytical levels. These levels consist of (1) a qualitative "Scale, Intensity, and Consequence Analysis" (SICA), (2) a semi-quantitative "Productivity Susceptibility Analysis" (PSA), and (3) quantitative "Model-based" assessment. The result revealed that 46 of 158 habitats of bottom trawl were identified as a potentially higher risk and deserving management attention. The authors highlight three critical findings of mitigating risk to fishery habitats, which are (1) identifying performance measures to determine the acceptable levels of impact, (2) determining what monitoring is required to assess recovery from the impact, and (3) defining ways to increase habitat-specific data collection.

In sum, the risk management was widely applied in other sectors to prevent losses from the impact of risks. However, employed of risk management in aquaculture was much lesser extent because of the diversified and unstandardized the scope and scale of production activities, especially at the small-scale level in developing country. Although there is a different application of risk management framework in fisheries and aquaculture, the frameworks are either too specific or too general for particular aims. At this moment, no existing risk management framework covers all risk factor and provides a comprehensive treatment of risk that faced by farmers especially at the farm level.

2.10 Conceptual Framework

The main purpose of this study is to develop risk management framework for small-scale shrimp farming in Indonesia. In detail, this study aims to define a risk management framework by identifying, categorizing, and assessing each risk in small-scale shrimp farming and recommend management strategies to mitigate the risks. The whole study is illustrated by the conceptual framework that is shown in Figure 11. The framework has three main phases, consist of (1) a wide review of Indonesian shrimp industry and its relevant issues, (2) the assessment phase which include three topics, and (3) the conclusion and recommendation phase. The first phase provides the broad view of Indonesian shrimp industry and its related

issues. As the second largest aquaculture producer in the world, shrimp was the leading Indonesian export commodity for a couple of years. The fast growth of shrimp production not only brought benefits, such as creating job opportunities, increasing foreign exchange, and improving farmers' income, but also changed the risk environment in the shrimp industry. Thus, a risk management framework became increasingly needed to enhance the ability of shrimp farmers to deal with risks and maintaining the sustainability of their livelihood. The next part of this phase includes discussion in depth on theoretical and empirical study on risk management and its application in aquaculture. The study design and procedures are presented in last part of the first phase.

The second phase begins with assessing the farmers' perception of risk and risk management strategies in shrimp farming. Also, socio-economics and shrimp farm characteristics are included in the analysis to distinguished difference perception among the farmers. Then, business process modeling was used to identify risk and management strategies in each sub-process along the shrimp farming production. This part is the foundation for developing risk management framework in the following section. The framework was developed based on AS/NZS ISO 31000:2009 standard, which includes seven steps: (1) communication and consultation, (2) establishing the context, (3) risk identification, (4) risk analysis, (5) risk evaluation, (6) risk treatment, and (7) monitoring and review. The last part of this phase presents the influence factors on the acceptance of framework for managing risk in small-scale shrimp farming. The third phase of this thesis includes conclusion and recommendation for future work. Lastly, a discussion of the limitation of this study also presented in this phase.

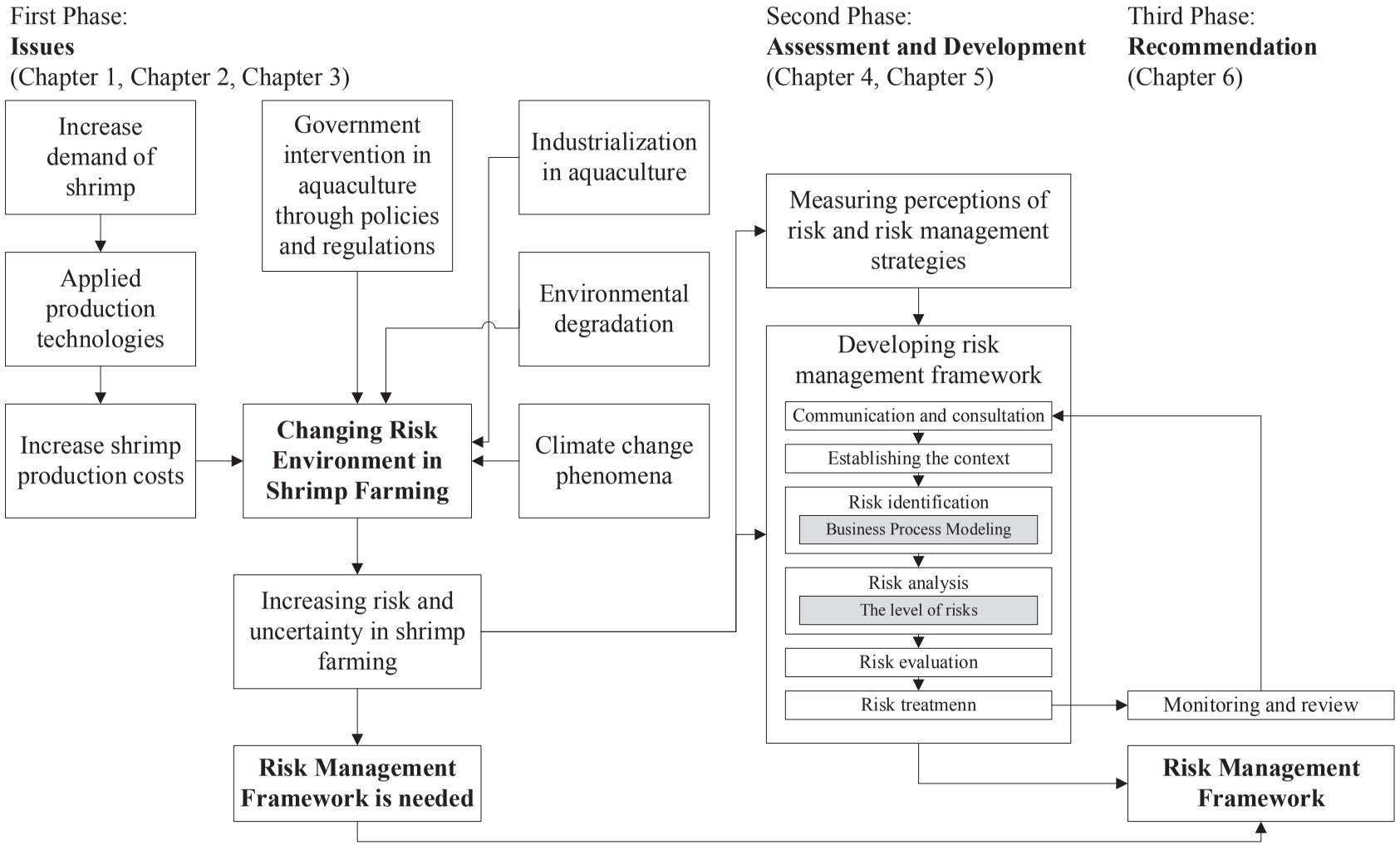

Figure 11. The Conceptual Framework

Chapter 3

Methodology

3.1 Introduction

This chapter describes the methodology used in this study, including areas, population and sample, research tools and justification of research tools. Data analysis is divided into two stages to address the research objectives. The first stage is to analyze the shrimp farmers' perception of risk and risk management strategies in small-scale shrimp farming. Understanding the shrimp farmers' perception is crucial information and foundation for developing risk management framework. In the second stage, the methods used for developing risk management framework are presented in detail. Moreover, the general risk management processes in this study is based on the AS/NZS ISO 31000:2009 standard.

3.2 Data and Data Collection

3.2.1 Study Areas

The data used for this study originated from a series of field surveys in the south and north coasts of East Java, Indonesia (Figure 1). Two regencies were selected: (1) Banyuwangi Regency in the south, and (2) Lamongan Regency in the north. The research areas are selected purposively because they are the main shrimp producing areas in East Java.

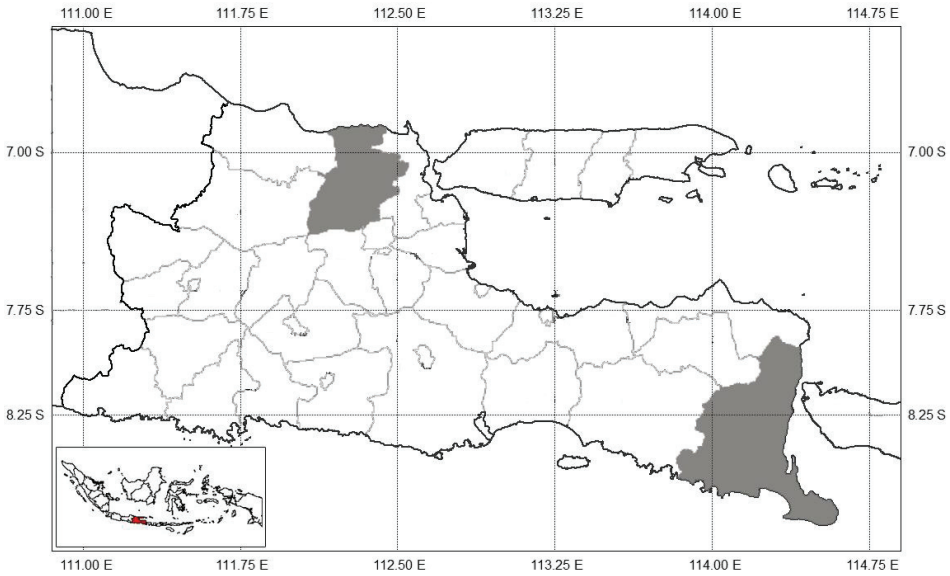

Figure 12. Study areas in East Java, Indonesia.

3.2.2 Population and Sample

In this study, the population used in data analysis was the small-scale shrimp farmers with the intensive system in their shrimp cultivation. Small-scale shrimp farmers define as the farmers with land holding less than five hectares. In 2015, the total population of small-scale shrimp farmers in study areas was 683 shrimp farmers in the north coast and 755 shrimp farmers in the south coast respectively.

Simple random sampling technique was used to select a sample from the list of small-scale shrimp farmers, publish by Ministry of Marine and Fisheries Affairs in each study areas. In addition, Taro Yamane formula (Yamane, 1967) was used to determine sample size at confidence level 95% and margin of error 10%.

$$n = \frac{N}{(1 + Ne^2)}$$

Where;

n : Sample size

N : Population size

e : Margin of error

As the results, the sample size of 79 and 87 was obtained. The first survey was conducted during February to April 2016, while the second survey on September 2017.

3.2.3 Research Tools

Semi-structured questionnaire was constructed to gather information from small-scale shrimp farmers. The questionnaire was divided into three parts. The first part aims to explore the socioeconomic characteristics of shrimp farmers and investigate shrimp farming characteristics. This part contained 20 open-ended questions. The second part consists of 32 close-ended questions. The purpose of the second part is to investigate the sources of risks in shrimp farming, assess the consequences, and measure the likelihood of those risks. Five points Likert scale was used to measure the consequences and the likelihood of risk sources. The range varied from 1 (minor impact) to 5 (severe impact) for the consequences fo risk, while 1 (rare) to 5 (almost certain occurrence) for the likelihood of risk. The last part contained 34 close-ended questions. This part aims to examine the risk management strategies and evaluate the effectiveness of those strategies in protecting their farms and income. Regarding risk

management strategies, the five-point Likert scale ranged from 1 (not effective at all) to 5 (very effective).

3.2.4 Pretest the Questionnaire

Before the actual survey is conducted, the questionnaire was directed to 30 shrimp farmers to check its appropriateness. Several adjustments have been made and the questionnaire ready for the survey.

3.3 Data Analysis

- The first stage

In the first stage, this study analyzed the shrimp farmers' perception of risk and risk management strategies in small-scale shrimp farming using field survey data of 166 farmers. Then, the 32 sources of risk found from field survey data were grouped into eight factors through exploratory factor analysis. Regarding risk management, 34 strategies from field survey data were reduced to ten factors through the same method. The scores for each factor are saved for subsequent regression analysis.

In addition, Varimax Rotated Matrix used to maximize the independency of the factor. Varimax rotation is an orthogonal rotation of the factor axes to maximize the variance of the squared loadings of a factor (column) on all the variables (rows) in a factor matrix, which has the effect of differentiating the original variables by extracted factor.

Two regression models are developed to measure the impact of socioeconomic characteristics of shrimp farmers on their perception of risk and management strategies to deal with the risk. The first regression model analyzes the impact of farm and farmer characteristics on the perception of risk sources. Last, the second model measures the impact of farm and farmer characteristics and their perception of risk on the perception of risk management strategies.

- The second stage

The purpose of the second stage is to develop risk management framework for small-scale shrimp farming based on AS/NZS ISO 31000:2009 standard. Refers to AS/NZS ISO 31000:2009 standard, there are seven steps for risk management process which are related to each other. These steps consist of 1) communication and consultation, 2) establishing the context, 3) risk identification, 4) risk analysis, 5) risk evaluation, 6) risk treatment, and 7) monitoring and review. The method used for risk management process will describe in the following steps:

Step 1. Communication and consultation

To improve understanding of stakeholders about risks and risk management strategies in shrimp farming is the main purpose of this step. To achieve the aims, the researcher communicates and consult with several stakeholders, including an in-depth interview with expertise in shrimp farming (Indonesian Aquaculture Society and Shrimp Club Indonesia) and focus group discussions with the shrimp farmers themselves.

Step 2. Establishing the context

This step is intended to set the boundaries or scope of risk assessment and risk management strategies in small-scale shrimp farming. In this step, in-depth interview and focus group discussion used to establish the context for (1) the scope of risk management, (2) the criteria in which the risk will be measured, and (3) the structure of risk identification, assessment, and process.

Step 3. Risks and risk management strategies identification

This step aims to identify all risks and management strategies along the shrimp production process. This study used Business Process Model (BMP) to identify all the possibility of risks and risk management strategies involved in the shrimp production. Zott, Amit & Massa (2011) defined a business process as a set of activities a cross the time and place, and clearly identified the inputs that designed to produce a specified output. They also mentioned that identifying the activities along the business process, and the sources risk that may arise in each activity is the key factor to maintaining the sustainability of the business. In general, business could define as a collection of activities or structure for action (Wirtz, 2011; Karduck, Sienou, Lamine & Pingaud, 2007). In a business process, activities are the fundamental of the process. Segatto, Padua, & Martinelli (2013) mention that each activity in the business process is performed with the idea to fulfill a particular transformation.

In this study, risk in small-scale shrimp farming defined as any probable event in each activity that able to cause the deviation from the expected enterprise's goals. By definition, it is possible to set the following structure of process risks for the small-scale shrimp farming in the research area.

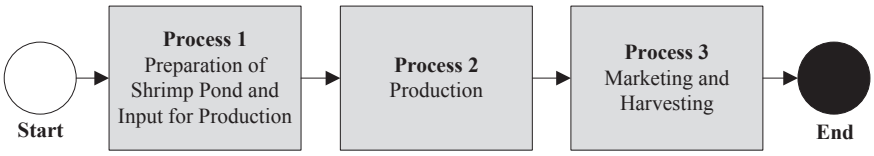

Figure 13. Structure of Business Process for Small-scale Shrimp Farming

The structure of process risk above represents each a sub process along the shrimp production. The sub process 1 "shrimp pond preparation" risk defined as the risks associated with activities before the production process begins including maintenance and preparation of shrimp pond. The risk in the sub process 2 (preparation of inputs for production) is a risk that associated with the preparation of all inputs for growing out of shrimp. Then, "production" risks in sub process 3 described as the risks which interrupted production cycles, such as finance and credit access, weather and environment, business environment, and change of government policies and regulations in shrimp farming. The sub process 4 "harvesting" risks are the risk that associated with loss of product quality and lack of knowledge of harvesting methods. Last, risk the sub process 5 "marketing" defined as the risk that related to the variability of shrimp size and price in the harvesting time.

Step 4. Risk analysis

The objective of this step is to measure the level of risks that already identified in the previous step. Based on AS/NZS ISO 31000:2009 standard, the level of risk is the results of consequence and likelihood of risk. In other words, the level of risk could be defined as the function of risk consequence and risk likelihood.

$$The\ Level\ of\ Risk = Consequence\ of\ Risk\ \times Likelihood\ of\ Risk$$

As already mentioned above, this study used a five-point Likert scale to measure risk consequence and risk likelihood. Thus, this study used a quantitative approach to analyze the level of risk. The first stage in quantitative approach is to measure discrete probability distribution function (PDF) for of risk consequence and risk likelihood. The Chi-square criteria used to select the best-fit probability distribution function. Second, cumulative probability density function (CDF) used to measure the risk consequence and risk likelihood. Once the consequence and likelihood of risk already determined for both PDF and CDF, the level of risk can be measured as the result of the two calculated probability (PDF and CDF) of risk consequence and risk likelihood.

Step 5. Risk evaluation

The goal of this step is to build a list of risk sources that give detail information, which risks will be accepted and which risks need treatment by shrimp farmers. shrimp farmers have two options for each risk source, treat the risk or accept the risk. The risk could be accepted for several reasons, such as the cost of managing the risk outweighs the benefit or the level of risk is low.

List of the levels of risk calculated in step 4 will be sorted in a descending order, ranked and prioritized in step 5. Refers to AS/NZS ISO 31000:2009 standard, this study used the ALAAR[1] criteria to determined which risks are going to accepted or which risks are going to be treated. Based on this the ALAAR criteria, the risk with rating 1 on a 5-point Likert scale, either the risk consequence or risk likelihood, will be accepted, no treatment needed, and no further consideration in risk management. Rating 1 on a 5-point Likert scale in the risk consequence and risk likelihood can be interpreted as minor impact and rare respectively

Step 6. Risk treatment

This step aims to determine treatment for the sources of risk that identified as "to be treated risk" in the previous step. In other words, this step linked between the risk management strategies and the risk that identified as "to be treated risk". In this study, each risk source matched with all risk management strategies for that risk. Then, risk management strategies are listed according to the degree of efficacy in reducing the risk. Moreover, the higher degree of efficacy of risk management strategies considers as a higher priority risk management strategies to be used.

Step 7. Monitoring and review

The last step is monitoring and review. The objective of this step is to review the effectiveness of risk management plan and confirm that the changing of circumstances do not alter the current risk treatment.

[1] ALAAR is abbreviation of "As Low As Acceptable Risk".

Chapter 4

The Perception of Risk and The Small-scale Shrimp Farmers' Attitudes Toward Risk

4.1 Introduction

Shrimp farming has a long history in Indonesia, having started in the mid-1960s at North Sulawesi and spread rapidly to other islands in a few years later (Poernomo, 2004). In the beginning, most of the shrimp farmers cultivated species of black tiger (*Penaeus monodon*). However, the production of black tiger stagnated at around 90,000 tons during 1997 to 2001 due to outbreaks of *White Spot Syndrome Virus* (FAO, 2003). To improve the Indonesian shrimp production, the Government introduced the Pacific white-leg shrimp (*Penaeus vannamei*) in the early 2000s. As a result, the total production of shrimp was increased gradually since the early 2000s, and at the same period, the production of black tiger sharply decreased due to the fact that the farmers shifted from the traditionally farmed black tiger shrimp to vannamei (Ablaza, 2003; Rimmer et al., 2013).

Recently, several studies revealed that the outbreaks of shrimp diseases had impacted the production of vannamei. During the period from 2008 to 2009, vannamei farming suffered from Infectious Myonecrosis Virus (IMNV) (Sustainable Fisheries Partnership, 2009). Afterward, Indonesian shrimp industry has encountered a serious problem caused by White Spot Syndrome Virus in the mid-2011 (Kilawati et al., 2015). Vannamei production dropped in 2014 after *White Feces Disease* suffered in East Java and Lampung.

Besides diseases problems, the environmental degradation, shrimp price fluctuation, and product rejections due to food safety and food security issues from importing countries were several problems that occurred in the last several years (Lebel, 2008; Oktaviani et al., 2009; Tongeran et al., 2010; Rimmer et al., 2013). Therefore, shrimp farming today is being increasingly exposed to risk and uncertainty in which those risks inherent to all activities in their business. The farmers have to work in an environment with numerous types of risk and uncertainty. Regarding risk management at the shrimp farm level, the farmers' attitude and perception of risks play a significant role. Their perception of risks may assist them to assess the probability and consequences of exposed risks. Flaten et al., (2005) revealed that the assessment of farmers' perception is crucial in observing the decision-making behavior of farmers at the time of confronting uncertainty situation. Moreover, Lucas & Pabuayon (2011)

mentioned that understanding the farmer's decision in risk and uncertainty conditions is necessary to observe how they perceive risk and behave in various kind of risks (Lucas & Pabuayon, 2011).

A better understanding of small-scale shrimp farmers' risk perceptions and the way they deal with the risk is essential to formulate a proper policy and to maintain the sustainability of Indonesian shrimp industry. As far as we know, there are no previous studies have focused on shrimp farmers' risk perception and their management strategies, particularly on the small-scale level. Therefore, this chapter aims to investigate the small-scale farmers' attitude and perception of risk related to shrimp farming and the factor affecting the farmers' risk perceptions. Rohrmann (2008) revealed that risk perception refers to farmer's judgment and their evaluations of hazards that they are or might be exposed, while risk attitude is defined as the farmer's intention to evaluate a risk environment in a favorable of the unfavorable way and to act accordingly. Specifically, this chapter has two objectives: 1) to explore the relationship between perception of risk and farmer's characteristics, and 2) to explore the relationship between perception of risk management strategies and farmer's characteristics. the findings of the chapter could potentially help the small-scale shrimp farmers and policy makers providing risk management services.

