Production Efficiency Analysis for White Shrimp (*Panaeus vannamei*) Aquaculture Farms in Lamongan Regency, East Java Province, Indonesia

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ABSTRACT

The main objectives of this study were to: 1) study the socio-economic characteristics of small-scale white shrimp farmers; 2) study the existing conditions of small-scale white shrimp farming of the farmers, consisting of white shrimp farming characteristics, production, marketing and problems in white shrimp farming; 3) examine the main factors affecting shrimp production; 4) measure the efficiency of input use in shrimp production. Data was collected from 125 small-scale white shrimp farmers through the period of November 2011 and January 2012. Data was analyzed using the ordinary least square (OLS) multiple regression technique. The level of efficiency inputs used in white shrimp production was calculated by comparing the value of marginal product (*VMP*) of each input with the prices of inputs (P_x).

The results revealed that white shrimp farmers are 44 years of age on average. Each household has an average of 3.7 family members. White shrimp farmers attended school for an average of 9.3 years. They have had experience in shrimp production for 6 years. Eighty percent of the farmers produced shrimp as their main occupation. The majority (72.8%) of the farmers occupied land below one ha, with an average of 0.78 ha per household. Around one-third of the farmers had access to credit services. Most farmers had 1-2 shrimp ponds, with an average pond size of 0.42 ha. Most of the ponds are rectangular. The farmers used an average amount of

around 6.4 tons of fertilizer per ha. The average amount of shrimp fries, applied in shrimp cultivation, was 931,750 fries per ha. Most of the fries were from private sources. The farmers used formulated feed and labour of around 23,850 kg and 188 man-days per ha, on average respectively. The farmers produced white shrimp two crops a year. The average amount of shrimp harvested was 13,116 kg per ha per crop. More than half of the farmers produced a big size of shrimp, at no less than 50 heads per kg. Nearly two-thirds of the farmers sold their shrimp to both wholesalers and retailers at an average price of 46,375 IDR per kg. Shrimp farmers also faced key problems in shrimp production. These were shrimp diseases, lack of capital, low shrimp prices, poor quality of shrimp fry, water pollution, and high production costs respectively.

The results of the regression analysis also showed that double-log functional form had the best fit in explaining the relationship between output of white shrimp and inputs used. The coefficient of determination (*Adj.* $R^2 = 0.840$) indicated that 84% of variation in output was explained by the independent variables. The estimated coefficients are positive; the coefficients of labour, fertilizer, feed, and stocking density are 1.653, 0.106, 0.589 and 0.302 respectively. Furthermore, labour, feed, and stocking density significantly affects the output of white shrimp at $\alpha = 0.01$, while fertilizer at $\alpha = 0.1$. The allocative ratio for labour, fertilizer, feed, and stocking density was 80.9, 0.2, 1.2, and 3.9 respectively. These indicated that labour, feed and stocking density were under-utilized, having allocative efficiency ratios greater than one. While fertilizer with an allocative efficiency ratio below one, was over-utilized.

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AE	Allocative Efficiency
AP	Average Product
EE	Economic Efficiency
FAO	Food and Agriculture Organisation of the United Nations
FCR	Feed Conversion Ratio
IDR	Indonesian Rupiah
IMV	Infectious Myonecrosis Virus
MFC	Marginal Factor Cost
MMAF	Minister of Marine Affairs and Fisheries, Republic of Indonesia
MP	Marginal Product
OLS	Ordinary Least Square
PL	Post Larvae
SPF	Specific Pathogen Free
TE	Technical Efficiency
TFC	Total Factor Cost
TP	Total Product
VMP	Value of Marginal Product
WSSV	White Spot Syndrome Virus

CHAPTER 1

Introduction

1.1 Statement of the Problems

Aquaculture plays an important role to Indonesian fisheries in providing employment, food security, income, foreign exchange and securing livelihoods for its people (Nurdjana, 2006; Herianto, 2010). In addition, aquaculture activities can also reduce the pressure on fishery resources by supporting rural economic development (FAO, 2010).