4.2 Methodology

To measure the potential impact of risk sources, we used the concept of level of risk based on the Australia and New Zealand risk management standard (AS/NZS ISO 31000:2009). In this study, the level of risk is defined as the results of consequence and the likelihood of risk (i.e., the level of risk = consequences * likelihood). Based on AS/NZS ISO 31000:2009, a consequence is the outcome of an event and influences the shrimp farm's objective. Moreover, the likelihood defines as a change that something might happen. Then, the score of the level of risk will be used for the analysis. In this study, five points Likert scale was used to measure the consequences and likelihood of risk sources. The range varied from 1 (minor impact or rare) to 5 (severe impact or almost certain occurrence). Regarding risk management strategies, the five-points Likert scale ranged from 1 (not effective at all) to 5 (very effective).

Two stages were designed to address the objectives. In the first stage, this study examines the perception of risk sources and risk management strategies in small-scale shrimp farming. First, through exploratory factor analysis, the sources of risk and risk management strategies

in shrimp farming were grouped into several risk factors and management strategies. Factor analysis is a multivariate technique used to assess the variability of variables of a data-set (risk and management strategies) through a linear combination of a smaller number of latent variables, called factors. The relationship of variables to the underlying factor is expressed by the value between 0.0 to 1.0 and called factor loading (see Table 4 in Page 45 and Table 5 in Page 50). Regarding the factor loading, a minimum cut-off of 0.4 is generally accepted in the literature. Thus, the source of risk and management strategies were sorted based on the score of factor loading. The higher value of factor loading in each variable (risk and management strategies) represent the particular factor or group.

The assumptions of factor analysis were verified using the Kaiser-Meyer-Olkin (KMO) test. The Kaiser-Meyer-Olkin test is a statistical test that indicates the proportion of variance in variables that might be caused by underlying factors. Moreover, The Bartlett test was employed to verify the homogeneity of variances across the data set. Bartlett's test for homogeneity of variances is a statistical test to measure the variances and test the variances are equal for all samples.

For the second stage, two regression models were developed to measure the impact of socioeconomic characteristics of shrimp farmers on their perception of risk and management strategies. The first model analyzed the impact of farmer characteristics on the perception of risk sources. Last, the second model measured the impact of characteristics and their perception of risk on the perception of risk management strategies. Specifically, the regression models could be represented in the form of equation 1 and 2 as shown below;

$$RF_i = f(Age, Exp, Educ\_level, Land\_hold, D\_offincome, D\_location) \quad (1)$$

$$RFM_j = f(Age, Exp, Educ\_level, Land\_hold, D\_offincome, D\_location, RF_i) \quad (2)$$

Where;

RF_i : Factor scores for source of risk (i=1, 2, 3, …, 8) from Factor Analysis

RMF_j : Factor scores for risk management strategy (j=1, 2, 3, …, 9) from Factor Analysis

Age : Age of shrimp farmers, measure in years.

Exp : Number of years in shrimp farming.

Educ_level : Formal education level of shrimp farmers, measured in years.

Land_hold : Number of land for shrimp cultivation that operated by a farmer

D_offincome : Dummy variable, 1 denotes the shrimp farmer who had off-farm income, and 0 denotes otherwise.

D_location : Dummy variable, 1 denotes the shrimp farmers in the north coast of East Java, and 0 denotes otherwise (south coast).

4.3 Results and Discussions

4.3.1 Socioeconomic characteristics of respondents

The socioeconomic characteristics of small-scale shrimp farmers in the south and north coast of East Java are compared with the average of total respondents in Table 1. The result revealed that the average age and experience in shrimp farming in the north are higher than the average of shrimp farmers in the south coast. However, the other characteristics of shrimp farmers in the north, such as education level, landholding, and off-farm income were lower than the farmers in the south.

Table 4. Socioeconomic Characteristics of Small-scale Shrimp Farmers

Characteristics	**South Coast of East Java** [a]	**North Coast of East Java**	**Total**
	(n=79)	(n=87)	(n=166)
Age (years)	*38.1	43.8	41.3
Experience (years)	***7.9	8.4	7.5
Education (years of schooling) [b]	*9.6	9.2	9.2
Land holding (ha)	**4.3	2.5	3.7
Off-farm income (%) [c]	**23.2	16.1	18.9

Note:
[a] Mean number mark with asterisks show that the mean scores of South Coast of East Java and North Coast of East Java are significantly different at * *0.1*; ***0.05*; ****0.001*.
[b] Measured as total years of formal education.
[c] Measured as a percent of shrimp farmer who had off-farm income from a total number of the respondent.

The survey revealed that the small-scale shrimp farmers in the north and south coast had similar average ages, being 38.1 and 43.8 years, respectively. In accordance with the Indonesian government standard, the farmers in both areas were included in productive age range (15 to 64 years old). The farmers in the north coast had more experience in shrimp farming than the farmers in the south. The farmers in northern East Java have a long history in shrimp farming with the species of *Penaeus monodon* (Black tiger shrimp), and some of them changed to cultivated *Penaeus vannamei* (Pacific white-leg shrimp) in the 2000s.

In terms of education level, there was no significant difference between the two survey areas in East Java. Small-scale shrimp farmers in the south coast have a larger farm (4.3

hectares), comparing to the farmers in the north (2.5 hectares). Of the 166 small-scale shrimp farmers, 31 farmers (18.9%) had off-farm income. Moreover, the percentage of shrimp farmers in the south (23.2%) who have off-farm income was slightly higher than in the north (16.1%).

4.3.2 The Sources of Risk in Small-scale Shrimp Farming in East Java.

In order to measure the possible impact of each risk, this study uses the concept of level of risk that is defined as the result of the consequences and likelihood. In total, 32 sources of risk were identified in small-scale shrimp farming at the study areas (see Table 2, column 1).

Among the risk sources, *shrimp price volatility* and *high mortality due to diseases* have been identified as the most significant sources of risk, being 21.90 and 21.84, respectively (see Table 2, column 2). The second level with risk scores ranging between 15.01 and 20.00 includes two sources of risk. As shown in Table 2, the second level consisted of *increasing formulated feed price* (18.73) and the *water pollution due to excessive formulated feed* (15.92) risks. Moreover, the next 19 risk sources, of which the level risk score ranges between 11.00 and 15.00 with corresponding ranks from 5 to 23, constituted the third level of risk (moderately significant). Finally, nine sources of risk with the level of risk score varying from 5.00 to 10.00 were classified into the fourth level, which is slightly significant. However, no source of risk was classified at an insignificant level.

Regarding the risk level in Table 2, the small-scale shrimp farmers in East Java focused on the several risk sources affecting financial aspect of their shrimp farms. These risk sources consisted of s*hrimp price volatility* and *increasing formulated feed price*. The condition reflected not only the shrimp farmers running their enterprise without any price insurance but also represented the very high level of uncertainty in shrimp farming. The underlying reason for this condition was an imbalance of supply-demand in the market due to the spread of shrimp diseases in the last several years. Several studies reported that various kind of shrimp diseases, such as Infectious Myonecrosis Virus (IMNV), White Spot Syndrome Virus (WSSV), and White Faces Diseases (WFD) led to significant losses for shrimp farmers (Kilawati et al., 2015). Hence, it is not surprising that *high mortality due to diseases* was the second-ranked source of risk.

Table 5. The Level of Risk and Varimax Rotated Factor Loading for The Sources of Risk

Sources of Risk	Risk Level	Rank	Factors[a]							
			12.74[b]	*12.68*	*11.79*	*11.41*	*7.09*	*6.24*	*6.23*	*4.94*
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Shrimp price volatility	21.9	1	-0.19	-0.11	-0.04	0.14	***0.7***	0.36	0.43	-0.01
High mortality due to diseases	21.84	2	0.29	0.06	***0.74***	-0.21	0.06	-0.04	0.25	-0.11
Increasing formulated feed price	18.73	3	0.12	***0.88***	-0.06	-0.01	-0.11	0.06	-0.03	0.12
Water pollution due to excessive formulated feed	15.92	4	0.16	0.09	***0.72***	0.01	0.4	0.08	0.2	0.28
Low quality of shrimp fries	14.96	5	***0.87***	0.11	0.26	0	0.03	0.03	-0.05	0.23
Not enough formulated feed supply	13.75	6	***0.84***	0.06	0.09	-0.13	0.43	0.13	-0.01	-0.37
Shrimp farmers doesn't have brackish water treatment facility	13.75	7	-0.03	0.17	0.08	***0.83***	0.13	0.18	0.05	-0.15
Not enough capital to operating shrimp farms	13.53	8	-0.01	***0.79***	0.09	0.17	0.09	0.16	-0.38	0.27
Low quality of formulated shrimp feed	13.29	9	***0.77***	0.33	0.02	0.31	-0.03	0.24	0.03	-0.11
Feeding management failure	13.19	10	-0.07	0.37	***0.67***	-0.01	0.43	0.23	0.1	0.23
Lack of knowledge to prevent shrimp diseases	12.67	11	0.18	0.07	0.25	***0.81***	0.1	0.12	0.02	-0.07
Polluted brackish water sources	12.6	12	0.03	-0.05	0.22	0.08	-0.19	***0.8***	-0.17	-0.08
Excessive stocking density	12.21	13	0.35	0.08	***0.65***	0.07	-0.22	0.09	0.25	0.18
Change government policy and regulation	12.17	14	0	-0.05	0.26	-0.04	0.28	-0.06	***0.67***	0.09
Lack of information about shrimp fries origin	11.49	15	-0.15	0.21	0.03	***0.8***	0.1	-0.01	-0.33	0.23
Lack of knowledge of pond preparation	11.31	16	0.2	0.26	0.18	***0.6***	-0.13	0.52	0.09	-0.08
Inappropriate pond location	11.25	17	***0.74***	-0.09	0.28	0.27	0.07	-0.15	0.19	0.35
Do not conduct treatment before stocking shrimp fries	11.04	18	***0.69***	0.44	0.16	0.06	-0.21	0.02	0.01	0.12
Lack collateral for loan	10.87	19	0.09	***0.74***	0.11	0.17	-0.01	0.1	-0.06	-0.08
Lack of labor knowledge	10.73	20	0.23	0.12	-0.03	***0.62***	0.26	0.35	0.07	0.04
Shrimp size variability	10.56	21	-0.14	0.4	-0.26	-0.26	***0.61***	0.17	0.2	0.03
Inappropriate pond design	10.53	22	***0.6***	-0.07	0.07	0.13	0.23	-0.07	0.15	-0.14
Brackish water quality	10.23	23	-0.07	-0.4	***0.64***	-0.31	0.09	-0.15	-0.03	-0.17
Inappropriate harvesting method	9.69	24	0.09	0.02	-0.35	0.3	***0.5***	0	0.08	-0.1
Harvesting without grading	9.56	25	0.33	0.21	-0.16	0.46	***0.41***	-0.04	-0.11	-0.17
Asymmetric information between buyer and farmers	9.36	26	0.06	0.13	-0.15	-0.25	0	0.25	0.14	***0.53***
Inappropriate shrimp fries size	9.12	27	***0.61***	0.01	0.15	-0.1	0.18	0	0.07	0.22
High interest rate for loan	8.95	28	0.12	***0.74***	0.2	0.06	0.13	0.05	-0.06	-0.21
Not enough labor supply	8.37	29	***0.47***	0.19	0.24	0.15	-0.07	-0.05	0.03	-0.08
Flood	7.79	30	-0.05	0.28	0.24	-0.07	-0.29	**0.64**	0.06	0.27
High wages of hired labor	7.76	31	0.15	***0.7***	0.05	0.4	0.05	0.11	-0.13	0.11
Low level of awareness from community	7.34	32	0.11	-0.02	-0.08	0.53	-0.1	0.24	***0.62***	-0.12

Note:

[a] Factors 1 to 8 are; (1) Input and pond preparation; (2) Finance and credit access; (3) Production; (4) Personal; (5) Harvesting and marketing; (6) Weather and environment; (7) Policy and institutional; (8) Business environment.

[b] This number (in percentage) represents the total variance explained based on the results of Exploratory Factor Analysis.

Furthermore, the total 32 risk sources were reduced using varimax rotation factor analysis to gain a deeper understanding of small-scale shrimp farmers' perception regarding sources of risk. Before conducting the exploratory factor analysis, the assumptions of factor analysis were verified using the Kaiser-Meyer-Olkin (KMO) test and Bartlett test. The result revealed that the KMO is 0.644, and Bartlett test is statistically significant at the 0.01 level. Referring to Hair et al. (2006), these results indicated that the data were satisfactory for factor analysis. Based on this justification, 32 sources of risk were reduced to eight factors (see Table 2, column 4 to 11).

The factors 1 to 8 could be best denoted as (1) Input and pond preparation, (2) Finance and credit access (3) Production, (4) Personal, (5) Harvesting and marketing, (6) Weather and environment, (7) Policy and institutional, and (8) Business environment. These factors explained 73.1% of the total variance that was observed. The highest loading items, total variance, and extracted factors are shown in the fourth, fifth and sixth columns in Table 1, respectively. Moreover, after checking the non-significant level of loading items, no risk sources were removed.

For the factor extracted, the result revealed that factor 1, namely 'input and pond preparation,' explained 12.74% of the observed variation. Several risk sources, such as *low quality of shrimp fries*, *not enough formulated feed supply*, and *low quality of formulated shrimp feed*, were high loading factors among the risk sources in this group. The results showed that the problems of input and pond preparation triggered the shrimp diseases in the study areas. In line with this, a recent survey by Ahsan (2011) about risk management strategies in shrimp industry in Bangladesh indicated that shrimp diseases were identified as the top-rated source of risk and the greatest threat to coastal shrimp farming.

Factor 2, 'finance and credit access,' had a relatively high loading of *increasing formulated feed price* and *not enough capital to operating shrimp farms*. This finding showed that formulated feed price could have a major impact on shrimp farmers' income. A recent study by Hung and Quy (2013) also noted that formulated feed cost comprised 66 to 68% of the total production cost in intensive shrimp farming system.

High mortality due to diseases, *water pollution due to excessive formulated feed*, and *feeding management failure* were loaded strongly on factor 3 of the 'production' risks. This factor explained 11.79% of the observed variation. Production risk is one of the essential problems in aquaculture and agriculture activities. Several kinds of literature indicated similar results of the high loading of diseases in production risk (Meuwissen et al., 2001; Flaten et al.,

2005; Gebreegziabher and Tadesse, 2014). The high loading of shrimp diseases in 'production' risk is likely to reflect small-scale shrimp farmers' concern on shrimp mortality. Moreover, Bush et al. (2010) stated that shrimp farming is complicated due to a close relationship between social and ecological systems. Lack of knowledge in preventing diseases was making their business riskier.

The small-scale shrimp farmers are also affected by risks that were associated with 'personal' risk factor. This factor explained 11.41% of the observed variation. *Lack of knowledge to prevent shrimp diseases*, *lack of information about shrimp fries' origin*, and *lack of knowledge of pond preparation* were the highest loading factor in personal risk. The small-scale farmers tended to use their experience in managing their shrimp ponds. Hence, the personal risk associated with lack of knowledge in shrimp farms management was the real constraint in maintaining their livelihood and sustainability of the shrimp industry in East Java, Indonesia.

Majority, 'harvesting and marketing' risk in factor 5 was affected by *shrimp price volatility* and *shrimp size variability*. Harvesting and marketing risk sources were associated with an oversupply of shrimp in the market and inappropriate harvesting method. Several studies also noted that marketing risk was considered as one of the most significant risk sources in aquaculture and agriculture (Bergfjord, 2005; Ahsan and Roth, 2010; Ahsan, 2011).

The sixth factor, 'weather and environment' risk include *polluted brackish water source* and *flood*. This factor explained 6.24% of the observed variation. Furthermore, *change government policy* and *low level of awareness from the community about environmental protection* loaded strongly on factor 7 of the 'policy and institutional' risk. Last, 'business environment' risk on factor 8, which explained 4.94% of the observed variation, is associated with *asymmetric information between buyer and farmers*. The same study finding had supported the study of Ahsan (2011) about shrimp farmers' motivation, risk perception and risk management strategies in Bangladesh which stated that shrimp production involves a complex supply chain. Thus, the exploitation by the middle man in shrimp farming was considered a major risk source.

4.3.3 The Risk Management Strategies in Small-scale Shrimp Farming

In this study, 35 risk management strategies were rated on five points Likert scale by shrimp farmers in regard to their efficacy of mitigating each source of risk. The average score of strategies and their ranks presented in the second and third columns of Table 3. The result

revealed that 16 risk management strategies were classified as very effective in coping with the risk in shrimp farming with the average score varying between 4.1 to 5.0. *Strict management of water quality*, *strict feeding management*, *applying better management practices*, *preventing shrimp diseases by regular checking*, and *reducing brackish water pond size* were the top five strategies in this category. The second group included ten strategies. This group had an average score that ranged between 3.1 and 4.0 with corresponding ranks from 17 to 26. The next six risk management strategies, such as *change consumption pattern*, *use of large-sized shrimp fries*, *informal marketing contract with the wholesaler*, *applying new technology*, *using family labor*, and *dissaving*, were classified as average effective. Last, only three strategies were categorized as little effective (ranges between 1.1 and 2.0), which included *sharing machinery and paddle wheel*, *follow the government policy and regulation*, and *off-farm work*.

Although *shrimp price volatility* was perceived as the most damaging source of risk (see Table 1 in column 3), the rank of risk management strategy to cope with this risk, such as *production contract*, was not perceived as the most effective strategy (see Table 3, column 3). The study found that the small-scale shrimp farmers preferred to rely on the daily activities to cope with the risk and maximize their income. Several strategies, such as *strictly managed water quality*, *strict feeding management*, and *applying better management practices*, were more effective to cope with the risk in their shrimp farms.

Moreover, the factor analysis with varimax rotation was applied to reduce many risk management strategies. Thus, nine factors loadings were obtained for risk management strategies in study areas. These nine factors explained 83.61% of the total cumulative variance. The last three columns in Table 3 presented the loading items, total variance, and factors extracted. The factors 1 to 9 in Table 2 were identified as: (1) Diseases prevention, (2) Education and technology improvement; (3) Input of production; (4) Farm management; (5) Government support; (6) Risk sharing and insurance; (7) Financial; (8) Household adjustment; and (9) Alternative income sources.

Factor 1, which was named 'diseases prevention,' explained 17.33% of the observed variation. *Strictly managed water quality*, *strict feeding management*, and *partial harvest* were the top three strategies in this group with the loading scores of 0.92, 0.85, and 0.85, respectively. These strategies remained the most effective risk management strategies to prevent shrimp diseases and minimize income losses. This study finding was also supported by Kilawati et al. (2015) which stated that shrimp diseases were the biggest problem for Indonesian shrimp farming during the last several years.

Factor 2 represented 'education and technology improvement' by *attending a workshop in shrimp farming* and *applying new technology in shrimp production*. These strategies were perceived as an effective strategy in small-scale shrimp farming in East Java to manage their risk. Previous studies also indicated that the farmers tended to adopt new technology to enhance production (Bergfjord, 2009; Ahsan and Roth, 2010; Ahsan, 2011).

Factor 3 identified as 'input of production.' This factor includes high loading of risk management strategies that were associated with management of input in shrimp farms, such as *only buy shrimp fries from the reliable place* and *buying formulated feed from reliable brands*. Factor 4 (farm management) comprised the strategies concerning the internal management of shrimp farms. High loadings of this factor were: *applying better management practices*, *hire a technical assistant*, *enforcing the shrimp pond dike*, and *follow the government policy and regulation*.

Two risk management strategies, which are *request government support for technical assistance* and *request social assistance after the natural disaster*, were grouped into factor 5 (government support). Factor 6, 'risk sharing and insurance,' includes high loading risk management strategies that were associated with the efforts of shrimp farmers to share with third parties. Seven strategies are listed in this factor. These strategies include *production contract*, *sharecropping*, *contract for farm inputs*, *informal marketing contract*, *vertical integration,* and *marketing contract with the wholesaler*. Ahsan and Roth (2010) obtained similar results regarding risk management for mussel aquaculture in Denmark. They found that cooperative marketing was one of the important strategies to mitigate the impact of risk on their farms.

Three strategies were grouped into factor 7, which is identified as 'financial' strategies. This group had high loadings for the items of *use informal loan*, *make credit arrangement before production cycle*, and *dissaving*. Factor 8 was named 'household adjustment' due to the dominant strategies for this factor which are *change consumption pattern* and *use family labor*, which explained 6% of the observed variation. Finally, two risk management strategies, such as *farm diversification* and *off-farm work*, were classified into factor 9 (alternative income sources). In Greece, Theodorou, (2010) found a similar result. Greek mussel farmers preferred the certainty of income from other sources as a risk management strategy.

Table 6. The Varimax Rotated Factor Loading for The Risk Management Strategies

Risk Management Strategies	Mean	Rank	Factors[a]								
			17.32[b]	*16.01*	*9.53*	*8.42*	*7.85*	*6.29*	*6.21*	*6.01*	*5.96*
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Strictly manage water quality	5.00	1	***0.92***	0.08	-0.03	0.03	-0.03	0.04	-0.03	0.04	-0.11
Strictly feeding management	4.99	2	***0.86***	-0.08	-0.16	-0.16	0.05	-0.09	-0.13	0.22	0.04
Applying better management practices	4.91	3	0.13	0.03	-0.07	***0.91***	0.08	-0.01	-0.12	0.07	0.08
Prevent shrimp diseases by regular checking	4.79	4	***0.74***	0.1	-0.04	0.06	-0.19	-0.05	0.2	0.34	0.07
Reduce brackish water pond size	4.78	5	***0.85***	0.09	-0.02	0.15	0.07	-0.04	0.1	-0.29	-0.03
Production contract	4.77	6	0.03	0.14	0.03	-0.1	0.1	***0.89***	-0.11	-0.15	-0.11
Contract for shrimp farms inputs	4.69	7	0.3	-0.06	-0.04	0.39	-0.24	***0.65***	0.29	-0.05	0.14
Partial Harvest	4.67	8	***0.85***	0.17	0.08	-0.03	0.52	0.17	0.05	-0.15	0.05
Attending workshop in shrimp farming	4.55	9	0.06	***0.92***	0	0.02	0.02	-0.1	-0.08	0.03	-0.07
Sharecropping	4.52	10	0.02	0.02	0.11	-0.06	0.01	***0.88***	0.19	0.17	0.01
Only buy shrimp fries that have SPF certificate	4.41	11	-0.07	0.07	***0.77***	-0.09	-0.19	0.06	0.09	0.07	0.01
Reduce stocking density	4.22	12	***0.77***	-0.01	0.24	0.38	-0.02	-0.04	-0.12	-0.03	-0.11
Vertical integration	4.21	13	0.31	-0.35	-0.13	0.01	0.21	***0.51***	0.17	0.16	0.19
Only buy shrimp fries from reliable place	4.14	14	-0.01	0.26	***0.85***	0	-0.04	0.24	0.06	-0.03	0.08
Request government support for technical assistant	4.14	15	-0.1	0.2	-0.1	0.15	***0.78***	0.06	-0.13	-0.31	-0.14
Reallocated shrimp pond to designed area	4.11	16	***0.51***	-0.35	0.48	0.16	0.17	0.01	-0.23	-0.22	0.08
Marketing contract with processor	3.80	17	0.13	0.4	-0.51	0.16	0.17	***0.53***	-0.19	0.26	0.12
Use informal loan	3.72	18	-0.21	-0.05	0.5	-0.12	0.02	0.08	***0.65***	-0.09	0.15
Develop brackish water treatment	3.54	19	***0.46***	-0.16	-0.16	-0.38	0.3	0.28	-0.03	0.13	-0.22
Buying formulated feed from reliable brands	3.50	20	-0.27	-0.05	***0.67***	-0.08	-0.06	0.23	0.03	0.19	0.29
Make credit arrangement before production cycle	3.45	21	-0.07	-0.02	0.1	-0.17	-0.07	-0.06	***0.86***	-0.11	0.07
Hire technical assistant	3.44	22	0.12	-0.05	-0.04	***0.86***	0.03	-0.3	-0.04	0.27	0.17
Enforcing the shrimp pond dyke	3.43	23	0.28	0.15	-0.17	***0.57***	0.26	-0.21	0.11	0.11	0.39
Request social assistance after natural disaster	3.29	25	-0.1	0.38	0.08	-0.11	***0.62***	-0.14	-0.31	-0.29	-0.18
Farm diversification	3.29	24	0.11	-0.06	-0.18	0.02	0.07	-0.26	-0.06	0.09	***0.82***
Buying shrimp fries from public hatchery	3.02	26	-0.33	-0.17	***0.64***	-0.02	0.09	-0.4	0.13	0.27	0.15
Use large size shrimp fries	2.76	28	0.19	0.12	***0.61***	0.33	0.14	-0.35	0.2	0.29	0.18
Change consumption pattern	2.76	27	-0.08	0.06	0.13	-0.15	0.26	0	0.05	***0.53***	0.14
Informal marketing contract with wholesaler	2.52	29	0.14	-0.12	0.48	0.24	0.08	***0.53***	-0.1	-0.12	0.26
Apply new technology in shrimp production	2.38	30	-0.2	***0.81***	0.2	0.05	0.12	-0.07	-0.17	-0.05	0.27
Use family labor	2.11	31	0.18	0.35	-0.05	0.28	0.24	-0.27	-0.29	***0.54***	0.06
Dissaving	2.09	32	-0.15	-0.3	-0.11	0.14	-0.43	-0.02	***0.56***	-0.43	-0.12
Sharing machinery and paddle wheels	1.96	33	-0.24	0.04	0.18	0.35	0.05	***0.47***	0.17	0.3	0.36
Follow the government policy and regulation	1.22	34	0.42	0.1	0.36	***0.47***	0.3	0.32	-0.1	0.15	-0.24
Off-farm work	1.20	35	-0.2	-0.24	0.03	-0.08	0.38	0.03	-0.07	0.17	***0.64***

Note:

[a] Factors 1 to 9 are; (1) Diseases prevention; (2) Education and technology improvement; (3) Input of production; (4) Farm management; (5) Government support; (6) Risk sharing and insurance; (7) Financial; (8) Household adjustment; (9) Alternative income sources.

[b] This number (in percentage) represents the total variance explained based on the results of Exploratory Factor Analysis.

4.3.4 Relationship between shrimp farmer's characteristics and perception of risk

Based on Table 4, all socioeconomic variables had at least one significant relationship with the sources of risk. The regression results showed that the shrimp farmer characteristics, such as; experience in shrimp farming, education level, and location had a significant impact on their perception of *input and pond preparation* risks. Moreover, the result revealed that the small-scale shrimp farmers in the north coast of East Java were more concerned about input and pond preparation risks. These results may be explained by the fact that the shrimp ponds on the north coast are located close to an industrial area thus affecting the brackish water quality and environmental conditions around the shrimp pond.

Table 7. Results of Multiple Regression for Risk Sources

Independent variables	Sources of Risk (Dependent variables)							
	Input and Pond Preparation	Finance and Credit Access	Production	Personal	Harvesting and Marketing	Weather and Environment	Policy and Institutional	Business Environment
Age	0.017	0.005	*0.018	-0.002	*0.003	0.015	**0.011	-0.001
Experience	*0.002	0.001	*-0.001	-0.003	*0.001	-0.001	0.000	0.002
Education level [a]	**0.000	-0.002	-0.001	***0.001	0.000	0.002	-0.001	0.000
Land holding	-0.006	-0.011	0.001	-0.002	-0.008	0.005	0.010	***0.002
Off-farm income [b]	0.015	*-0.008	-0.006	0.007	-0.005	0.014	-0.002	*-0.017
Dummy location [c]	***0.006	0.009	***0.002	0.000	0.011	*0.019	-0.005	0.012
Adj R^2	*0.312*	*0.237*	*0.482*	*0.252*	*0.256*	*0.202*	*0.147*	*0.261*

Note:
Variables significant at * *0.1*; ***0.05*; ****0.001*.
[a] Measured as total years formal education of shrimp farmers.
[b] Measured as a dummy variable where 1 denotes the shrimp farmer who had off-farm income, and 0 denotes otherwise.
[c] Measured as a dummy variable where 1 denotes the north coast of East Java, and 0 denotes otherwise (the south coast).

Among exploratory variables, only off-farm income variable has a significant impact on their perception of *finance and credit access* risks with a negative sign. The sign implies that the shrimp farmers who do not have off-farm income tend to be more concerned about *finance and credit access* risks. Perceptions about *production* risks are significantly impacted by the age of small-scale shrimp farmers, experience in shrimp farming and location of shrimp pond. The results showed that the older and the less experienced farmers are more concerned about *production* risks compare to the younger and the farmers who have more experience in shrimp farming. Lack of knowledge and experience of applying better aquaculture practices to prevent *production* risks, such as high mortality due to diseases, water pollution, and feeding management failure, makes their business riskier.

In the case of *personal* risks, only education level showed significant impact on the perception of *personal* risks. This might be explained by the fact that shrimp farmers with higher educational attainment would make easier to adopt new technology in shrimp

production. Only such variables as the age of farmers and experience in shrimp farming have a significant impact on the perception of *harvesting and marketing* risks. It means that the older and more experienced of shrimp farmer tend to be more concerned about harvesting and marketing risks. This is probably because most of the small-scale shrimp farmers in East Java face with the same market conditions. In general, the price of shrimp determined by middleman or processing factories as price makers, while the farmers only act as the price taker. Moreover, the shrimp farmers in north coast perceived the *weather and environment* risks, such as flood and polluted brackish water sources, as the most substantial compared to the farmers in the south. This result was indicated by the positive sign in the coefficient regression of the *weather and environment* risk factor in Table 4. The shrimp farmers' perception of *policy and institutional* risks are impacted by the age of farmer and educational level. The older farmers are more worried about *policy and institutional* risks, such as changes government regulation in shrimp farming, than younger farmers.

The regression results also showed that the farmers with land holding above the average level are more concerned about the *business environment* risks. That might be explained by the fact that the impact of *business environment* risk, such as asymmetric information between buyer and shrimp farmers, will hurt the farmers with large shrimp pond areas more seriously than farmers with small areas. Last, the shrimp farmers who do not have off-farm income revealed give more attention to *business environment* risk than those shrimp farmers with off-farm income activities

4.3.5 Relationship between shrimp farmers' characteristics, the perception of risk, and risk management strategies

The relationship between small-scale shrimp farmers' characteristics, the perception of risk, and risk management strategies were determined using multivariate regression. The result of regression coefficients and the goodness-of-fit ($Adj\ R^2$) for each exploratory variable are presented in Table 3. The results revealed that all the models are statistically significant, with the $Adj\ R^2$ varying from 0.287 to 0.759.

Two socioeconomic variables, off-farm income and dummy location, were revealed to have a statistically significant impact on the perception of *diseases prevention* strategies. The age of small-scale shrimp farmers has a substantial influence on the perception of the efficacy of *education and technology improvement* strategies. Also, the regression coefficient (-0.023)

revealed that the younger shrimp farmers are more concerned with the *education and technology improvement* strategies as risk management strategy for their shrimp farms.

Moreover, only land holding variable does not have a significant impact on any risk management strategies. The shrimp farmers in the northern coast of East Java rated the efficacy of *farm management* strategies as significantly important compared to the shrimp farmers in the south. The farmers who do not have off-farm income tend to be more concerned with these *household adjustment* strategies compare with the farmers who have off-farm income from other activities. Next, the shrimp farmers that more experienced rated the efficacy of *alternative income sources* strategies as significantly important compare to less experienced farmers.

The sources of risk were the last independent variables. As shown in the lower part of Table 5, several sources of risk were found to be strongly associated with multiple risk management strategies. Input and pond preparation risks, such as low quality of shrimp fries, inappropriate pond location, and low quality of formulated feed, are connected with the perception of two risk management strategies, which are *diseases prevention* strategies and the *input of production* strategies. Moreover, due to shrimp farming has been dramatically affected by many pathogenic diseases during couple years ago. Thus, *diseases prevention* strategies, such as strict management of water quality and feeding management, are considered the most efficient way to prevent income loss due to the spread of shrimp disease.

Finance and credit access risks were related to *risk sharing and insurance* strategies. However, the finance and credit access risks appear not significantly impact on the farmer's perception of financial strategies. Due to lack of collateral and access to credit, the shrimp farmers tend to use *risk sharing and insurance* strategies to cope with finance and credit access risks. These strategies include production contract, sharecropping, contract for shrimp farms inputs, and informal marketing contract with the wholesaler.

The result revealed that production risks strongly impact the farmers' perception of *educational and technology improvement* and *farm management* strategies. These strategies include attending the workshop and applying recent technology in shrimp cultivation. Those strategies reflect that knowledge plays a significant role in successful shrimp farming. Moreover, personal risks, such as lack of farmer's knowledge about shrimp fries' origin and diseases, were found to be highly connected with the perception of *farm management* strategies.

Table 8. Results of Multiple Regression for Risk Management Strategies

Independent variables	Risk Management Strategies (Dependent variables)								
	Diseases prevention	**Educational and technology improvement**	**Input of production**	**Farm management**	**Government support**	**Risk sharing and insurance**	**Financial**	**Household adjustment**	**Alternative income sources**
Socioeconomic Characteristics									
Age	-0.018	***-0.023	0.011	-0.012	0.007	0.009	0.008	-0.002	-0.008
Experience	-0.009	0.004	0.001	-0.002	0.002	0.000	0.000	0.000	*0.001
Education level	0.004	0.001	-0.002	**0.003	-0.001	-0.001	-0.001	0.000	0.001
Land holding	-0.003	0.007	0.001	0.006	-0.003	-0.009	0.007	0.009	0.007
Off-farm income	*0.069	-0.023	0.012	0.011	-0.002	-0.018	0.006	**-0.002	0.007
Dummy location	**0.039	0.008	-0.011	***0.016	0.002	0.023	-0.007	-0.006	-0.011
Risk Factors									
Input and pond preparation risks	***0.399	0.223	**0.555	0.127	0.057	-0.374	-0.139	-0.215	0.099
Finance and credit access risks	-0.069	0.211	-0.150	0.059	0.177	***0.472	0.111	-0.118	-0.053
Production risks	0.383	**0.137	0.189	*0.030	0.052	-0.413	0.426	-0.151	-0.097
Personal risks	-0.201	0.174	-0.133	**0.049	-0.044	-0.182	0.090	-0.009	-0.056
Harvesting and marketing risks	0.460	0.163	0.143	-0.135	0.290	**0.068	**0.017	0.330	0.043
Weather and environment risks	0.101	-0.158	0.376	***0.288	0.133	0.026	0.029	0.026	-0.247
Policy and institutional risks	-0.555	0.164	0.307	**0.215	***0.003	-0.577	0.235	-0.224	-0.048
Business environment risks	0.788	-0.361	-0.233	0.211	0.137	-0.566	0.030	**0.166	0.049
Adj R^2	*.727*	*.356*	*.612*	*.759*	*.287*	*.494*	*.346*	*.394*	*0.269*

Note:
Variables significant at **0.1*; ***0.05*; ****0.001*.
[a] Measured as total years of formal education.
[b] Measured as a dummy variable where 1 denotes the shrimp farmer who had off farm income, and 0 denotes otherwise.
[c] Measured as a dummy variable where 1 denotes the north coast of East Java, and 0 denotes otherwise (the south coast).

Based on Table 5, two management strategies, *risk sharing and insurance* and *financial*, have been influenced by the farmers' perception of harvesting and marketing risks, such as shrimp price volatility. It may be related to the fact that oversupply of shrimp on peak season push the shrimp price goes down. Previous studies also found that marketing risks were considered as one of the most significant risks sources (Bergfjord, 2005; Ahsan and Roth, 2010; Ahsan, 2011). Also, weather and environment risks, such as flood and polluted brackish water sources, are significantly influenced the farmers' perception of the efficacy of *farm management* strategies.

Farm management strategies, such as applying better management practices and follow the government regulation, are essential to response changes of policy in shrimp farming. Therefore, the result found that policy and institutional risks were significantly impacted on shrimp farmers' perception of *farm management* and *government support* strategies. Last, business environment risks shown to be significantly associated with the shrimp farmers' perception of *household adjustment* strategies. The business environment risks, such as

asymmetric information between buyer and shrimp farmers, represent that degree of uncertainty in shrimp farming are higher than others aquaculture activities. The efficacy of *household adjustment* strategies, including use family labor and changed household consumption patterns strategy, rated as a very effective strategy to reduce losses due to business risks.

The results found that the relationships between the perceptions of risks significantly impact on shrimp farmers' perception of risk management strategies. However, these relationships are multidimensional and represent characteristics of farm and shrimp farmers. Also, the result found a mismatch between shrimp farmers' perception and the risk management strategies implemented to reduce the impact of finance and credit access risks. The result revealed that *financial* strategies, such as use informal loan, make credit arrangement with third parties to ensure sufficient capital during production cycle and dissaving strategies, are not perceived as essential for reducing the impact of financial and credit access risks. Eventually, there is no particular risk management strategy for the specific type of risk source. The results showed that the shrimp farmers develop a range of strategies and conversely, a risk management strategy can apply to mitigate different types of risk source.

4.4 Conclusions

This study aimed to provide empirical insights into small-scale shrimp farmer's perceptions of risk and risk management strategies, and the relationship of those perceptions with farmer's socioeconomic characteristics. The result revealed that the older shrimp farmers are more concerned about production risks, harvesting and marketing risks, and policy and institutional risks than the younger shrimp farmers. The farmers with less experience tend to be perceived the production risks as important. Input and pond preparation and personal risks, such as lack of knowledge to prevent shrimp diseases and pond preparation significantly impact the farmers' perception. Statistically, the farmers' perception of input and pond preparation and personal risks, such as lack of knowledge to prevent shrimp diseases and pond preparation, was significantly influenced by their education level.

The regression coefficient showed that the farmers with land holding above average level consider business environment risks as potential threats that can alter their farm earnings. Based on the source of income, the result revealed that those farmers who do not have any off-farm income perceived that the finance and credit access and business environment risks are the most likely source of risk in their shrimp farm. Moreover, we found that the shrimp farmers

in north coast perceived several risk factors, such as; input and pond preparation risks, production risks, and weather and environment risks, as more important than the shrimp farmers in the south.

The result revealed that shrimp farmers' characteristics and their perception of risks significantly influence the risk management behavior. The findings of regression indicate that the small-scale shrimp farmers' perceptions were influenced by various factors such as the age of farmers, experience, formal education level, availability of off-farm income, and location of a shrimp farm. Due to the environmental conditions, the shrimp farmers in north coast rated the efficacy of diseases prevention and farm management strategies as significantly important compared to farmers in the south. Regarding the relationship of the perceptions of risk source on management strategies, several risk factors were found associated with multiple risk management strategies. However, we found a discrepancy between risk perception and management strategies. The result showed that financial strategies were not perceived as the necessary strategies to reduce the impact of finance and credit access risks in shrimp farming. Last, the small-scale shrimp farmers tend to use risk sharing and insurance strategies, such as production contract, sharecropping, and contract for farm inputs as preventive actions to mitigate impact from financial and credit access risks.

The government policies to improve the shrimp farmers' ability to deal with the risks should be considered. Based on our results, enhancing the farmer education level can help them to manage risk in pond preparation and personal risk. Encourage the shrimp farmers to have off-farm income can improve their ability to deal with several risks from finance and credit access. Thus, this study suggests that the policy design of risk management at regional or national level ought to be guided by a better understanding of the perceptions and risk attitudes of farmers to be able to achieve the effectiveness and efficiency. Moreover, the findings suggest a greater role for government in developing risks management framework and in providing the shrimp farmers with accurate information on the source of risks and proper risk management strategies. If properly informed, the shrimp farmers would be able to adjust and be willing to take risks to increase their productivity and profitability. For the future study, risk perception can be integrated into business process model to identify the sources of risk in each step of the shrimp production process.

Chapter 5

Developing Risk Management Framework for Small-scale Shrimp Farming

5.1 Introduction

This chapter aims to develop risk management framework for small-scale shrimp farming in Indonesia. The following sub-chapter will describe seven steps of risk management process based on AS/NZS ISO 31000:2009 risk management standard. These steps include (1) Communication and consultation, (2) Establishing the context, (3) Risk identification, (4) Risk analysis, (5) Risk evaluation, (6) Risk treatment, and (7) Monitoring and review.

Business Process Model (BPM) method has been used specifically in the third step to identify the sources of risk involved in small-scale shrimp farming. To determine the risk in detail, the shrimp farming processes were break into three main processes by BPM method; the process starts with the preparation of shrimp pond and inputs of production. The second process is a production of shrimp. In the second process, there are six sub-processes that the shrimp farmers have to take care of simultaneously throughout the whole crop duration. Then, the last process is harvesting and marketing.

To develop the risk management framework for Indonesian small-scale shrimp farming, the data were collected from small-scale shrimp farmers in East Java Province, through face to face and in-depth interview. A sample has been selected randomly from south and north coast of East Java. After data processing, 166 observations were usable for analysis.

5.2 Risk Management Framework for Small-scale Shrimp Farming

The Figure 1 showing the general risk management processes of small-scale shrimp farming based on the AS/NZS ISO 31000:2009 standard. The process begins with the communicate and consult both internal and external stakeholders in shrimp farming. Establish the context is the second process. The criteria in which risk will be evaluated should be established in the second process. The third process, identify the risk, is the

essential compared to other processes. Activities in this process include identifying the risks, the areas of impact, and the potential consequences of risk. Once the risk in shrimp farming has been identified, the next process is analyzing the risk. The fifth process is evaluating the risk. In this process, the shrimp farmers should decide whether the risk is acceptable or unacceptable. Once the risk assessment in the previous process is complete, the next process treats the risk. This process aims to develop the activities and implements treatment to control the risk in shrimp farming. The last process is monitoring and review. This process is to monitor, review and report the sources of risk. Given the dynamic nature of shrimp farming business, it is essential to be alert emerging risks as well as monitoring the known risk in small-scale shrimp farming. All activities are done in each step will describe in the following section.