According to the Marine and Fisheries Statistics (MMAF, 2010), there were 1,099,684 households involved in the aquaculture industry, representing around 60.17% of the total number of people employed in the fisheries sector in 2009. Indonesian aquaculture grew rapidly with an average growth rate of 21.47% between 2005 and 2009 (MMAF, 2010). In 2009, Indonesia aquaculture production reached 4.70 million metric tons with a value of IDR 40,584,000 million. Indonesia was the fourth ranking of the top ten producing countries for aquaculture in the world by 13.7% (FAO, 2010).

The main activity and source of investment in aquaculture is shrimp farming. Following the government regulation no. 39/1980 regarding the prohibition of the use of trawlers in catching shrimp, shrimp farming in Indonesia has become one alternative to support the national shrimp production. Shrimp production has grown significantly from 280,629 metric tons in 2005, and then production in 2009 was reported to have risen to 338,062 metric tons. This represents an average annual increase of 5.73% in quantity since 2005. Shrimp continues to be the most important commodities traded in value terms, accounting for 40.85% of the total value of export fishery products in 2009 (MMAF, 2010).

Shrimp farming produced for more than half of the Indonesian shrimp production. The five major shrimp producing provinces, during 2005 until 2009, are indicated in Table 1.1. In 2009, the main provinces were South Sumatera, Lampung, and the East Java Province. The production of white shrimp in each area reached 21.57%, 19.35%, and 11.46% of national shrimp production, respectively.

Table 1.1 Major Shrimp Producing Provinces in 2005 – 2009

Unit: Metric Ton

Provinces	Years				
	2005	2006	2007	2008	2009
South Sumatera	21,448	26,585	32,222	38,005	72,908
Lampung	114,150	149,680	152,423	145,880	65,424
West Java	24,486	27,932	30,569	36,579	27,922
East Java	22,799	22,065	27,075	27,972	38,730
South Sulawesi	24,125	13,228	14,139	19,934	17,829
Others	73,621	88,129	103,668	141,224	115,249
Total	280,629	327,619	360,096	409,594	338,062

Source: MMAF, 2010

An increase in shrimp production triggered by export, local consumer demand and the government policy on fishery was revitalization in 2005. Fishery revitalization policies were emphasis on selected commodities, which were tuna, shrimp and seaweed. Furthermore, the government stated that Indonesia should consider white shrimp as a source of raw materials for the processing industry and enhancement of export volume from aquaculture commodities.

To support the fishery revitalization policy, the extensive black tiger shrimp brackish water ponds with an area of 140,000 ha (40% of extensive brackish water ponds) has been shifted to extensive white shrimp farming with a target production of 0.6–1,5 metric ton/ha/year. In addition, more than an area of 8,000 ha of intensive black tiger shrimp brackish water ponds has been shifted to intensive white shrimp farming with a target production of 20-30 metric ton/ha/year (MMAF, 2006).

In accordance with the program to increase fishery production, in 2010, the Indonesian government, through the Minister of Marine Affairs and Fisheries (MMAF) issued policies to develop 41 fishery areas in Indonesia. These were based on the potential of each area, such as: seaweed, catfish, shrimp, tilapia, and grouper. These programs called the Minapolitan Policy, consisted of nine fishing based areas, 24 aquaculture areas and eight salt areas. In East Java Province, the two areas that have been selected to produce shrimps were Gresik and Lamongan Regency.

Lamongan Regency is one of the largest areas of brackish water ponds in the East Java Province with areas of brackish water pond being 1,745 ha. In 2009, total aquaculture production has been reported to reach 3,606 metric tons. This was dominated by white shrimp as the main commodity by 52.9%. Total white shrimp farmers that involved in white shrimp farming reached 683 farmers (Table 1.2).

The majority of white shrimp farmers in Lamongan Regency are small-scale farmers. Based on annual reports issued by the Department of Marine and Fisheries of Lamongan Regency, white shrimp farmers who have brackish water ponds less than one ha reached 496 farmers, while the rest possess brackish water ponds at least one ha.

Table 1.2 Total Shrimp Household in Lamongan Regency
Classified by Shrimp Pond Area

Shrimp Pond Area (ha)	Total Shrimp Households
< 1	496
1 – 2	121
> 2	66
Total	683

Source: MMAF, 2010

In general, shrimp was cultivated in brackish water ponds with different levels of cultivation systems. Cultivation systems that applied were in shrimp farming depended on the presence or absence of water exchange management, biomass and water quality monitoring, fertilization, aeration system, the mechanism of food and stocking density levels. Based on cultivation used in the production, shrimp farming in Indonesia was divided into four systems, which are traditional, extensive, semi-intensive and intensive systems (MMAF, 2006).

To support the government policy, in order to increase national shrimp production, white shrimp farmers in Lamongan Regency used the intensive system in their shrimp cultivation. Intensive system in shrimp cultivation comes at a high cost. On the other hand, white shrimp farmers in this area were dominated with small-scale farmers. In production, small-scale farmers are often faced with the problems of scarcity of resources as their inputs of production, due to limited capital and brackish water pond area.

The efficiency of inputs use is one of the important factors to improve shrimp farms production. Efficiency of inputs used in the production such as labor, feed, shrimp fry and other inputs will ensure economic performance of shrimp production. Therefore, it is important to study the efficiency of production in shrimp farms.

1.2 Objectives

This research has the following objectives:

1) To study the socio-economic characteristics of small-scale white shrimp farmers (who use intensive systems) in Lamongan Regency, the East Java Province, Indonesia.
2) To study the existing conditions of small-scale white shrimp farming of the farmers, consisting of white shrimp farming characteristics, production, marketing and problems in white shrimp farming.
3) To investigate the main factors affecting production of small-scale white shrimp farming of the farmers in study area.
4) To measure the efficiency of input use in the production of white shrimp farms in the study area.

1.3 Scope of Study

1) Study Area

The selected shrimp farming area is the East Java Province, Indonesia. Currently, the East Java Province is the third largest shrimp producing province, below South Sumatera and Lampung Province. The specific region in the East Java Province is Lamongan Regency. Lamongan Regency was selected due to one of the largest white shrimp producing areas in the East Java Province.

Areas of brackish water ponds in Lamongan Regency are 1,745 ha, spread along the northern coast of Java island, in the Brondong District. In 2009, total aquaculture production has been reported to reach 3,606 metric tons, dominated by white shrimp as the main commodity by 52.9% (MMAF, 2010). Therefore, Brondong district was purposively selected for the study.

2) Population

Population of this study is small-scale white shrimp farmers who have brackish water ponds below five ha that use intensive systems. Brackish water pond with intensive systems in this study defined as; “brackish water ponds that uses formulated feed, water pumping and aerators with stock density is more than 50 fry per m^2”. Total population of small-scale white shrimp farmers that use intensive system in Brondong District reached 683 white shrimp farmers (MMAF, 2010).

3) Analysis

To answer the objectives, this study conducted some analysis methods, which are descriptive analysis such as; frequencies distribution and quantitative analysis such as; regression analysis, and efficiency analysis. Three functional forms, which are log-linear, double-log and linear-log were used to determine the main factors affecting production of small-scale white shrimp farming.

4) Data Collection

The data that has been used to answer the study objectives are secondary and primary data. Primary data that was used in this study was the last production data (first crop in 2011) from each small-scale white shrimp farmer selected as respondents. Data collection was conducted in November 2011 to January 2012.

1.4 Study Benefits

Efficiency is one of the problems faced by the farmers in Indonesia. The findings of this study will help informing white shrimp farmers in Indonesia towards the possibility of increasing productivity, by improving the efficiency of input used.

Secondly, the results of this study are expected to provide information and recommendations to the government officials in concerning institutions such as Marine and Fisheries Department, Extension Officers in formulating appropriate policies and projects to develop Indonesian shrimp production and economic status of shrimp farmers.

1.5 Definitions

The definitions used in this study are presented below.

1) Small-scale shrimp farmer

A small-scale shrimp farmer typically has less than five ha in total brackish water pond area, and usually operated the farms activities by family members and sometimes hired labor.

2) Intensive system

Intensive system in white shrimp farming is the system that use formulated feed, fertilizer, water pumping and paddle wheels. Stock density is more than 50 fry per m^2. Yield of white shrimp and production costs are generally high.

3) Fertilizer

Fertilizer is all kinds of natural and synthetic materials applied in shrimp production to increase pH of brackish water pond and stimulate plankton growth. Fertilizer used in shrimp farming consists of lime, dolomite, urea, and bran.