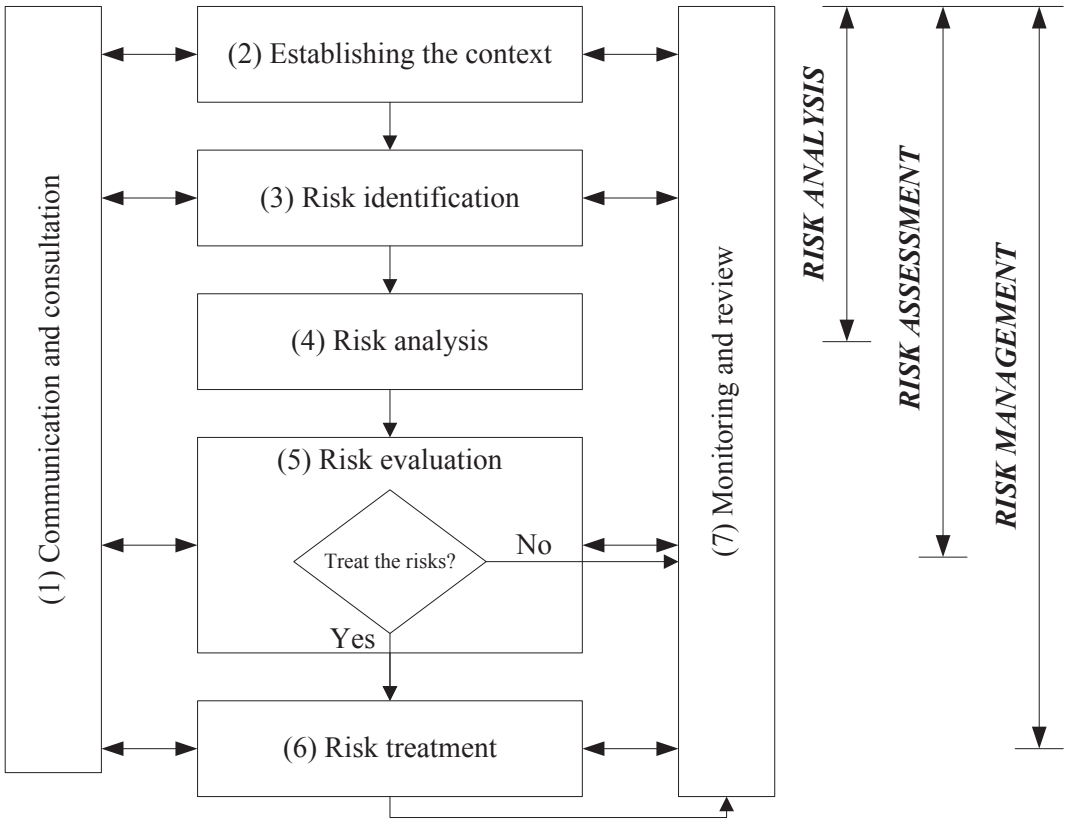

Figure 14. Risk Management Process (AS/NZS ISO 31000:2009)

5.2.1 Communication and Consultation

To improve understanding of stakeholders about risks and risk management strategies in shrimp farming is the main purpose of this step. In the early stage of this study, communicates and consults were done through the in-depth interview and focus group discussion. The in-depth interviews were mainly conducted with the expertise in shrimp farming, consist of shrimp farmers associations and extension officer. Then, focus group discussions were organized with the small-scale shrimp farmers in study areas.

5.2.2 Establishing the Context

This step is intended to set the boundaries or scope of risk assessment and risk management strategies in small-scale shrimp farming. In this step, in-depth interview and focus group discussion used to establish the context for:

a) The shrimp farm's objective.

b) The criteria in which the risk will be measured.

c) The structure of risk identification, assessment, and process.

Based on the group discussions, the context of the risk management framework was established as follows:

a) The objective of shrimp farms was to maximize profit.

b) The economic criteria were used to measure the consequence of risks.

c) The level of risk was used to assess the risks. The higher degree of efficacy of risk management strategies considers as a higher priority risk management strategy to be used.

5.2.3 Risk Identification

This step aims to identify all risks and management strategies along the shrimp production process. This study used Business Process Model (BMP) to identify all the possibility of risks and risk management strategies involved in the shrimp production. In general, business could define as a collection of activities or structure for action (Zott, Amit & Massa, 2011; Wirtz, 2011; Sienou, Karduck & Pingaud, 2006). In a business process, activities are the fundamental of the process. Karduck, Sienou, Lamine &

Pingaud (2007) mention that each activity in the business process is performed with the idea to fulfill a particular transformation. Personal interview and focus group discussion were organized to identify and verify the risk and risk management strategies in each process.

The core business process of general shrimp farming is shown in Figure 15. The overview of this process starts with the process preparation of shrimp pond and input for production. The second process is production. Production is the most important among all processes in shrimp farming. The process of production takes 110 to 130 days to complete, starting from stocking shrimp fries to harvesting. Shrimp farmers should simultaneously take care of many managerial activities, such as finance and credit access, growing out of shrimp, personal risk, managing weather and environment. Moreover, the shrimp farmers deal with business process risks related to changes in government policies and business environment. Then, the last process consists of two sub-processes, which are; harvesting and marketing.

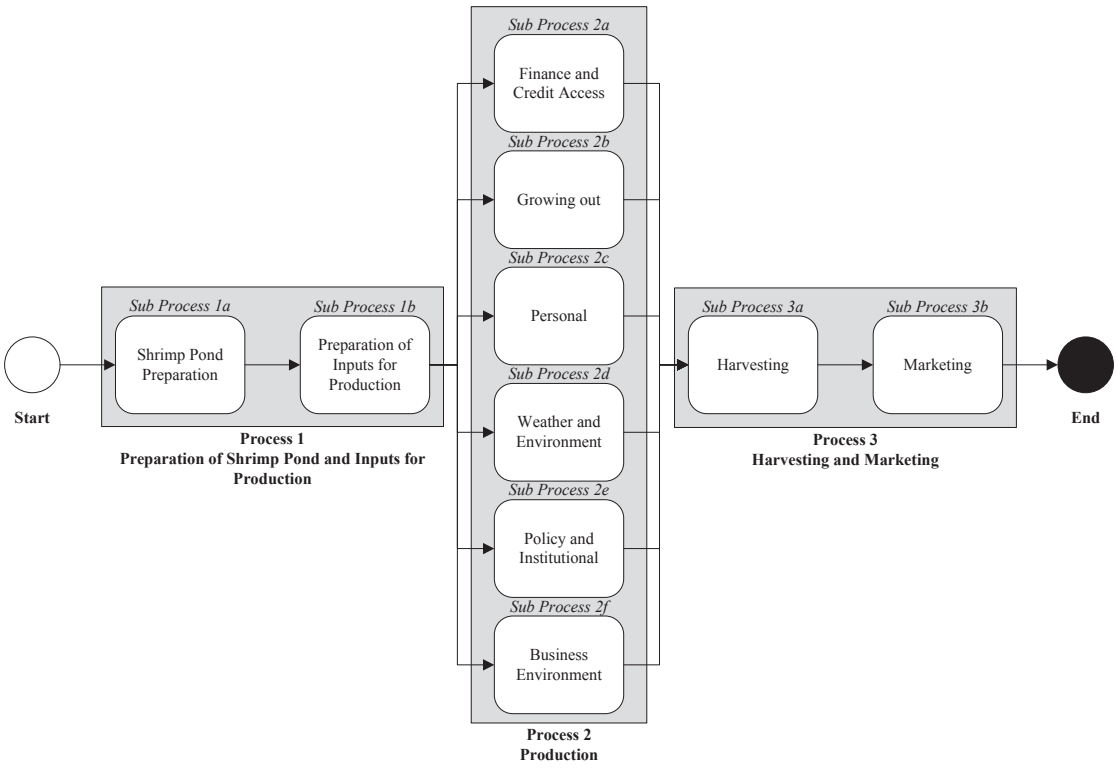

Figure 15. The Core Small-scale Shrimp Farming Business Process

The list of risks and risk management strategies related with each sub-process is provided in the following sections.

5.2.3.1 The First Process: Preparation of Shrimp Pond and Inputs for Production

Preparation of shrimp pond and inputs for production is the first step in the entire process of shrimp farming. This process consists of two sub-processes as follows;

- *Sub Process 1a: Shrimp Pond Preparation*

The shrimp pond preparation is an activity that is regularly conducted before starting a new crop. To provide a healthy and suitable environment for rearing the shrimp, carefully preparation for brackish water pond is a significant activity.

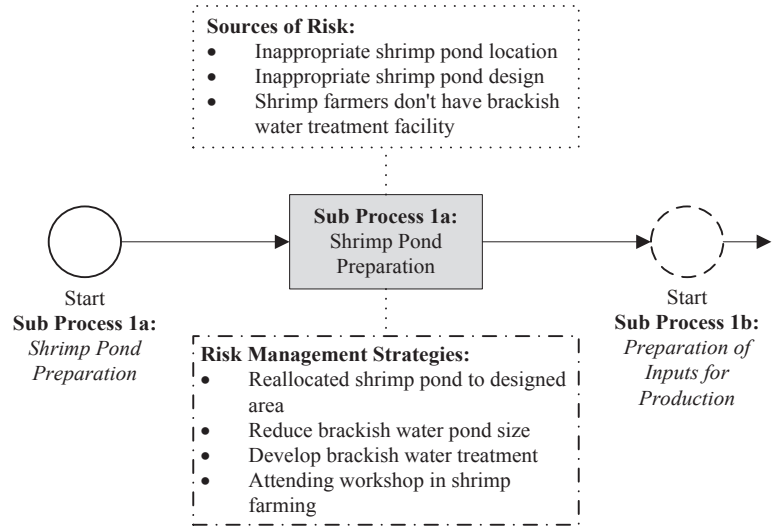

Figure 16. Sub Process 1a: Shrimp Pond Preparation

As shown in Figure 16, the risk involved in the sub-process of *shrimp pond preparation* consists of (1) inappropriate shrimp pond location, (2) inappropriate shrimp pond design, and (3) unavailability of brackish water treatment facilities. Several risk management strategies are available for these risks, including (1) relocating the shrimp pond to suitable areas for shrimp farming, (2) reducing brackish water pond size, (3) developing brackish water treatment, and (4) attending a workshop in shrimp farming to improve their knowledge and skill in managing water quality.

- *Sub Process 1b: Preparation of Inputs for Production*

The second sub-process is the preparation of inputs for production. The purpose of this sub-process is to ensure all inputs for production, such as shrimp fries, formulated feed, capital, and labor, ready for production. In the study areas, the farmers used shrimp fries at size PL (post-larvae) 8 – 10 that produced artificially at hatcheries. The shrimp fries should be healthy and good quality, not infected by any diseases. However, the supply of shrimp fries from private and public hatcheries does not fulfill the demand due to the fast-growing of the shrimp industry.As the results, the farmers used low quality of shrimp fries for production. Therefore, the risks involved in the preparation of inputs for production consist of (1) low quality of shrimp fry, and (2) inappropriate shrimp fries size. To reduce impact from these risks, the farmers applied several strategies, including: (1) only buying shrimp fries from the trusted hatchery and (2) only buying shrimp fries from a hatchery that have Specific Pathogen Free (SPF) for their broodstocks.

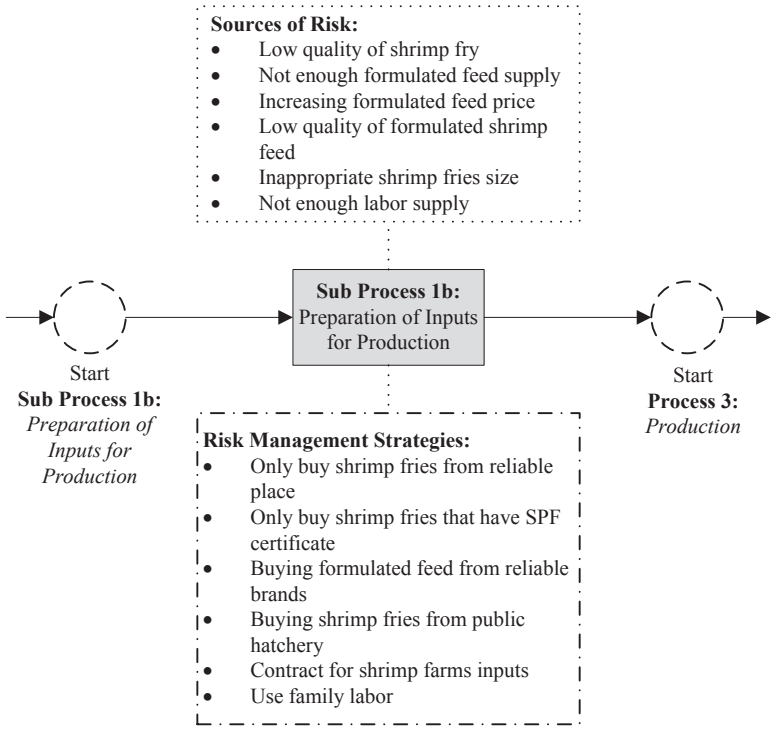

Figure 17. Sub Process 1b: Preparation of Inputs for Production

Most of the shrimp farmers apply the intensive system in their cultivation. This system highly depends on formulated feed for growing out the shrimp fries. The shrimp requires good quality of feed and nutritionally balanced for healthy growth. The

formulated feed should be contained nutrient like fat, protein, fiber, vitamins, and mineral for faster growth. However, the price of formulated feed is often high and not stable. Thus, some of the shrimp farmers used low quality of formulated feed in their shrimp cultivation to reduce production cost. They often face the risks as follows: (1) lack of supply of formulated feed from the factory, (2) rise of feed price, and (3) low quality of formulated shrimp feed. To manage these risks, shrimp farmers conducted risk management strategies, such as; (1) buying formulated feed from trusted brands, and (2) contract for shrimp farm inputs.

5.2.3.2 The Second Process: Production

The next step is the process of production of shrimp. Regarding time required to complete, the process of production is the longest step. This process requires 110 to 130 days to complete. The process of production can be broken into six sub-process and happen simultaneously throughout the whole crop duration. Moreover, the following section will describe these sub-processes and identify the risks and management strategies in each sub-process.

- *Sub Process 2a: Managing Finance and Credit Access*

Shrimp farming, especially intensive system, requires a significant amount of capital for pre-production activities and during operation of shrimp farms. In the normal condition, the shrimp farming duration could last up to four months (from preparation until harvesting), during which operation expenses for formulated feed, labor, medicines, electricity, and fuel take place throughout the shrimp cultivation. Lacking capital for operation can damage sustainability of their shrimp farm, which can affect the farmer's income and their livelihood. Moreover, limited access to credit from the formal financial institution (i.e., bank or cooperatives) is the main risk to shrimp farmers. Hence, they need to give more attention on financial arrangement for their farms. Financial risks that shrimp farmer's face is (1) increasing formulated feed price, (2) lack of capital to operate shrimp farms, (3) lack of collateral for loan, (4) high-interest rate for loan, and (5) high wages for hired labor. The following financial risk management strategies are effective to mitigate impact of lacking capital for shrimp farm: (1) contract for shrimp farm inputs, (2) use informal loan, (3) make production arrangement before production cycle, (4)

dissaving, (5) use family labor, (6) sharing machinery and paddle wheels, and (7) off-farm work. Figure 18 summarizes the risk and management strategies related to finance and credit access of shrimp farms.

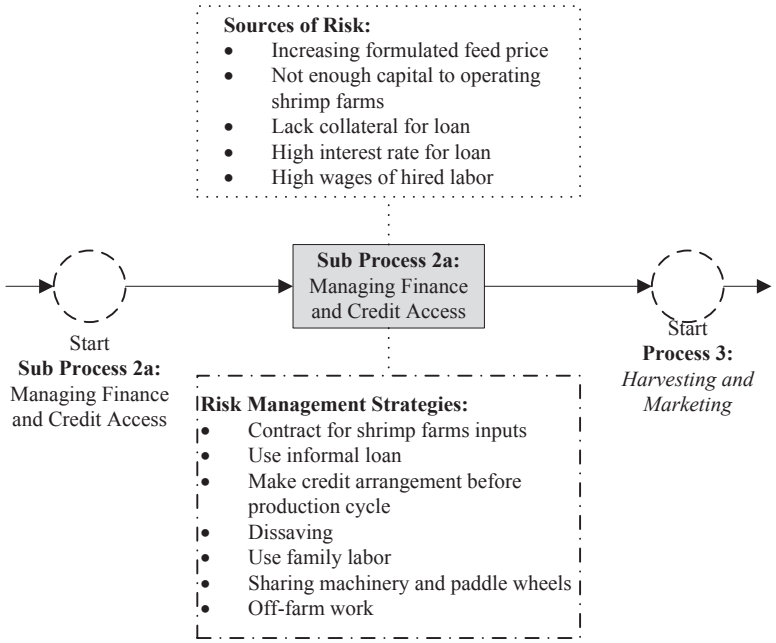

Figure 18. Sub Process 2a: Managing Finance and Credit Access

- *Sub Process 2b: Managing Growing Out of Shrimp*

Growing out of shrimp is the most significant management activity in the process of production. Diseases infection, feed and feeding preparation, and managing brackish water quality are the main farmer's concern in this step. In the recent years, Indonesian shrimp farming has had problems with several shrimp diseases. These diseases reduce shrimp growth hence decrease both output and quality of the harvest.

Moreover, shrimp diseases cause from both inside and outside brackish water pond. First, inside sources are incriminated as brackish water quality in shrimp pond and quality of shrimp fries' problems. Second, outside sources of shrimp diseases come from environmental issue around the shrimp pond. Hence, in the growing out process, the shrimp farmers may face the risks as follow: (1) high mortality due to diseases, (2) water pollution due to excessive formulated feed, (3) feeding management failure, (4) excessive stocking density, and (5) brackish water quality. To manage these sources of risk, the shrimp farmers conduct several risk management strategies, such as (1) strictly managing

water quality, (2) strictly feeding management, (3) conducting partial harvest, (4) reducing stocking density, (5) reducing brackish water pond size, (6) preventing shrimp disease by regular checking, (7) developing brackish water treatment, (8) attending workshop in shrimp farming, (9) applying new technology in shrimp production, (10) applying better management practices, and (11) requesting government support for technical assistant.

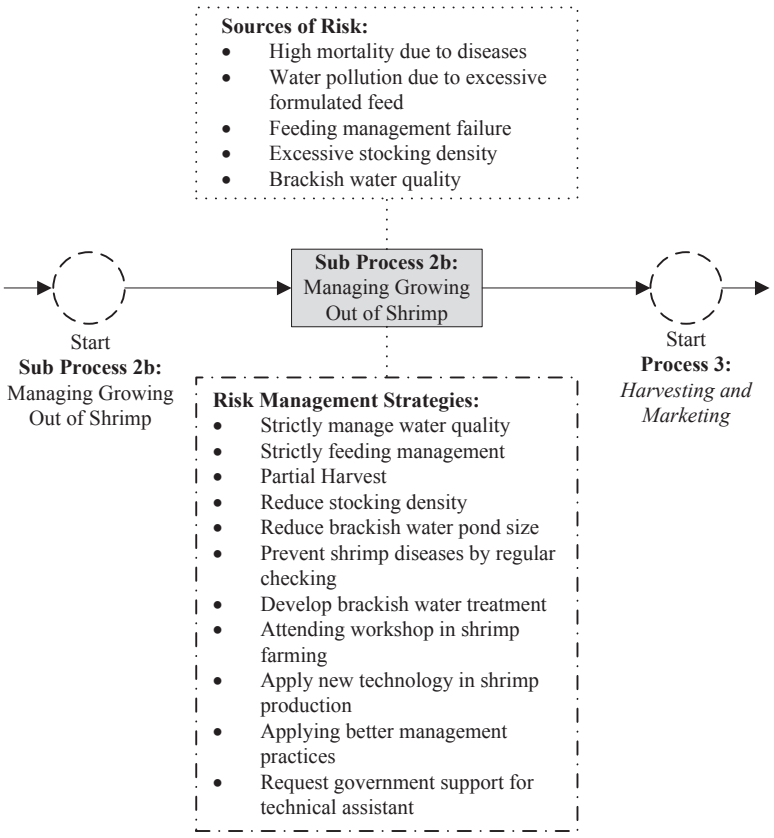

Figure 19. Sub Process 2b: Managing Growing Out of Shrimp

- *Sub Process 2c: Managing Personal Risk*

Figure 20 summarizes the risk and risk management strategies related to personal risk in shrimp farming. Besides technical aspect that is directly related to shrimp farming, the farmers also need to consider their personal risks that are associated with their capabilities (knowledge, experience, infrastructure, management, etc.). In general, the shrimp farmer's face two groups of risk. The first group related to the shortage of facility such as; (1) shrimp farmers don't have brackish water treatment facility and (2) lack of

labor knowledge about shrimp farming. Then, the second group consists of risks related to the lack of facilities, such as (3) lack of knowledge to prevent shrimp diseases, (4) lack of information about shrimp fries origin, (5) lack of knowledge for pond preparation.

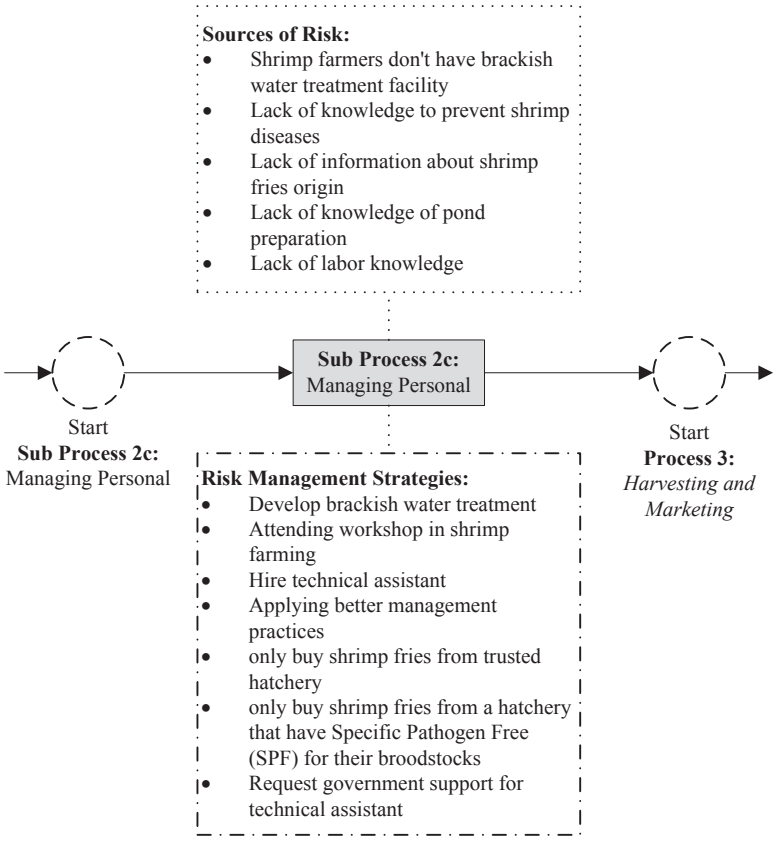

Figure 20. Sub Process 2c: Managing Personal Risk

In order to manage personal risk, the shrimp farmers adopted certain strategies, such as (1) to develop brackish water treatment facility, (2) attend workshop in shrimp farming, (3) to hire technical assistants, (4) to apply better management practices, (5) buy shrimp fries only from trusted hatchery and (6) only buy shrimp fries only from a hatchery that have Specific Pathogen Free (SPF) for their broodstocks, and (7) to request government support for technical assistant.