1.6 Organizing of Study

The thesis is organized into five chapters. The first chapter presents introduction; consisting of statement of problems, objectives, scope of the study, study benefits, definition, and organizing of study. Literature review is described in the second chapter followed by the third chapter on research methodology. The fourth chapter presents the results and discussions of study. Finally, conclusions and recommendations are presented in chapter five.

CHAPTER 2

Literature Review

The purpose of this study is to investigate the efficiency of input usage in the production of white shrimp farming. Chapter two provides a review of literature on the study and previous empirical findings related to efficiency of input use in production process. This chapter is divided into three sections, which are 2.1) shrimp farming in Indonesia, 2.2) production and efficiency concepts, and 2.3) related research.

2.1 Shrimp Farming in Indonesia

2.1.1 Historical Background, Production and Marketing

Aquaculture has a long history in Indonesia, starting with the milkfish (*Chanos chanos*) farming in Java Island. Until 1960, the brackish water ponds culture is only used for the cultivation of milkfish. Subsequently, wild shrimp larvae were introduced into the brackish water ponds and grown extensively either in monoculture or polyculture with milkfish. Extensive shrimp culture was initiated in South Sulawesi in the mid 1960s and spread to other islands in Indonesia with suitable environments. The first shrimp hatchery in Indonesia was commissioned in the early 1970s in Makassar, South Sulawesi Province followed by Jepara, Central Java Province (Poernomo, 2004)

The shrimp species that are cultivated in Indonesia are still limited. These are black tiger shrimp (*Penaeus monodon*), white shrimp (*Penaeus vannamei*), rostris shrimp (*Litopenaeus stylirostris*), green shrimp (*Penaeus semisulctus*), pink shrimp (*Metapenaeus*) and *Penaeus indicus.* The shrimp fries of black tiger, white shrimp and rostris have been cultured in hatcheries, but other shrimp fries, are still caught as wild shrimp in limited quantity (Dyspriani, 2007). White shrimp and rostris shrimp are not native species from Indonesia. The Government introduced these species in 2000 and 2001, respectively.

Some characteristics of shrimp farming in Indonesia are small farms, local ownership, low capital, technology, and productivity. According to size of management and input factors, shrimp farming is classified into small, medium and large scales. Small-scale farms are typically less than five ha in total brackish water pond areas usually operated by a family group and sometimes hired labour, and a low level of management.

This results in low productivity and production of shrimp. Medium scales have a total area of brackish water ponds of about 5 to 40 ha. They have some seasonal local labour, medium facilities, and improved management. Large scales have high tech facilities along with controlled management, and use the intensive system with a high stock density of shrimp fry, which results in high productivity. They also require paid technicians and scientific staff to support their activities, because they are profit oriented.

In terms of cultivation systems that are applied in shrimp farming, it varies from location to location. Based on cultivation used in the production, shrimp farming in Indonesia is divided into four systems. These being traditional, extensive, semi-intensive and intensive systems.

Traditional systems used little or no fertilization and no supplementary feeding with low production costs, biomass rates are below 10 fry per m^2.

Then, extensive systems use fertilizer to grow plankton as a source of shrimp feed, and sometimes uses formulated feeds and water pumping with the densities between 10 to 25 fry per m^2.

Semi-intensive systems use more regularly inputs with higher densities between 26 to 50 fry m^2.

Intensive systems use formulated feed (made from various kinds of fish meals with added nutrient and vitamins), water pumping and aerators. Stock density is much higher (more than 50 fry per m^2) and production costs are generally high.

In the past, most of the shrimp farmers in Indonesia cultivated species of black tiger shrimp (*Penaeus monodon*). But since they faced a harvest failure in the last few years, due to the outbreaks of shrimp diseases, some of them tried to cultivate white shrimp (*Penaeus vannamei*) and rostris shrimp (*Litopenaeus stylirostris*). The recent fast growth of white shrimp cultivation is due to a faster reproduction rate than black tiger. White shrimp also has a stronger endurance capacity than black tiger shrimp, and can be cultivated with a higher biomass density. Rostris farming does not develop well, because it cannot be cultivated at a high density unlike white shrimp, and the price is lower than black tiger shrimp.