• *Sub Process 2d: Managing Weather and Environment*

Shrimp farming is a biological process that highly depends on environmental condition. This condition should maintain shrimp pond environment, hence affect the shrimp growth. In the study area, some of the shrimp ponds were located near the river

and close to the coast. Therefore, the flood is one of the primary risks during the rainy season. Water overflows or breaks the shrimp pond dyke. As a result, the shrimp may freely escape to the environment and thus makes a loss of income for the shrimp farmers.

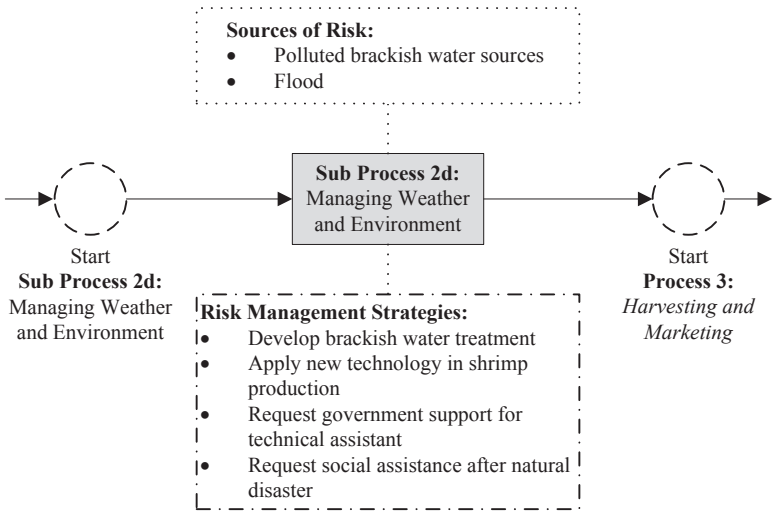

Figure 21. Sub Process 2d: Managing Weather and Environment

In this sub-process, the risks involved in the managing weather and environment are (1) polluted brackish water sources and (2) flood. To reduce impact of these risks, the farmers applied the following strategies: (1) developing brackish water treatment, (2) applying new technology in shrimp production, (3) requesting government support for technical assistant, (4) enforcing the shrimp pond dyke, and (5) requesting social assistant after natural disaster.

- *Sub Process 2e: Managing Policy and Institutional*

Changing the government policies related to environmental protection and standard for food safety and hygiene are also faced the shrimp farmers in the study area. Figure 22 presents the policy and institutional risks in shrimp farming and the risk management strategies to mitigate the impact of those risks. Recently, strict requirements derive from customers, not only in domestic market but also in the foreign markets in developed countries. For the small-scale farmers, strict regulations for food safety and environmental protection can be big challenges that should be managed.

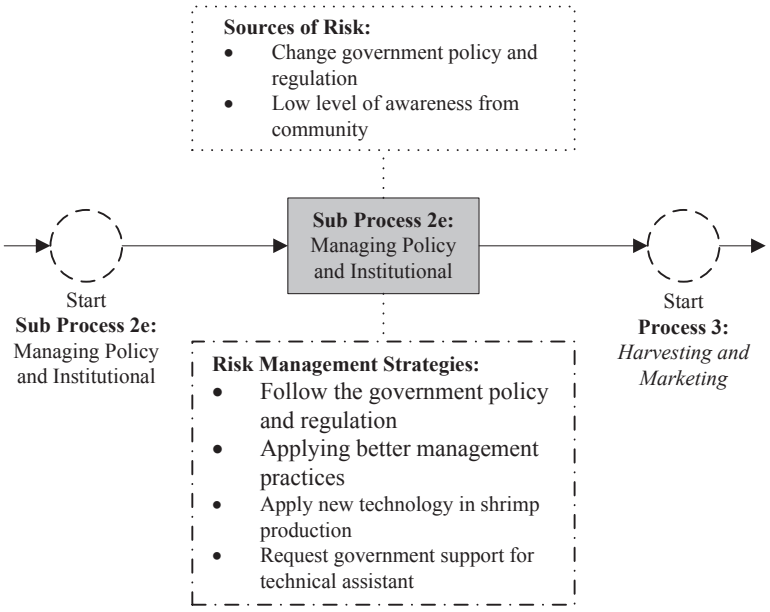

Figure 22. Sub Process 2e: Managing Policy and Institutional

Moreover, the intensive system in shrimp farming releases a significant amount of brackish water waste from the shrimp pond into water bodies around the ponds. Waste water could affect other shrimp pond and other users, such as agriculture and domestic uses. However, not all shrimp farmers concern to these issues and make shrimp farming riskier. Hence, in the managing policy and institutional activity, the shrimp farmers faced the risk as follows: (1) changeable government policy and regulation, and (2) low level of awareness from the community about the environmental condition. Furthermore, the following risk management strategies are effective to mitigate the impact of policy and institutional risks: (1) following the government policy and regulation, (2) applying better management practices, (3) applying new technology in shrimp farming, and (4) requesting government support regarding technical assistant.

- *Sub Process 2f: Managing Business Environment*

Shrimp farming is a dynamic business, which depends on not only biology aspect but also economic aspects. Regarding economic aspect, two main factors are affecting the shrimp industry. First, market power in both input and output sides strongly influences the business stability of shrimp industry. Secondly, the number of actors along the supply chain in both input and output is enormous. Hence, asymmetric information between

buyer and seller becomes the main obstacle while managing the business environment in the shrimp industry. To overcome this risk, the possibility of risk management strategies are (1) vertical integration, (2) contract-based production (3) marketing contract with the processor and (4) informal marketing contract with the wholesaler.

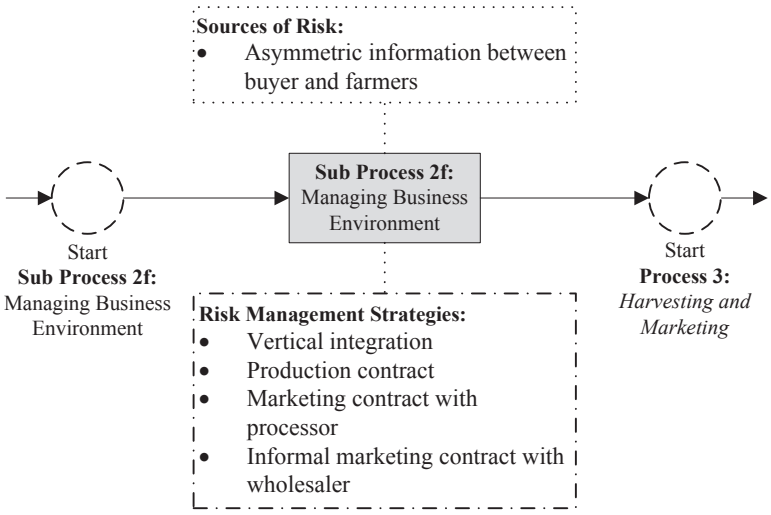

Figure 23. Sub Process 2f: Managing Business Environment

5.2.3.3 The Third Process: Harvesting and Marketing

Harvesting and marketing are the most important sub-process in the entire shrimp farming business process. The outcome, such as income or profit, of the whole process is realized at this stage.

- *Sub Process 3a: Harvesting*

Shrimp can reach marketable size after 110 to 130 days of rearing in a brackish water pond. However, harvesting time and size of shrimp can be harvested mainly depend on two factors, that is, stocking density and feeding management. In the intensive system, the farmers can cultivate shrimp with stocking density more than 100 shrimp fries per meter^2. Nevertheless, to get optimum growth rate, they should conduct partial harvest after 60 or 90 days of rearing the shrimp.

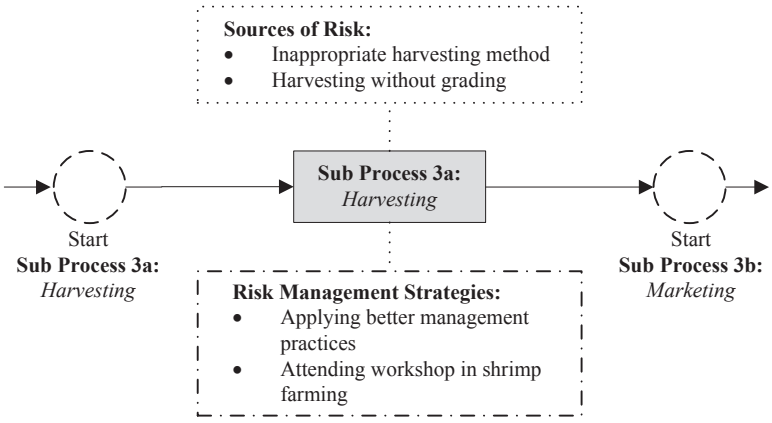

Figure 24. Sub Process 3a: Harvesting

Figure 24 depicts the risks and risk management strategies in the harvesting activity of shrimp farming. There are two sources of risk involved in this sub-process, consist of inappropriate harvesting method and harvesting without grading. To reduce the impact of these risks, the shrimp farmers applied the following strategies, which are (1) applying better management practices and (2) attending a workshop in shrimp farming.

- *Sub Process 3b: Marketing*

The last sub-process in the whole shrimp farming business process is marketing. All activities in the previous stage result in this sub-process. Moreover, the outcome (i.e., income or profit) of the whole shrimp farming process is realized in sub-process of marketing.

Two sources of risk were identified in marketing, which are (1) shrimp price volatility and (2) shrimp size variability. The shrimp price volatility is the most important for Indonesian shrimp farming. Usually, the buyers set a price at harvesting time, and the farmers have little bargaining power in setting the shrimp price. Even if they have a contract, there is no guarantee for them to get a high price for their product. The farmers only got a market guarantee from the contractor. To minimize impact of marketing risk, they could apply the following strategies; (1) production contract, (2) sharecropping, in which the owner of the brackish water pond allows a tenant to use the pond in return for a share of the crops produced on their portion of pond, (3) informal marketing contract with wholesaler, (4) vertical integration, in which the shrimp farmers tried to link their business with the shrimp feed supplier and processors, (5) marketing contract with

processor, (6) conducting partial harvest to reduce biomass at the shrimp pond in the middle of production cycle, (7) reducing brackish water pond size, and (8) reducing stocking density.

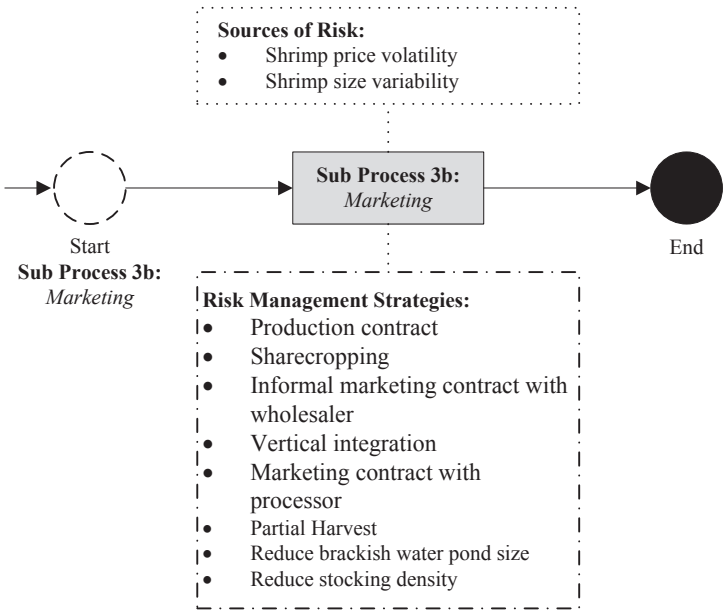

Figure 25. Sub Process 3b: Marketing

5.2.3.4 Summary the Sources of Risk based on Business Process Model (BPM)

The summary of all risk sources along the shrimp farming business process was presented in figure 26. Refers to the figure below, the majority of risk sources were concentrated in the second of shrimp business process, which is production. In the shrimp farming, particularly production phase, the duration of growing out the shrimp fries is from 110 to 130 days. During this period, the shrimp fries are exposed with almost all sources of risk that can affect their growth. The results of Business Process Model (BPM) revealed that 20 of 32 sources of risk were identified in the second process.

The first process, which is preparation of shrimp pond and inputs of production, had the second largest number of risk sources (8 of 32 sources of risk). Last, four risk sources were identified in the third process, harvesting and marketing.

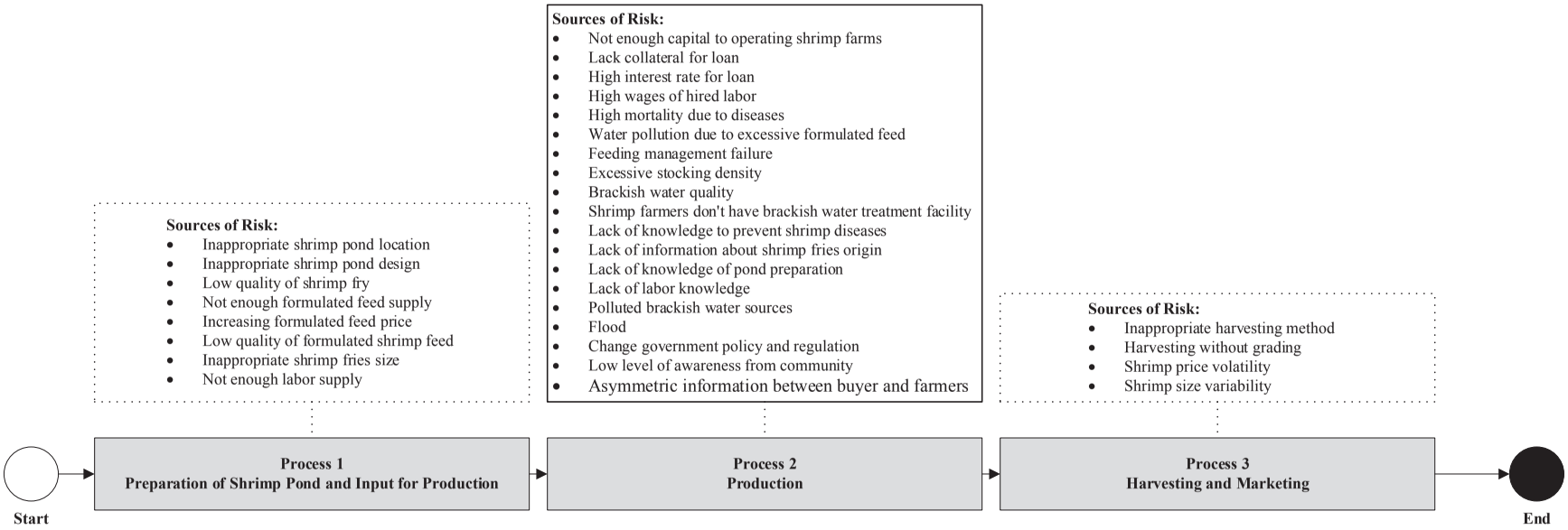

Figure 26. Summary the Sources of Risk based on Business Process Model (BPM)

5.2.4 Risk Analysis

The objective of this step is to measure the level of risks that already identified in the previous section. Based on AS/NZS ISO 31000:2009 standard, the level of risk is the results of consequence and likelihood of risk. In other words, the level of risk could be defined as the function of risk consequence and risk likelihood. In the next three sub sections, will consecutively describe the consequence, likelihood and the level of risk for Indonesian small-scale shrimp farming.

5.2.4.1 Measuring the Consequence of Risk

Thirty-two sources of risk were presented to the small-scale shrimp farmers to measure their perception about the potential impact of risk sources. The farmers were asked to rate the consequences of the sources of risk on the five-point Likert scale. In this study, the range varies from 1 to 5, which 1 representing neglibigle impact, and 5 representing severe impact.

Regarding the consequence of risk, Table 9 below shows the mean scores of consequence and rank of the sources of risk. Thirteen risk sources were categorized into the first group with the average scores of 4.09 to 4.92 (ranked from 1 to 13). This group was label as severe impact or the most damaging sources of risk on shrimp farmers' income. *High mortality due to diseases* was ranked as the top of risk source (4.92 of 5.00). This risk reflecting that the farmers in study area were more concerned with shrimp diseases to prevent income losses. Taukhid & Nur'aini (2009) stated that the main constraint of shrimp farming in Indonesia encountered was the diseases outbreaks since the last two decades. Kilawati, Maimunah, & Ekawati (2015) reported that various kind of diseases, such as Infectious Myonecrosis Virus (IMV), White Spot Syndrome Virus (WSSV), and White Faces Disease (WFD) led to significant losses for Indonesian shrimp farming since the 2000s. Those shrimp diseases can reduce the survival rate of shrimp below 30% (Anderson, Valderrama, & Jory, 2017).

In the second group, more than a half of the risks sources were categorized as major impacts, with the consequences range from 3.03 to 3.95. These risks have the ranked from 14 to 31 in Table 1. This finding showed that business environment in Indonesian shrimp farming was risky and need serious attention. Besides diseases, several scholars mentioned that the availability of inputs for shrimp production, product rejection from imported countries due to lack of farmers' knowledge were some of the few issues that affected Indonesian shrimp production (FAO, 2016; Sustainable Fisheries Partnership, 2013; Undercurrent News, 2014).

Last, only one risk source was categorized as moderate, which is a *low level of awareness among shrimp farmers* about environmental condition around the shrimp farms.

Table 9. The Consequence of the Sources of Risk

Risk ID	Sources of Risk	Consequence	Rank
PR1	High mortality due to diseases	4.93	1
HM1	Shrimp price volatility	4.92	2
IN1	Low quality of shrimp fries	4.92	3
IN3	Low quality of formulated shrimp feed	4.90	4
PL1	Shrimp farmers do not have brackish water treatment facility	4.84	5
WE1	Polluted brackish water sources	4.65	6
FC1	Increasing formulated feed price	4.64	7
PR2	Water pollution due to excessive formulated feed	4.56	8
PR3	Feeding management failure	4.50	9
PI1	Changed government policy and regulation	4.25	10
IN4	Inappropriate pond location	4.25	11
PL4	Lack of knowledge of pond preparation	4.22	12
FC2	Not enough capital for operating shrimp farms	4.09	13
PL5	Lack of labor knowledge	3.98	14
PL3	Lack of information about the origin of shrimp fries	3.96	15
IN2	Not enough formulated feed supply	3.90	16
PL2	Lack of knowledge to prevent shrimp diseases	3.89	17
FC3	Lack collateral for loan	3.76	18
IN5	Do not conduct treatment before stocking shrimp fries	3.71	19
PR4	Excessive stocking density	3.59	20
MH4	Harvesting without grading	3.54	21
HM3	Inappropriate harvesting method	3.52	22
BE1	Asymmetric information between buyer and farmers	3.48	23
IN6	Inappropriate pond design	3.42	24
FC4	High interest rate for loan	3.39	25
HM2	Shrimp size variability	3.38	26
IN8	Not enough labor supply	3.18	27
IN7	Inappropriate shrimp fries size	3.14	28
FC5	High wages of hired labor	3.04	29
WE2	Flood	3.03	30
PR5	Brackish water quality	3.02	31
PI2	Low level of awareness among shrimp farmers	2.72	32

5.2.4.2 Measuring the Likelihood of Risk

In this study, the likelihood of risk source was measured on a five-point Likert scale, which 1 point is representing rare occurrence to 5 points representing almost certain occurrence. Table 10 shows the mean scores and rank of the likelihood of 32 risk sources.

Table 10. The Likelihood of the Sources of Risk

Risk ID	Sources of Risk	Likelihood	Rank
HM1	Shrimp price volatility	4.45	1
PR1	High mortality due to diseases	4.43	2
FC1	Increasing formulated feed price	4.04	3
IN2	Not enough formulated feed supply	3.53	4
PR2	Water pollution due to excessive formulated feed	3.49	5
PR4	Excessive stocking density	3.40	6
PR5	Brackish water quality	3.39	7
FC2	Not enough capital for operating shrimp farms	3.31	8
PL2	Lack of knowledge to prevent shrimp diseases	3.26	9
HM2	Shrimp size variability	3.13	10
IN6	Inappropriate pond design	3.08	11
IN1	Low quality of shrimp fries	3.04	12
IN5	Do not conduct treatment before stocking shrimp fries	2.97	13
PR3	Feeding management failure	2.93	14
PL3	Lack of information about the origin of shrimp fries	2.90	15
IN7	Inappropriate shrimp fries size	2.90	16
FC3	Lack collateral for loan	2.89	17
PI1	Changed government policy and regulation	2.86	18
PL1	Shrimp farmers do not have brackish water treatment facility	2.84	19
HM3	Inappropriate harvesting method	2.75	20
IN3	Low quality of formulated shrimp feed	2.71	21
WE1	Polluted brackish water sources	2.71	22
PL5	Lack of labor knowledge	2.70	23
MH4	Harvesting without grading	2.70	24
PI2	Low level of awareness among shrimp farmers	2.70	25
BE1	Asymmetric information between buyer and farmers	2.69	26
PL4	Lack of knowledge of pond preparation	2.69	27
IN4	Inappropriate pond location	2.65	28
FC4	High interest rate for loan	2.64	29
IN8	Not enough labor supply	2.63	30
WE2	Flood	2.58	31
FC5	High wages of hired labor	2.56	32

Three sources of risk have been classified into the first group that has the average score above 4 points. The first group consists of *shrimp price volatility*, *high mortality due to diseases*, and *increasing formulated feed price*. These sources of risk expected to occur regularly (high probability) during shrimp cultivation in study areas.

In the top three of risk sources, two of them closely related to output and input sides of shrimp farming, which are *shrimp price volatility* and *increasing formulated feed price*. In general, markets for output and input are beyond the control of small-scale shrimp farmers due

to set by shrimp processors and shrimp feed factories. Both of output and input markets are imperfect markets regarding price mechanism. Thus, the shrimp farmers often must face with the unstable output and input prices.

Nine sources of risk have been classified into the second group. These risks had a probability of occurrence between 3.0 to 4.0. The second group consisting of (1) *not enough formulated feed supply*, (2) *water pollution due to excessive formulated feed*, (3) *excessive stocking density*, (4) *brackish water quality*, (5) *not enough capital for operating shrimp farms*, (6) *lack of knowledge to prevent shrimp diseases*, (7) *shrimp size variability*, (8) *inappropriate pond design*, and (9) *low quality of shrimp fries*. These risks were considered as having the potential to occur in shrimp farming with relatively high probability. The third group includes the rest of sources of risk in shrimp farming. These sources of risk have an average score of likelihood between 2.0 to 3.0. Twenty sources of risk in this group might occur at some time in shrimp production.

5.2.4.3 Measuring the Level of Risk

As already mentioned above, this study used the concept of the level of risk to measure the risk in Indonesian small-scale shrimp farming. Refers to AS/NZS ISO 31000:2009 standard, the level of risk is defined as the result of the consequences of risk and the likelihood of risk. Based on this concept, thirty-two source of risk in Indonesian shrimp farming were calculated and the result presented in Table 11.

The result showed that two sources of risk, *shrimp price volatility* and *high mortality due to diseases*, were classified as a very high risk with the potential of having the most severe impact on shrimp farmers' income. The second level consists of two sources of risk, *increasing formulated feed price* and *water pollution due to excessive formulated feed* were classified as a high. The remaining 28 sources were classified as moderate with ratings between 10.0 and 14.9. These indicators need serious attention for risk management in Indonesia small-scale shrimp farming.

Table 11. The Level of Risk Sources

Sources of Risk	Risk ID	Consequence	Likelihood	Risk Level	Rank
Shrimp price volatility	*HM1*	4.92	4.45	21.90	1
High mortality due to diseases	*PR1*	4.93	4.43	21.84	2
Increasing formulated feed price	*FC1*	4.64	4.04	18.73	3
Water pollution due to excessive formulated feed	*PR2*	4.56	3.49	15.92	4
Low quality of shrimp fries	*IN1*	4.92	3.04	14.96	5
Not enough formulated feed supply	*IN2*	3.90	3.53	13.75	6
Shrimp farmers do not have brackish water treatment facility	*PL1*	4.84	2.84	13.75	7
Not enough capital for operating shrimp farms	*FC2*	4.09	3.31	13.53	8
Low quality of formulated shrimp feed	*IN3*	4.90	2.71	13.29	9
Feeding management failure	*PR3*	4.50	2.93	13.19	10
Lack of knowledge to prevent shrimp diseases	*PL2*	3.89	3.26	12.67	11
Polluted brackish water sources	*WE1*	4.65	2.71	12.60	12
Excessive stocking density	*PR4*	3.59	3.40	12.21	13
Changed government policy and regulation	*PI1*	4.25	2.86	12.17	14
Lack of information about the origin of shrimp fries	*PL3*	3.96	2.90	11.49	15
Lack of knowledge of pond preparation	*PL4*	4.22	2.68	11.31	16
Inappropriate pond location	*IN4*	4.25	2.65	11.25	17
Do not conduct treatment before stocking shrimp fries	*IN5*	3.71	2.97	11.04	18
Lack collateral for loan	*FC3*	3.76	2.90	10.87	19
Lack of labor knowledge	*PL5*	3.98	2.70	10.73	20
Shrimp size variability	*HM2*	3.38	3.13	10.57	21
Inappropriate pond design	*IN6*	3.42	3.08	10.53	22
Brackish water quality	*PR5*	3.02	3.39	10.23	23
Inappropriate harvesting method	*HM3*	3.52	2.75	9.69	24
Harvesting without grading	*MH4*	3.55	2.70	9.56	25
Asymmetric information between buyer and farmers	*BE1*	3.48	2.69	9.36	26
Inappropriate shrimp fries size	*IN7*	3.14	2.90	9.12	27
High interest rate for loan	*FC4*	3.39	2.64	8.95	28
Not enough labor supply	*IN8*	3.18	2.63	8.37	29
Flood	*WE2*	3.03	2.58	7.79	30
High wages of hired labor	*FC5*	3.04	2.56	7.76	31
Low level of awareness among shrimp farmers	*PI2*	2.72	2.69	7.34	32

5.2.5 Risk Evaluation

The goal of this step is to build a list of risk sources that give detail information, which risks will be accepted, and which risks need treatment by shrimp farmers. The shrimp farmers have two options for each risk source, treat the risk or accept the risk. The risk could be accepted for several reasons, such as the cost of managing the risk outweighs the benefit or the level of risk is low. List of the levels of risk calculated in step 4 will be sorted and listed in two dimensional matrix. This matrix consists of two dimensions, with consequences variable on horizontal axis and the likelihood variable on the vertical axis.

A scale was assigned to measure the magnitude of all risk source on both the consequence and the likelihood. Regarding the consequence of risk, the scale consists of (1) negligible, (2) minor, (3) moderate, (4) major, and (5) severe. Similarly, the likelihood was measured on five scales representing the probability of occurance, which are (I) rare, (II) unlikely, (III) possible, (IV) likely, and (V) almost certain. The interpretations of the two-dimensional matrix are as follows: (1) the sources of risk with the very high level are listed in cells *5-V*, *5-IV*, and *4-V*; (2) the risks with high level are located in cells *2-V*, *3-V*, *3-IV*, *4-IV*, *4-III*, *5-III*, and *5-II*; (3) the sources of risk with moderate level are listed in cells *1-V*, *1-IV*, *2-IV*, *2-III*, *3-III*, *3-II*, *4-II*, *4-I*, and *5-I*; (4) the risk sources with the low level are located in cells *1-III*, *1-II*, *2-II*, *2-I*, and *3-I*; and the last (5) the risks with very low level are listed in cells *1-I*.

Refers to AS/NZS ISO 31000:2009 standard, this study used the "As Low As Acceptable Risk" (ALAAR) criteria to determined which risks are going to accepted or which risks are going to be treated. Based on ALAAR criteria, there are no sources of risk located in the low-level cell, either the risk consequence or risk likelihood (See Table 11). Hence, all source of risk should be a treat in the next step.

Table 12. Two-dimensional Matrix of Risk Levels

Likelihood	Negligible (1)	Minor (2)	Moderate (3)	Major (4)	Severe (5)
Almost Certain (V)					
Likely (IV)				• Increasing formulated feed price	• Shrimp price volatility • High mortality due to diseases
Possible (III)			• Lack of knowledge to prevent shrimp diseases • Polluted brackish water sources • Excessive stocking density • Changed government policy and regulation • Inappropriate harvesting method • Harvesting without grading • Asymmetric information between buyer and farmers • Inappropriate shrimp fries size	• Low quality of shrimp fries • Not enough formulated feed supply • Shrimp farmers do not have brackish water treatment facility • Not enough capital for operating shrimp farms • Low quality of formulated shrimp feed • Feeding management failure	• Water pollution due to excessive formulated feed
Unlikely (II)				• High interest rate for loan • Not enough labor supply • Flood • High wages of hired labor • Low level of awareness among shrimp farmers	• Lack of information about the origin of shrimp fries • Lack of knowledge of pond preparation • Inappropriate pond location • Do not conduct treatment before stocking shrimp fries • Lack collateral for loan • Lack of labor knowledge • Shrimp size variability • Inappropriate pond design
Rare (I)					
	Consequence				

Note:
5 : Very high-risk level 4 : High risk level 3 : Moderate risk level 2 : Low risk level 1 : Very low level

5.2.6 Risk Treatment

This step aims to determined treatment for the sources of risk that identified as "to be treated risk" in the previous step. In other words, this step linked to the risk management strategies and the risk that were identified as "to be treated risk". In this study, each risk source matched with all risk management strategies for that risk. Then, risk management strategies are listed according to the degree of efficacy in reducing the risk. Moreover, the higher degree of efficacy of risk management strategies considers as a higher priority risk management strategies to be used. The following sub-sections will describe all process to treat the risks in detail.

5.2.6.1 Measuring the Efficacy of Risk Management Strategies (RMS)

In this study, the degree of efficacy of risk management strategies was rated on a five-points Likert scale. The scale ranged from 1 (not effective at all) to 5 (very effective). The average scores of efficacy and rank of risk management strategies in descending order are presented in Table 12.

The results revealed that 16 management strategies were rated as very effective to mitigate the impact of risks in shrimp farming. The average scores of these strategies varying between 4.11 to 5.00. The top five strategies in this category were the s*trict management of water quality*, *strict feeding management*, *applying better management practices*, *preventing shrimp diseases by regular checking*, and *reducing brackish water pond size*.

The second category, which is effective strategies, consists of ten risk management strategies This category had an average score that ranged between 3.1 and 4.0 with corresponding ranks from 17 to 26. The next six risk management strategies, such as *change consumption pattern*, *use of large-sized shrimp fries*, *informal marketing contract with the wholesaler*, *applying new technology*, *using family labor*, and *dissaving*, were classified as average effective. Last, only three strategies were categorized as little effective (ranges between 1.1 and 2.0), which included *sharing machinery and paddle wheel*, *follow the government policy and regulation*, and *off-farm work*.

Regarding risk management strategies, the second column in Table 5 presented the nine factors of management strategies (called RMS ID) from the exploratory factor analysis (See Table 2 in Chapter 4). The factors 1 to 9 were identified as diseases prevention (*DP*); education and technology improvement (*ET*); input of production (*IP*); farm management (*FM*); government support (*GS*); risk sharing and insurance (*RS*); financial (*FN*); household

adjustment (*HA*); and alternative income sources (*AI*). These factors will be used to match the sources of risk with particular risk management strategies in the next step.

Table 13. The Risk Management Strategies

Risk Management Strategies	RMS ID	Degree of Efficacy	Rank
Strictly manage water quality	*DP1*	5.00	1
Strictly feeding management	*DP2*	4.99	2
Applying better management practices	*DP7*	4.91	3
Prevent shrimp diseases by regular checking	*RS1*	4.79	4
Reduce brackish water pond size	*DP6*	4.78	5
Production contract	*FM2*	4.77	6
Contract for shrimp farms inputs	*GS2*	4.69	7
Partial Harvest	*FM1*	4.67	8
Attending workshop in shrimp farming	*ET1*	4.55	9
Sharecropping	*FM3*	4.52	10
Only buy shrimp fries that have SPF certificate	*DP5*	4.41	11
Reduce stocking density	*DP4*	4.22	12
Vertical integration	*IP4*	4.21	13
Only buy shrimp fries from reliable place	*IP2*	4.14	14
Request government support for technical assistant	*IP3*	4.14	15
Reallocated shrimp pond to designed area	*RS3*	4.11	16
Marketing contract with processor	*IP5*	3.80	17
Use informal loan	*RS4*	3.72	18
Develop brackish water treatment	*DP3*	3.54	19
Buying formulated feed from reliable brands	*RS5*	3.50	20
Make credit arrangement before production cycle	*ET2*	3.45	21
Hire technical assistant	*RS6*	3.44	22
Enforcing the shrimp pond dyke	*FN1*	3.43	23
Request social assistance after natural disaster	*FN2*	3.29	24
Farm diversification	*FM4*	3.29	25
Buying shrimp fries from public hatchery	*IP1*	3.02	26
Use large size shrimp fries	*GS1*	2.76	27
Change consumption pattern	*FN3*	2.76	28
Informal marketing contract with wholesaler	*AI1*	2.52	29
Apply new technology in shrimp production	*RS2*	2.38	30
Use family labor	*RS7*	2.11	31
Dissaving	*HA2*	2.09	32
Sharing machinery and paddle wheels	*HA1*	1.96	33
Follow the government policy and regulation	*DP8*	1.22	34
Off-farm work	*AI2*	1.2	35

5.2.6.2 Selecting Risk Management Statagies based on Degree of Efficacy

This sub-section aims to match the risk and their corresponding risk management strategies that already identified in the previous sub-section. To achieve the objective, two stages have been used in this study. In the first stage, the identified risks in shrimp farming and their corresponding risk management strategies are matched into a two-dimensional table. This table consists of two dimensions, including the sources of risk listed in vertical dimension and risk management strategies listed in the horizontal dimension. The matching process between

the risk and corresponding risk management strategies is based on the results of Business Process Model (BPM) in the previous sub-section.

Table 13 presents a result of matching the sources of risk and their risk management strategies. The results showed that there is no particular risk management strategy for the specific type of risk source. The shrimp farmers in the study areas develop a range of strategies and conversely, a risk management strategy can apply to mitigate different types of risk source.

In the second stage, the sources of risk and risk management in Table 13 are rearranged by the level of risk and the efficacy of risk management strategies. Specifically, we break the source of risk in the vertical dimension and rank the risks into descending order. Regarding risk management strategies in the horizontal dimension, we ranked the strategies in descending order based on their the efficacy to cope the particular risk. Table 14 presents the results of rearranging the source of risk and risk management strategies. Given that arrangement, the source of risk listed at the top of Table 14 (in the vertical dimension) received higher priority in treating because of their higher risk exposure. In case of the source of risk was selected for treatment, the particular risk management strategies (in the horizontal dimension) toward this risk might be implemented. The order of implementing the risk management strategies is from left to right as shown in the last six columns in Table 14. It means that the risk management strategies on the left have the higher effectiveness and should be received higher priority.

Table 14. Matching the Risks and Risk Management Strategies

		Risk Management Strategies								
		Diseases Prevention	**Education and Technology Improvement**	**Input of Production**	**Farm Management**	**Government Support**	**Risk Sharing and Insurance**	**Financial**	**Household Adjustment**	**Alternative Income Sources**
Source of Risks	*Code*	*DP*	*ET*	*IP*	*FM*	*GS*	*RS*	*FN*	*HA*	*AI*
Input and Pond Preparation	*IN*	IN4 – DP7 IN6 – DP7		IN1 – IP1 IN1 – IP2 IN1 – IP4 IN3 – IP3 IN7 – IP1 IN7 – IP4 IN7 – IP5	IN5 – FM1		IN2 – RS3		IN8 – HA2	
Finance and Credit Access	*FC*						FC1 – RS3	FC1 – FN1 FC1 – FN2 FC1 – FN3 FC2 – FN2 FC3 – FN1 FC3 – FN3 FC4 – FN1 FC4 – FN3	FC2 – HA2 FC5 – HA2	FC2 – AI2
Production	*PR*	PR1 – DP1 PR1 – DP6 PR2 – DP1 PR2 – DP2 PR2 – DP8 PR3 – DP2 PR4 – DP3 PR4 – DP5 PR5 – DP1 PR5 – DP4 PR5 – DP8	PR1 – ET1 PR1 – ET2 PR4 – ET2 PR5 – ET1		PR1 – FM1 PR3 – FM1	PR1 – GS1 PR4 – GS1 PR5 – GS1				
Personal	*PL*	PL1 – DP4 PL1 – DP7 PL1 – DP8	PL1 – ET1 PL2 – ET1 PL3 – ET1 PL4 – ET1 PL5 – ET1	PL3 – IP1 PL3 – IP2	PL3 – FM1 PL4 – FM1	PL2 – GS1 PL4 – GS1 PL5 – GS1		PL2 – FM2		
Harvesting and Marketing	*HM*	HM2 – DP2 HM2 – DP4 HM2 – DP5	HM3 – ET1		HM3 – FM1 HM4 – FM1		HM1 – RS1 HM1 – RS2 HM1 – RS4 HM1 – RS5 HM1 – RS6			
Weather and Environment	*WE*	WE1 – DP8	WE1 – ET2			WE1 – GS1 WE2 – GS2				
Policy and Institutional	*PI*		PI1 – ET2		PI1 – FM4 PI2 – FM1	PI1 – GS1				
Business Environment	*BE*						BE1 – RS1 BE1 – RS3 BE1 – RS4 BE1 – RS5			

Table 15. Prioritizing Mitigation Strategies of Identified Risks

Source of Risk		Risk ID	Options for Risk Management Strategies					
Rank	*Risk Level*		*First Priority*	*Second Priority*	*Third Priority*	*Fourth Priority*	*Fifth Priority*	*Sixth Priority*
1	**21.90**	***HM1***	RS1 (4.79)	RS4 (3.72)	RS5 (3.50)	RS6 (3.44)	RS2 (2.38)	
2	**21.84**	***PR1***	DP1 (5.00)	DP6 (4.78)	FM1 (4.67)	ET1 (4.55)	ET2 (3.45)	GS1 (2.76)
3	**18.73**	***FC1***	RS3 (4.11)	FN1 (3.43)	FN2 (3.29)	FN3 (2.76)		
4	**15.92**	***PR2***	DP1 (5.00)	DP2 (4.99)	DP8 (1.22)			
5	**14.96**	***IN1***	IP2 (4.14)	IP4 (4.21)	IP1 (3.02)			
6	**13.75**	***IN2***	RS3 (4.11)					
7	**13.75**	***PL1***	DP1 (5.00)	DP7 (4.91)	ET1 (4.55)	DP8 (1.22)		
8	**13.53**	***FC2***	FN2 (3.29)	HA2 (2.09)	AI2 (1.20)			
9	**13.29**	***IN3***	IP3 (4.14)					
10	**13.19**	***PR3***	DP2 (4.99)	FM1 (4.67)	GS1 (2.76)			
11	**12.67**	***PL2***	ET1 (4.55)	FM2 (4.77)	GS1 (2.76)			
12	**12.60**	***WE1***	ET2 (3.45)	GS1 (2.76)	DP8 (1.22)			
13	**12.21**	***PR4***	DP5 (4.41)	DP3 (3.54)	ET2 (3.45)			
14	**12.17**	***PI1***	ET2 (3.45)	FM4 (3.29)	GS1 (2.76)			
15	**11.49**	***PL3***	FM1 (4.67)	ET1 (4.55)	IP2 (4.14)	IP1 (3.02)		
16	**11.31**	***PL4***	FM1 (4.67)	ET1 (4.55)	GS1 (2.76)			
17	**11.25**	***IN4***	DP7 (4.91)					
18	**11.04**	***IN5***	FM1 (4.67)	FN1 (3.43)	FN3 (2.76)			
19	**10.87**	***FC3***	FN1 (3.43)	FN3 (2.76)				
20	**10.73**	***PL5***	ET1 (4.55)	GS1 (2.76)				
21	**10.56**	***HM2***	DP2 (4.99)	DP5 (4.41)	DP4 (4.22)			
22	**10.53**	***IN6***	DP7 (4.91)					
23	**10.23**	***PR5***	DP1 (5.00)	ET1 (4.55)	DP4 (4.22)	GS1 (2.76)	DP8 (1.22)	
24	**9.69**	***HM3***	FM1 (4.67)	ET1 (4.55)				
25	**9.56**	***MH4***	FM1 (4.67)					
26	**9.36**	***BE1***	RS1 (4.79)	RS3 (4.11)	RS4 (3.72)	RS5 (3.50)		
27	**9.12**	***IN7***	IP1 (3.02)	IP4 (4.21)				
28	**8.95**	***FC4***	FN1 (3.43)	FN3 (2.76)				
29	**8.37**	***IN8***	HA2 (2.09)					
39	**7.79**	***WE2***	GS2 (4.69)					
31	**7.76**	***FC5***	HA2 (2.09)					
32	**7.34**	***PI2***	FM1 (4.67)					

5.2.7 Monitoring and review

The monitoring and review are an important part of the risk management options to ensure the options is still relevant concerning internal and external changes. The monitoring and review are an ongoing review of the risk management framework to ensure the options is still relevant concerning internal and external changes. However, since the risk management framework in this study still on developing process, the monitoring and review cannot be done.

5.3 Conclusions

This chapter developed risk management framework for Indonesian small-scale shrimp farming by combining the Exploratory Factor Analysis (EFA), Business Process Model (BPM), and the AS/NZS ISO 31000:2009 risk management process. Specifically, Business Process Model (BPM) employed to break the shrimp farming process into three sub-process, which are (1) pond preparation and inputs for shrimp production, (2) production, and (3) marketing and harvesting. In each sub process, all shrimp business activities were identified. Then, we identified the sources of risk and risk management strategies at the business activity level. As the results, thirty-two sources of risk and thirty-five risk management strategies were identified throughout the shrimp farming production process.

Next, the sources of risk and management strategies applied to develop the framework through the AS/NZS ISO 31000:2009 risk management process. As a result, a complete list of risks and risk management strategies with six risk management options (See Table 7). Based on this result, the shrimp farmers could make their own decision on choosing the management strategies that best meet their risk mitigation objectives.

The risk management framework in this chapter allows the shrimp farmers to manage the sources of risk and management strategies systematically and efficiently. Specifically, the framework allows the shrimp farmers to measure, rank, analyses, and priorities the risk for treatment in their shrimp farms. Moreover, the framework allows the farmers to choose the optimal risk management strategies based on the degree of efficacy of management strategies. Last, the framework developed in this chapter is aimed at managing the risk in Indonesian shrimp farming. However, the risk management framework could be adopted to other aquaculture activities due to the similarities in characteristics of their business.

Chapter 6

Conclusion and Recommendations

6.1 Conclusions

Recently, there are many sources of risk involved in the shrimp farming process due to uncertainty business environment. Hence, activities to identify the risk sources and the appropriate management strategies are essential to avoid a significant loss to shrimp farmers. In more detail, the shrimp farmers need a framework that allows them to measure, rank, analyses, and priorities the risk for treatment in their shrimp farms. By this framework, the shrimp farmers will enable to manage the sources of risk systematically and efficiently. Thus, the developed risk management framework will provide them with a tool to choose the optimal risk management strategies based on the degree of efficacy of management strategies. Moreover, the developed risk management framework in this study provides the critical guidance and tools for Indonesian shrimp farmers to select specific strategies on risk reduction, thus reducing the impact of risks in their shrimp farming.

The main purpose of this study is to develop the risk management framework for small-scale shrimp farming. Two research objectives were proposed, consist of (1) to examine the relationship between shrimp farmer's characteristics and their perception of risk and risk management strategies, and (2) to develop risk management framework Indonesian small-scale shrimp farming. Several statistical methods were applied to address the objectives, include descriptive statistic, exploratory factor analysis, and multivariate regression. Moreover, Business Process Modeling (BPM) method was used to identify the sources of risk and management strategies in shrimp farming systematically. Then, the sources of risk and management strategies applied to develop the framework through the AS/NZS ISO 31000:2009 risk management process. The following sub-chapter is composed of two conclusions for small-scale shrimp in East Java, Indonesia.

6.1.1 The Perception of Risk and The Small-scale Shrimp Farmers' Attitudes Toward Risk

This study has identified 32 sources of risks on small-scale shrimp farming in East Java, Indonesia. In general, production, harvesting and marketing risks, such as high mortality due to shrimp diseases and shrimp price volatility, were perceived as the most important risk sources. Then, risk sources were reduced using varimax rotation factor analysis to gain a deeper

understanding of shrimp farmers' perception regarding sources of risk. Hence, the 32 sources of risk were reduced to eight factors, consist of (1) Input and pond preparation, (2) Finance and credit access (3) Production, (4) Personal, (5) Harvesting and marketing, (6) Weather and environment, (7) Policy and institutional, and (8) Business environment.

Besides the sources of risk, the study found 35 risk management strategies. Nearly a half of those strategies were classified as very effective in coping with the risk in shrimp farming. Strict management of water quality, strict feeding management, applying better management practices, preventing shrimp diseases by regular checking, and reducing brackish water pond size were the top five strategies in this category. However, this study found some mismatch between the source of risk and the risk management strategies taken by shrimp farmers. For example, shrimp price volatility was perceived as the most damaging source of risk, but the rank of risk management strategy to cope with this risk, such as production contract, was not recognized as the most effective strategy. Rather than choosing production contract strategy, the shrimp farmers prefer applied several strategies, such as strictly managed water quality, strict feeding management, and applying better management practices in their business. Hence, this study concludes that the small-scale shrimp farmers preferred to rely on the daily activities to cope with the risks and maximize their income. The factor analysis with varimax rotation was applied to reduce many risk management strategies. Thus, nine factors loadings were obtained for risk management strategies in study areas. The factors 1 to 9 were identified as (1) Diseases prevention, (2) Education and technology improvement, (3) Input of production, (4) Farm management, (5) Government support, (6) Risk sharing and insurance, (7) Financial, (8) Household adjustment, and (9) Alternative income sources.

Moreover, the finding of regression analysis suggests that the characteristics of shrimp farmers significantly influence their perception of risks and risk management strategies. The results indicated that several factors, such as the age of farmers, experience, formal education level, availability of off-farm income, and location of a shrimp farm, were influenced the small-scale shrimp farmers' perceptions of risks and their management strategies. This study highlights that the farmers in the north coast of East Java rated the efficacy of diseases prevention and farm management strategies as significantly important compared to the shrimp farmers in the south coast. The findings support the fact that the shrimp farmers in the north coast of East Java have been more severely affected by the spread of shrimp disease during the last several years. Despite the study found that the relationships between the perceptions of risks significantly impact on shrimp farmers' perception of risk management strategies.

However, these relationships are multidimensional and represent characteristics of farm and shrimp farmers. Based on the findings, this study concludes that there is no particular risk management strategy for the specific type of risk source. The results showed that the shrimp farmers develop a range of strategies and conversely, a risk management strategy can apply to mitigate diverse types of risk source.

6.1.2 Developing Risk Management Framework for Small-scale Shrimp Farming

In regard to developing the risk management framework for shrimp farming, this study has used Business Process Model (BPM) to identify the sources of risk and associated the risk management strategies. Then, the seven steps of risk management process by AS/NZS ISO 31000:2009 standard was applied to develop the risk management framework. These steps consist of (1) Communication and consultation, (2) Establishing the context, (3) Risk identification, (4) Risk analysis, (5) Risk evaluation, (6) Risk treatment, and (7) Monitoring and review. Those steps enabled the farmers to manage the sources of risk and management strategies in their farms systematically and efficiently.

Based on the results, this study found that the farmers had six risk management options to deal with the risks in their shrimp farms. The framework allows the farmers to choose the optimal risk management strategies based on the degree of efficacy of management strategies. Specifically, the framework allows the shrimp farmers to measure, rank, analyses, and priorities the risk for treatment in their business.

6.2 Recommendations

The study found that the farmers could hardly adequately cover their farms business by kinds of insurance to cope with input and pond preparation risks, production risks, and harvesting and marketing risks. This fact was implying that the small-scale shrimp farmers are the risk-seeking. Although the Indonesian government has developed the business insurance scheme for shrimp farmers since 2017, it only covered farms business from shrimp diseases and natural disaster risks. Thus, the farmers are strongly suggested to diversifying their income, especially from off-farm income sources to improve welfare and reduce the income fluctuation from shrimp farming. Moreover, policies that enhance access to ensuring shrimp farms activities should be put in place.

To improve welfare and reduce the fluctuation of farmers' income from shrimp farming, diversifying the income sources by off-farm investments should be encouraged. Off-farm

income strategies can reduce risks by offsetting the seasonal nature of shrimp farming income. Moreover, expanding the income sources should be promoted due to the shrimp farmers are willing to trade-off their income or use their saving as a form of self-insurance. Furthermore, the local government should enhance and support the credit access that includes in-farm and off-farm investments as represent of rural development.

The results of the study in Chapter 4 revealed that harvesting and marketing risks significantly impact on the farmers' perception of risk sharing and insurance strategies. In order to maintain sustainability in shrimp business, the farmers are highly recommended to spread the risks in their shrimp farms to the third parties through production contract, sharecropping, marketing contract or vertical integration. In addition, policies that enhance the opportunities to share the risk with the third parties should be encouraged. Last, this study has shown that risk in shrimp farming can be systematically managed as long as there are guidelines for managing those risks. Thus, policies that encourage availability the risk management framework are needed to maintain shrimp farmers' livelihood and sustainability of small-scale shrimp industry.

6.3 Recommendations for Future Studies

During the last decades, the risk management has been widely applied to manage the risks and uncertainties in the manufacture, finance, and agricultural sectors. However, developing and implementing the risk management framework in aquaculture that provides comprehensive information about the source of risk and management strategies is limited. Hence, this study tried to develop the framework that allows the shrimp farmers to manage their risk systematically.

Several recommendations have been prepared for potential future studies. First, the risk management framework in this study specifically developed for small-scale shrimp farming. In general, this framework could be adopted for other aquaculture businesses. However, the sources of risk and risk management strategies might have different scope and scale. Thus, the sources of risk and management strategies may need to examine using process and framework created in this study.

Second, to capture the real effectivity of risk management strategies, applying the advanced method, such as benefit-cost analysis, should be considered. Although all farmers did not implement the same risk management strategies in the same way, capturing the impact

of strategies in economic terms could give valuable information regarding the degree of efficacy of risk management strategies.

References

Ablaza, E. (2003). *Profile of the Indonesia Marine and Fisheries Sector. Proposed Technical Assistance for The Marine and Fisheries Sector Strategy Study, Indonesia.* Manila: Asian Development Bank.

Adji, Y. (2016, January 5). *Ekonomi*. Retrieved from Pikiran Rakyat: http://www.pikiran-rakyat.com/ekonomi/2016/01/05/355880/petambak-udang-windu-di-blanakan-merugi

Ahsan, D. A. (2011). Farmers' motivations, risk perceptions and risk management strategies in a developing economy: Bangladesh experience. *Journal of Risk Research*, 14(3), 325-349.

Ahsan, D. A., & Roth, E. (2010). Farmers' perceived risks and risk management strategies in an emerging mussel aquaculture industry in Denmark. *Marine Resource Economics, 25(3)*, 309-323.

Alam, A. Y. (2016). Steps in the Process of Risk Management in Healthcare. *Epidemiology & Preventive Medicine*, 1-5.

Andersen, T. J., & Schrøder, P. W. (2010). *trategic risk management practice: how to deal effectively with major corporate exposures.* Cambridge University Press.

Anderson, J., Valderrama, D., & Jory, D. (2017, June). Retrieved from Global Aquaculture Alliance: https://www.aquaculturealliance.org/wp-c/2017/06/Day1_JimAnderson.pdf

Aqua Culture Asia Pasific. (2013, July). Industrialisation with a super intensive; An innovation by SCI Sulawesi targets production of 100 tonnes/ha/crop . *Shrimp Culture*, pp. 12-14.

Arafani, L., Ghazali, M., & Ali, M. (2016). Detection of White Spot Syndrome Viirus in Litopenaeus vannamei in Lombok Island using Real-time Polymerase Chan Reaction. *Jurnal Veteriner*, 22-95.

Arthur, J., Bondad-Reantaso, M., Campbell, M., Hewitt, C., Phillips, M., & Subasinghe, R. (2009). *Understanding and applying risk analysis in aquaculture: a manual for decision-makers.* Rome: FAO.

Azzura, S. N. (2017, January 20). *Uang*. Retrieved from Merdeka: https://www.merdeka.com/uang/menteri-susi-sebut-laut-jadi-harapan-masa-depan-indonesia.html

Bartley, D., Bondad-Reantaso, M., & Subasinghe, R. (2006). A risk analysis framework for aquatic animal health management in marine stock enhancement programmes. *Fisheries Research, 80(1)*, 28-36.

Bergfjord, O. J. (2009). Risk perception and risk management in Norwegian aquaculture. *Journal of Risk Research*, 12(1), 91-104.

Bush, S. R., Van Zwieten, P. A., Visser, L., van Dijk, H., Bosma, R., de Boer, W. F., & Verdegem, M. (2010). Scenarios for resilient shrimp aquaculture in tropical coastal areas. *Ecology and society, 15(2)*.

Central Bureau of Statistics. (2015). *Statistical Yearbook of Indonesia 2015.* Jakarta: The Indonesian Central Bureau of Statistics.

Central Bureau of Statistics. (2016). *Statistical Yearbook of Indonesia 2016.* Jakarta: The Indonesian Central Bureau of Statistics.

Chandra, W. (2016, August 3). Retrieved from Mongabay: http://www.mongabay.co.id/2016/08/03/sungai-tallo-tercemar-petambak-udang/

Chuku, C. A., & Okoye, C. (2009). ncreasing resilience and reducing vulnerability in sub-Saharan African agriculture: Strategies for risk coping and management. *frican Journal of Agricultural Research, 4(11)*, 1524-1535.

Crikette, G., Drobnis, K., Egerdahl, R., Fox, C., Gjerdrum, D., Gofourth, R., . . . Zavatsky, D. (2011). *An overview of widely used risk management standards and guidelines.* New York: Risk and Insurance Management Society. Retrieved from https://www.rims.org.

Cross, J. (2000). Risk management. In T. Beer, *Risk Management and the Future* (pp. 1-12). Melbourne: Australian Minerals and Energy Environment Foundation.

de Wolff, C. J., Drenth, P. J., & Henk, T. (1998). *Handbook of Work and Organizational Psychology (2nd Edn) Vol. 2 Work Psichology*. East Sussex, UK: Taylor & Francis group.

Doubleday, Z., Clarke, S., Li, X., Pecl, G., Ward, T., Battaglene, S., . . . Stoklosa, R. (2011). Assessing the risk of climate change to aquaculture: a case study from south-east Australia. *Aquaculture Environment Interactions, 3(2)*, 163-175.

Dyspriani, P. (2007, May 29). *Master thesis.* Retrieved from Norwegian College of Fishery Science, University of Tromso: https://munin.uit.no/handle/10037/1008

EU Indonesia Business Network. (2017, April). *Sector Reports*. Retrieved from EIBN: http://indonesien.ahk.de/fileadmin/ahk_indonesien/Publications/EIBN/Fisheries_and_Aquaculture_Sector_Report_2017_FULL.pdf

Even, T. (2010). On how to define, understand and describe risk. *Reliability Engineering & System Safety, 95(6)*, 623-631.

FAO. (2003). *National Aquaculture Sector Overview: Indonesia*. Retrieved from Food and Agriculture Organization of the United Nations: http://www.fao.org/fishery/countrysector/naso_indonesia/en

FAO. (2016). *The State of World Fisheries and Aquaculture: Opportunities and Challenges.* Rome: Food and Agriculture Organization of the United Nations.

Ferasyi, T., Zulpikar, Sugito, Muchlisin, Z., Razalo, Nurlina, & Al Azhar. (2015). A preliminary study of White Spot Syndrome Virus (WSSV) infection on vannamei shrimp (Litopenaeus vannamei) cultured in semi-intensive ponds in Bireuen District of Aceh Province, Indonesia. *AACL Bioflux, 8(5)*, 810-816.

Flaten, O., Lien, G., & Tveteras, R. (2011). A comparative study of risk exposure in agriculture and aquaculture. *Food Economics-Acta Agriculturae Scandinavica, Section C, 8(1)*, 20-34.

Flaten, O., Lien, G., Koesling, M., Valle, P. S., & Ebbesvik, M. (2005). Comparing risk perceptions and risk management in organic and conventional dairy farming: empirical results from Norway. *Livestock Production Science, 95(1)*, 11-25.

Gebreegziabher, K., & Tadesse, T. (2014). Risk perception and management in smallholder dairy farming in Tigray, Northern Ethiopia. *Journal of Risk Research, 17(3)*, 367-381.

Global Business Guide Indonesia. (2016). *Agriculture*. Retrieved from Global Business Guide Indonesia: http://www.gbgindonesia.com/en/agriculture/article/2016/indonesia_s_fisheries_sector_under_a_new_paradigm_11566.php

Gloede, O., Menkhoff, L., & Waibel, H. (2015). Shocks, individual risk attitude, and vulnerability to poverty among rural households in Thailand and Vietnam. *World Development, 71*, 54-78.

Gunning, J. W. (2012). *Risk management and coping menchanism in developing countries.* London: Foresight.

Hadiyan, M. (2017, November 11). Retrieved from Kebumen Ekspres: http://www.kebumenekspres.com/2017/11/banjir-rob-43-hektar-tambak-di.html

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2006). *Multivariate Data Analysis.* Uppersaddle River: John Wiley & Son Ltd.

Hanafi, A., & Ahmad, T. (1999). Shrimp Culture in Indonesia: Key Sustainability and Research Issues. *ACIAR PROCEEDINGS* (pp. 69-74). ACIAR.

Hung, L. T., & Quy, O. M. (2013). On-farm feeding and feed management in whiteleg shrimp (Litopenaeus vannamei) farming in Vietnam. *On-farm feeding and feed management in aquaculture*, 337-357.

Indonesia, M. o. (2017, November 16). Retrieved from www.djpb.kkp.go.id: ww.djpb.kkp.go.id/index.php/arsip/c/246/Udang-Vaname-dan-Udang-Windu-Masih-Andalan-Ekspor-Indonesia/?category_id=13

IPSOS Business Consulting. (2016, August). *Innovation & Knowledge : Consumer & Shopper* . Retrieved from IPSOS Web site: https://www.ipsos.com/sites/default/files/2016-08/indonesia-aquaculture-industry.pdf

Jaeger, C. C., Renn, O., Rosa, E. A., & Webler, T. (2013). *Risk, uncertainty, and rational action.* New York: Routledge.

Just, D. R., Wolf, S., & Zilberman, D. (2003). Principles of risk management service relations in agriculture. *Agricultural Systems, 75(2-3)*, 199-213.

Just, R. E., & Pope, R. D. (2013). *A comprehensive assessment of the role of risk in US agriculture.* Springer Science & Business Media.

Kanona, R. M., & Tawalbeh, L. A. (2007). Retrieved from Jordan University of Science and Technology: http://www.just.edu.jo/~tawalbeh/aabfs/iss6753/presentations/RMP.ppt

Karduck, A. P., Sienou, A., Lamine, E., & Pingaud, H. (2007). Collaborative Process Driven Risk Management for Enterprise Agility. *IEEE International COnference on Digital Ecosystems and Technologies* (pp. 535-540). Cairns, Australia: Institute of Electrical and Electronics Engineers (IEEE).

Kilawati, Y. M., Maimunah, Y., & Ekawati, A. W. (2015). ICP11 as Biomarker for WSSV Disease in Litopanaeus vannamei. *Research Journal of Life Science Vol. 02 No. 03*, 183-188.

Knight, F. H. (1921). *Risk, uncertainty and profit.* New York: The Riverside Press.

Knight, K. (2010). Risk Management; A Journey Not a Destination. *Presentation to the RusRisk.* Moscow. Retrieved from Universita di Verona.

Kochenderfer, M. J. (2015). *Decision making under uncertainty: theory and application.* MIT press.

Larcher, M., Schonhart, M., & Schmid, E. (2016). Risk Perception and Assessment in Austrian Agriculture and Forestry. *Österreichischen Gesellschaft für Agrarökonomie (25)*, 221-230.

Le Bihan, V., Pardo, S., & Guillotreau, P. (2013). Risk perception and risk management strategies of oyster farmers. *Marine Resource Economics, 28(3)*, 285-304.

Le, T. C., & Cheong, F. (2010). Perceptions of risk and risk management in Vietnamese catfish farming: an empirical study. *Aquaculture Economics & Management, 14(4)*, 282-314.

Lebel, L., Lebel, P., & Lebel, B. (2016). Impacts, Perceptions and Management of Climate-Related Risks to Cage Aquaculture in the Reservoirs of Northern Thailand. *Environmental management, 58(6)*, 931-945.

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, P., Whangchai, N., Chitmanat, C., & Lebel, L. (2015). Climate risk management in river-based Tilapia cage culture in northern Thailand. *International Journal of Climate Change Strategies and Managemen, 7(4)*, 476-498.

Lekprichakul, T. (2009). Ex ante and ex post risk coping strategies: How do subsistence farmers in southern and eastern province of Zambia cope? *Research Institute for Humanity and Nature, Kyoto, Japan.*

Lucas, M. P. (2011). Risk perceptions, attitudes, and influential factors of rainfed lowland rice farmers in Ilocos Norte, Philippines. *Asian Journal of Agriculture and Development*, 8(2), 61.

Makoka, D. (2008). *Risk, risk management and vulnerability to poverty in rural Malawi.* Göttingen, Germany: Cuvillier Verlag, Inhaberin Annette Jentzsch-Cuvillier.

Marchant, D. D. (2003). *A study of the effects of dairy farmers' personalities on their risk attitudes, decision making processes and risk management.* St Lucia, QLD, Australia: PhD Thesis, The University of Queensland.

Martins, C., Eding, E., Verdegem, M., Heinsbroek, L., Schneider, O., Blancheton, J., . . . Verreth, J. (2010). New developments in recirculating aquaculture systems in Europe: A perspective on environmental sustainability. *Aquacultural Engineering, 43(3)*, 83-93.

Mayudin, A. (2012). Kondisi Ekonomi Pasca Konversi Hutan Mangrove Menjadi Lahan Tambak Di Kabupaten Pangkajene Kepulauan Provinsi Sulawesi Selatan. *Jurnal Eksos*, 90-104.

McDaniels, T., Longstaff, H., & Dowlatabadi, H. (2006). A value-based framework for risk management decisions involving multiple scales: a salmon aquaculture example. *Environmental science & policy, 9(5)*, 423-438.

MMAF. (2015). *Marine and fisheries in figures.* Jakarta: Ministry of Maritime Affairs and Fisheries.

MMAF. (2016, February 26). Retrieved from Kementerian Kelautan dan Perikanan: http://news.kkp.go.id/index.php/2016-target-capaian-produksi-perikanan-budidaya-meningkat-194-juta-ton/

Mo, Y. (2017, February 13). *Instalasi Pengolahan Air Limbah Tambak Udang Super Intensif*. Retrieved from ISW.

Murray, A., & Peeler, E. (2005). A framework for understanding the potential for emerging diseases in aquaculture. *Preventive veterinary medicine, 67(2)*, 223-235.

Naylor, R., Goldburg, R., Primavera, J., Kautsky, N., Beveridge, M., Clay, J., . . . Troell, M. (2000). Effect of aquaculture on world fish supplies. *Nature. Vol. 405*.

News, U. (2014, May 27). Retrieved from https://www.undercurrentnews.com: https://www.undercurrentnews.com/2014/05/27/indonesian-farmers-report-panic-selling-on-falling-shrimp-prices/

Ngo, T., Azadi, H., Tran, H., & Lebaily, P. (2017). Assessment of household risk management strategies for coastal aquaculture: the case of clam farming in Thaibinh Province, Vietnam. *Aquaculture International*, 1-18.

Nguyen, N. C. (2007). *Risk management strategies and decision support tools for dryland farmers in southwest Queensland, Australia.* Gatton, Queensland, Australia: PhD Thesis, The University of Queensland.

Nguyen, N. C., Wegener, M., & Russell, I. (2016). Risk perception, insurance recognition and agricultural insurance behavior–An empirical based on dynamic panel data in 31 provinces of China. *International Journal of Disaster Risk Reduction, 20*, 19-25.

Oktaviani, R., Nuryartono, N., Novianti, T., Irfany, M. I., Pasaribu, A. M., & Malina, A. C. (2009). *Contract Farming Options for Shrimp Production in Eastern Indonesia.* Canberra: Australian Centre for International Agricultural Research.

Perdana, A. (2005). *Risk management for poor and vulnerable.* Jakarta: CSIS.

Pimolrat, P., Niwooti, W., Chanagun, C., Jongkon, P., & Lebel, L. (2013). Survey of climate-related risks to Tilapia pond farms in northern Thailand. *International Journal of Geosciences, 4(05)*, 54-59.

Poernomo. (2004). Sejarah perkembangan dan pilihan teknologi budidaya udang di tambak. *National Symposium on Development and Scientific and Technology.*

Pratruangkrai, P. (2013, June 11). *Business*. Retrieved from The Nation: http://www.nationmultimedia.com/business/Diseases-cut-back-supply-of-shrimp-plants-30207990.html

Rabin, M. (2013). Risk aversion and expected-utility theory: A calibration theorem. In *Handbook of The Fundamentals of Financial Decision Making: Part I* (pp. 241-252). California: University of California.

Rachev, S. T., Stoyanov, S. V., & Fabozzi, F. J. (2011). *A probability metrics approach to financial risk measures.* John Wiley & Sons.

Rapoport, A. (2013). *Decision theory and decision behaviour.* Canada: Springer Science Business Media.

Raz, T., & Hillson, D. (2005). A comparative review of risk management standards. *Risk Management, 7(4)*, 53-66.

Renn, O. (2008). Concepts of risk: An interdisciplinary review part 1: Disciplinary risk concepts. *Gaia-Ecological Perspectives for Science and Society, 17(1)*, 50-66.

Renn, O. (2008). Concepts of risk: An interdisciplinary review part 2: Integrative approaches. *GAIA-Ecological Perspectives for Science and Society, 17(2)*, 196-204.

Rice, J. C., & Garcia, M. G. (2011). Fisheries, food security, climate change, and biodiversity: characteristics of the sector and perspectives on emerging issues. *ICES Journal of Marine Science, 68(6)*, 1343-1353.

Rimmer, M. A., Sugama, K., Rakhmawati, D., Rofiq, R., & Habgood, R. H. (2013). A review and SWOT analysis of aquaculture development in Indonesia. *Reviews in Aquaculture, 5(4)*, 255-279.

Rohrmann, B. (2008). Risk perception, risk attitude, risk communication, risk management: A conceptual appraisal. *In Conferencia presentada en la Sociedad Internacional de Gerenciamiento de Emergencias.*

Sangadji, R. (2014, January 20). *Central Sulawesi: Tech-savvy shrimp farming*. Retrieved from The Jakarta Post: http://www.thejakartapost.com/news/2014/01/20/central-sulawesi-tech-savvy-shrimp-farming.html

Seaman, T. (2014, June 18). Retrieved from Undercurrent News: https://www.undercurrentnews.com/2014/06/18/disease-tightens-indonesian-shrimp-supply-as-sellers-feel-prices-have-hit-bottom/

Segatto, M., Padua, S. I., & Martinelli, D. P. (2013). Business Process Management: A Systemic Approach? *Business Process Management Journal*, 698-714.

Sethi, S. (2010). Risk management for fisheries. *Fish and Fisheries, 11(4)*, 341-365.

Si, T. H., & Thi, H. N. (2015). Risk analysis: case study for coffee growers in the central highland area (Tay Nguyen), Vietnam. *International Journal of Economics, Commerce and Management Vol.3(8)*, 194-212.

Sidik, A. S. (2010). The Changes of Mangrove Ecosystem in Mahakam Delta, Indoensia; A Complex Social-environmental Pattern of Linkages in Resources Utilization. *Borneo Research Journal, Volume 4*, 27-46.

Sienou, A., Karduck, A., & Pingaud, H. (2006). Towards A Framework for Integrating Risk and Business Process Management. *Information Control Problems in Manufacturing* (pp. 647-652). Saint-Etienne, France: IFAC.

Sigit, R. (2013, October 25). *Lingkungan hidup*. Retrieved from Mongabay: http://www.mongabay.co.id/2013/10/25/ekonomi-lingkungan-pilih-mangrove-atau-tambak/

Sjöberg, L., Moen, B.-E., & Rundmo, T. (2004). *Explaining risk perception An evaluation of the psychometric paradigm in risk perception research.* Trondheim, Norway: Norwegian University of Science and Technology.

Standards Australia & Standards New Zealand. (2009). *Risk Management Guidelines; Companion to AS/NZS 4360:2004.* Sydney: SAI Global.

Stensland, S. (2013). Landowners' Perception of Risk Sources and Risk Management Strategies in Norwegian Salmon Angling Tourism. *Scandinavian Journal of Hospitality and Tourism, 13(3)*, 208-227.

Sustainable Fisheries Partnership. (2013). *Sustainable shrimp industry.* Surabaya: Sustainable Fisheries Partnership.

Sustainable Fisheries Partnership. (2016, April). *Cms Development.* Retrieved from Sustainablefish: http://cmsdevelopment.sustainablefish.org./%20form-05098e04.pdf

Tacon, A. (2016). *Indoaqua.* Retrieved from Directorate General Aquaculture: http://www.djpb.kkp.go.id/indoaqua/public/upload/images/medium/3.%20Tacon-Surabaya-1-Feed%20Ingredients-Final.pdf

Taukhid, & Nur'aini, Y. L. (2009). Infectious Myonecrosis Virus (IMNV) in Pacific White Shrimp (Litopenaeus vannamei) in Indonesia. *The Israeli Journal of Aquaculture - Bamidgeh 61(3)*, 255-262.

Temmy. (2017, February 1). Retrieved from Beritajatim: http://www.beritajatim.com/peristiwa/288935/tergenang_banjir,_160_hektar_tambak_udang_dan_bandeng_gagal_panen.html

Thaler, R. H. (2000). From homo economicus to homo sapiens. *The Journal of Economic Perspectives*, 14(1), 133-141.

Theodorou, J., Tzovenis, I., Adams, C., Sorgeloos, P., & Viaene, J. (2014). Risk factors affecting the profitability of the mediterranean mussel (Mytilus galloprovincialis Lamarck 1819) farming in Greece. *Journal of Shellfish Research, 33(3)*, 695-708.

Theuvsen, T. (2013). Risks and Risk Management in Agriculture. *Zeszyty Naukowe Szkoły Głównej Gospodarstwa Wiejskiego w Warszawie. Problemy Rolnictwa Światowego*, 162-174.

Thitamadee, S., Prachumwat, A., Srisala, J., Jaroenlak, P., Salachan, P. V., Sritunyalucksana, K., . . . Itsathitphaisarn, O. (2016). Review of current disease threats for cultivated penaeid shrimp in Asia. *Aquaculture 452*, 69-87.

Thompson, K. M. (2002). Variability and uncertainty meet risk management and risk communication. *Risk Analysis, 22(3)*, 647-654.

Towers, L. (2016, October 4). Retrieved from The Fish Site: https://thefishsite.com/articles/aquacultureeurope2016-shrimp-disease-causes-millions-in-losses-across-asia

Ullah, R., Shivakoti, G. P., & Ali, G. (2015). Factors effecting farmers' risk attitude and risk perceptions: the case of Khyber Pakhtunkhwa, Pakistan. *International journal of disaster risk reduction, 13*, 151-157.

Undercurrent News. (2014, May 27). Retrieved from Undercurrent News: https://www.undercurrentnews.com/2014/05/27/indonesian-farmers-report-panic-selling-on-falling-shrimp-prices/

Utari, H. B., Senapin, S., Jaengsanong, C., Flegel, T., & Kruatrachue, M. (2012). A haplosporidian parasite associated with high mortality and slow growth in Penaeus (Litopenaeus) vannamei cultured in Indonesia. *Aquaculture*, 85-89.

Van Raaij, W. F. (1981). Economic psychology. *Journal of Economic Psychology*, 1(1), 1-24.

Van Tongeran, F., Disdier, A.-C., Ilicic-Komorowska, J., Marette, S., & Von Lampe, M. (2010). *Case Studies of Costs and Benefits of Non-Tariff Measures: Cheese, Shrimp and Flowers.* Paris: OECD Food, Agriculture and Fisheries Papers, No. 28, OECD Publishing.

Vlahos, K. (2001). Tooling up for risky decisions. In K. Vlahos, *In Mastering risk volume 1: Concepts* (pp. 47-52). London, UK: Pearson Education Limited.

Widiyanto, D. (2017, January 17). Retrieved from KRJogja: http://krjogja.com/web/news/read/21875/Pencemaran_Petani_Pesisir_Purworejo_Gagal_Panen

Widodo, A. (2016, January 7). *Lingkungan*. Retrieved from National Geographic Indonesia: http://nationalgeographic.co.id/berita/2016/01/mencegah-kerusakan-mangrove-dan-wilayah-pesisir-di-lampung

Williams, A., Dowdney, J., Smith, A., Hobday, A., & Fuller, M. (2011). Evaluating impacts of fishing on benthic habitats: a risk assessment framework applied to Australian fisheries. *Fisheries Research, 112(3)*, 154-167.

Wirtz, B. W. (2011). *Business Model Management.* Speyer: German University of Administrative Sciences Speyer.

World Bank. (2005). *Managing agricultural production risk.* Washington DC: The International Bank for Reconstruction and Development.

WWF. (2017, June 22). Retrieved from Worlwildlife: https://www.worldwildlife.org/press-releases/wwf-research-finds-improved-environmental-performance-is-good-for-shrimp-aquaculture-business

Yamane, T. (1967). *Elementary Sampling Theory.* New Jersey: Prentice-Hall, Inc.

Zealand, S. A. (2009). *AS/NZS ISO 31000 : 2009, Risk management : principles and guidelines. Standards Australia.* Sydney, N.S.W: SAI Global.

Zott, C., Amit, R., & Massa, L. (2011). The Business Model: Recent Developments and Future Research. *Journal of Management*, 1019–1042.

Appendix

Appendix 1: The field survey questionnaire

Name : …….…….
Date : ..……..……..
Place : …….…….

Developing Risk Management Framework for Small-scale Shrimp Farming in Indonesia

The objectives of this research are:

1. To explore the sources of risk (on-farm and risk sharing) and risk management strategies in small-scale shrimp farming
2. To assess the potential impact and probabilities of risk and risk management strategies in small-scale shrimp farming
3. To evaluate risk management strategies in small-scale shrimp farming
4. To develop risk management framework for small-scale shrimp farming

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This questionnaire is a tool for collecting data used for the thesis research. This questionnaire was divided into three sections, which are:

Section 1 : Questions related to shrimp farmers characteristics
Section 2 : Questions related to sources of risks in shrimp farming
Section 3 : Questions related to risk management strategies in shrimp farming

Section 1.

Shrimp Farmers Characteristics

1. Sex / Gender : (a) Male (b) Female
2. Age (year) :
3. Education Levels :
4. Marital Status :
5. How many your family members do you have?
   (a) Male: (b) Female:
6. In what activities your family members are involved in the production process?

Family members	**Activities**					
	Land preparation	Pre cultivation	Operation (i.e. feeding, health check, etc)	Post Cultivation	Harvesting	Marketing

7. Shrimp farmer is your main occupation? Yes / No
8. If Yes, do you have secondary occupation?
   If No, what is your main occupation?
9. Please explain about your shrimp farms:

No. of Ponds	**Hectare**	**Status of your shrimp farms** 1. Private 2. Rent 3. Sharing 4. Others

10. On average, how much input did you use in the last crop?

Input	**Unit**	**Amount**	**Price per Unit**
Formulated Feed	kg per ha		
Shrimp Fry	head per ha		
Fertilizer	kg per ha		
Labor	Man days		

11. What was the actual yield per hectare and the selling price for the last crop

Ponds	**Yield (kg per ha)**	**Price (IDR per kg)**

12. Please indicated the largest fluctuation on your shrimp farms

Item	**Check (X)**			
	< 25%	25% - 49%	50% - 75%	> 75%
Annual yield per ha				
Annual average shrimp price				
Profit				

13. Do you have any technical support from outside?
   (a) Yes (b) No
14. If Yes, which ones of the following are the sources of support?
   (a) Local extension service (d) Relatives / Communities
   (b) Feeding company (e) Others
   (c) Processors

15. How did you sell your shrimp in the last production cycle
    (a) Directly to processors under contract
    (b) Directly to processors without contract
    (c) Wholesalers
    (d) Contract farming with others
    (e) Others
16. Related with shrimp farming, is there any kinds of contract farming in your location?
    (a) Yes
    (b) No

    If the answer is NO, please move to Section 2
17. Do you have any kind of contract farming related with your shrimp farms?
    (a) Yes
    (b) No

    If the answer is NO, please move to Question number 20
18. If Yes, what kind of contract farming do you have?
    (a) Share cropping
    (b) Production contract
    (c) Marketing contract
    (d) Insurance
    (e) Others
19. If Yes, which whom?
    (a) Processors
    (b) Feeding companies
    (c) Wholesalers
    (d) Shrimp farmers group
    (e) Others
20. If Yes, can you explain the right and duty from both parties on your contract farming?

Right	**Duty**

21. Why you do not want to join with contract?

Section 2.

Sources of Risks in Shrimp Farming and Shrimp Farmers' Perception of those Risks

In the following questions, please indicate the significant and the frequency of the following risks factors improve your income from shrimp farming

Note: To measure the significant level of risks, we use 5 points Likert scale as follows:

1: Least significant

2: Slightly significant

3: Moderately significant

4: Significant

5: Most significant

To measure the frequency of risks occur, we use 5 points Likert scale as follows:

1: Almost always

2: Often

3: Moderately

4: Slightly

5: Never

1. The significant and frequency of risk factors related to pond preparation and stocking shrimp fries

No	**Risk Factors**	**Significant (1 – 5)**	**Frequency (1 – 5)**
1	Inappropriate pond design		
2	Inappropriate pond location		
3	Lack of information about shrimp fries origin		
4	Low quality of shrimp fries (doesn't have certificate / SFP)		
5	Do not conduct treatment before stocking shrimp fries		
6	Excessive stocking density		
7	Inappropriate shrimp fries size		
8			

2. The significant and frequency of risk factors related to production

No	**Risk Factors**	**Significant (1 – 5)**	**Frequency (1 – 5)**
1	Low quality of formulated shrimp feed		
2	Water pollution due to excessive formulated feed		
3	Feeding management failure		
4			

3. The significant and frequency of risk factors related to harvesting and marketing

No	Risk Factors	Significant (1 – 5)	Frequency (1 – 5)
1	Harvesting without grading		
2	Inappropriate harvesting method		
3	Shrimp size variability		
4	Shrimp price volatility		
5			

4. The significant and frequency of risk factors related climate and diseases

No	Risk Factors	Significant (1 – 5)	Frequency (1 – 5)
1	High mortality due to diseases		
2	Climate change impact		
3	Flood		
4	Water polluted		
5			

5. The significant and frequency of risk factors related to finance and credit access

No	Risk Factors	Significant (1 – 5)	Frequency (1 – 5)
1	High interest rate for loan		
2	Lack collateral for loan		
3	Not enough capital to operating shrimp farms		
4			

6. The significant and frequency of risk factors related to internal factors

No	Risk Factors	Significant (1 – 5)	Frequency (1 – 5)
1	Lack of knowledge to prevent shrimp diseases		
2	Shrimp farmers doesn't have brackish water treatment facility		
3	Lack of knowledge of pond preparation		
4			

7. The significant and frequency of risk factors related to policy and institutional

No	Risk Factors	Significant (1 – 5)	Frequency (1 – 5)
1	Low level of awareness from shrimp farmers (community) about environmental protection		
2	Change government policy and regulation		
3			

8. The significant and frequency of risk factors related to external factors

No	Risk Factors	Significant (1 – 5)	Frequency (1 – 5)
1	Asymmetric information between buyer and farmers (price, supply, demand, quality, etc)		
2	Not enough labor supply		
3	High wages of hired labor		
4	Not enough formulated feed supply		
5	Increasing formulated feed price		
6	Lack of labor knowledge		
7			

Section 3.

Risk Management Strategies in Shrimp Farming

In the following questions, please evaluate the effectiveness of applying risk management strategies in protecting your shrimp farms

Note: To measure the effectiveness of applying risk management strategies, we use 5 points Likert scale as follows:

1: Not effective at all

2: Of little effective

3: Of average effective

4: Effective

5: Very effective

1. The significant and frequency of risk factors related to pond preparation and stocking shrimp fries

No	Risk Factors	Risk Management Strategies	Effectiveness (1 – 5)
1	Inappropriate pond design	Add water pumping and paddle wheel	
2	Inappropriate pond location	Located brackish water pond in designated area	
		Change to other activities	
3	Lack of information about shrimp fries origin	Selected good shrimp fries	
		Only buy shrimp fries from reliable places	
		Pay attention the shrimp fries when buying	
4	Low quality of shrimp fries (doesn't have certificate / SFP)	Only buy shrimp fries that have Specified Pathogen Free (SFP) certificate	
		Only buy shrimp fries from reliable places	
5	Do not conduct treatment before stocking shrimp fries	Strictly treat the pond before stocking shrimp fries	
		Following better management practices in shrimp farming	
		Attending workshop in shrimp farming	
6	Excessive stocking density	Attending workshop in shrimp farming	
		Following better management practices in shrimp farming	
		Reduce stocking density of shrimp fries	

7	Inappropriate shrimp fries size	Following better management practices in shrimp farming	
		Use large shrimp fries	
		Attending workshop in shrimp farming	

2. The significant and frequency of risk factors related to production

No	Risk Factors	Risk Management Strategies	Effectiveness (1 – 5)
1	Low quality of formulated shrimp feed	Checking the contents of formulated feed	
		Buying formulated feed from reliable brands	
2	Water pollution due to excessive formulated feed	Strictly feeding management	
		Following better management practices in shrimp farming	
3	Feeding management failure	Attending workshop in shrimp farming	
		Following better management practices in shrimp farming	
		Strictly feeding management	

3. The significant and frequency of risk factors related to harvesting and marketing

No	Risk Factors	Risk Management Strategies	Effectiveness (1 – 5)
1	Harvesting without grading	Production contract	
2	Inappropriate harvesting method	Following better management practices in shrimp farming	
		Attending workshop in shrimp farming	
		Production contract	
3	Shrimp size variability	Following better management practices in shrimp farming	
		Partial harvested	
		Attending workshop in shrimp farming	
		Production contract	
4	Shrimp price volatility	Sale contract to processor	
		Vertical integration	
		Cooperation marketing	

4. The significant and frequency of risk factors related climate and diseases

No	Risk Factors	Risk Management Strategies	Effectiveness (1 – 5)
1	High mortality due to diseases	Strictly manage brackish water quality	
		Following better management practices in shrimp farming	
		Reduce shrimp fries density	
		Hire technical assistance	
2	Climate change impact	Reduce brackish water pond size	
3	Flood	Enforcing the brackish water pond dyke	
4	Water polluted	Develop brackish water treatment	

5. The significant and frequency of risk factors related to finance and credit access

No	Risk Factors	Risk Management Strategies	Effectiveness (1 – 5)
1	High interest rate for loan	Use informal loan	
2	Lack collateral for loan	Use informal loan	
3	Not enough capital to operating shrimp farms	Make credit arrangement before production cycle	
		Reduce brackish water pond size	
		Share ownership of equipment	
		Sharecropping	

6. The significant and frequency of risk factors related to internal factors

No	Risk Factors	Risk Management Strategies	Effectiveness (1 – 5)
1	Lack of knowledge to prevent shrimp diseases	Strictly manage brackish water quality	
		Following better management practices in shrimp farming	
		Attending workshop in shrimp farming	
2	Shrimp farmers doesn't have brackish water treatment facility	Develop brackish water treatment	
3	Lack of knowledge of pond preparation	Following better management practices in shrimp farming	
		Attending workshop in shrimp farming	

7. The significant and frequency of risk factors related to policy and institutional

No	Risk Factors	Risk Management Strategies	Effectiveness (1 – 5)
1	Low level of awareness from shrimp farmers (community) about environmental protection	Develop brackish water treatment	
		Following better management practices in shrimp farming	
		Attending workshop in shrimp farming	
2	Change government policy and regulation	Follow the government development (policy, regulation, etc) that related to shrimp farming	

8. The significant and frequency of risk factors related to external factors

No	Risk Factors	Risk Management Strategies	Effectiveness (1 – 5)
1	Asymmetric information between buyer and farmers (price, supply, demand, quality, etc)	Collect information related to shrimp price, demand, supply, quality, etc	
		Sale contract to processor	
2	Not enough labor supply	Family labor	
3	High wages of hired labor	Family labor	
4	Not enough formulated feed supply	Contract farming	
5	Increasing formulated feed price	Strictly feeding management	
6	Lack of labor knowledge	Following better management practices in shrimp farming	
		Attending workshop in shrimp farming	

Appendix 2: Documentation of the field survey

Shrimp pond preparation

Releasing the shrimp fries

Feeding preparation

Feeding the shrimp

Checking the shrimp growth

Checking the shrimp growth

Checking brackish water qualities

Maintenance the equipments

Harvesting the shrimp

Grading the shrimp