The development of shrimp farming has created wide impacts. Several studies have shown the positive and negative impacts of shrimp farming. The research done by Kongkeo (1997) about intensive shrimp farming systems in Indonesia, Philippines, Taiwan and Thailand concluded that small scale and intensive systems provide considerable socio-economic benefits. Kusumastanto, *et al*., (1998) compared with the impact of shrimp farming system in Indonesia: extensive, semi-intensive and intensive to the local community, as well as different farm sizes: small-scale (2 ha), medium (5 ha), large (10 ha) and extra large scale (30 ha). He argues that small and medium scale, with semi-intensive farming, generates more employment opportunities and economic benefits for rural communities. Sano (2000) studied the socio-economic impact of shrimp farming in South Sulawesi, and concluded that the impacts of shrimp farming depended on socio-economic and ecological conditions of each country, region, community, social actor and intervention of the Indonesian Government through the program.

Shrimp farming contributes in generating income through creating employment opportunities and foreign exchange earnings. On the other side, it causes the degradation of the environment, soil acidification, loss of valuable land (for agriculture) and mangrove and also brings unequal profit.

In 2009, Indonesia had 17.7 million ha areas with a potential for aquaculture, consisting of 2.9 million ha with a potential for brackish water pond farming, 2.2 million ha with a potential for fresh water farming and 12.5 million ha with a potential for marine culture (Table 2.1). Currently, exploitation of this potential has only reached 23.04% for brackish water pond farming and 0.34% for marine culture.

Table 2.1 Potency of Aquaculture Area and Usage Level in Indonesia, 2009

Type of Aquaculture	Potentiality (ha)	Usage (ha)	Developing Opportunity (ha)
1. Brackish Water	2,963,717	682,726	2,280,991
2. Marine Culture	12,545,072	42,675	12,502,396
3. Fresh Water:			
3.1 Pond	541,100	187,324	353,776
3.2 Inland Openwater	158,125	1,600	156,519
3.3 Paddy Field	1,536,289	127,679	1,408,610
Total	17,744,303	1,042,004	16,702,292

Source: MMAF, 2010

Millions of people in Indonesia depend on fisheries and aquaculture for their livelihoods. In 2009, number of households from aquaculture accounted for 60.17% from the total number of fishery households (MMAF, 2010).

As shown in Table 2.2, during the 2005 - 2009, the number of fish farmers in Indonesia has been increasing from 1.7 million to 2 million or increasing at a rate of 3.5% per year. In 2009, an estimated 2 million people worked as fish farmers. Significant increases over the past five years reflect the strong expansion of aquaculture activities. The number of fish farmer from brackish water ponds has a growth of about 1.6% per year, marine culture grows about 12.7% per year and fish farmers from fresh water pond show a growth of about 2.5% per year since 2005.

Table 2.2 Number of Fishery Households and Fish Farmers

Types	Years				
	2005	2006	2007	2008	2009
Fishery Household					
Brackish Water	233,318	254,256	277,783	219,291	232,543
Marine Culture	44,653	72,848	88,281	96,038	119,851
Freshwater	819,712	796,054	724,184	759,915	759,694
Total	1,097,683	1,123,158	1,090,248	1,075,244	1,112,088
Fish Farmers (People)					
Brackish Water	445,643	482,161	482,161	469,100	470,828
Marine Culture	101,400	134,419	134,419	232,274	278,613
Freshwater	1,162,590	1,144,557	1,144,557	1,166,138	1,332,782
Total	1,709,633	1,761,137	1,761,137	1,867,512	2,082,223

Source: MMAF, 2010

Over the last few decades, areas for shrimp farming in brackish water ponds and production have increased significantly. This expansion was triggered by an increase in demand for exports and domestic usage. The government policies on the prohibition to trawl to catch shrimp in 1980 also affected the growth of shrimp farming in brackish water ponds. According to the Fisheries Statistic Data from FAO (2010), the total of Indonesian shrimp production in 2009 reached 337,014 metric tons, consisting of 170,969 metric tons of white shrimp, black tiger at 124,561 metric tons, banana shrimp amounting to 22,364 metric tons and pink shrimp for 19,120 metric tons (Figure 2.1).

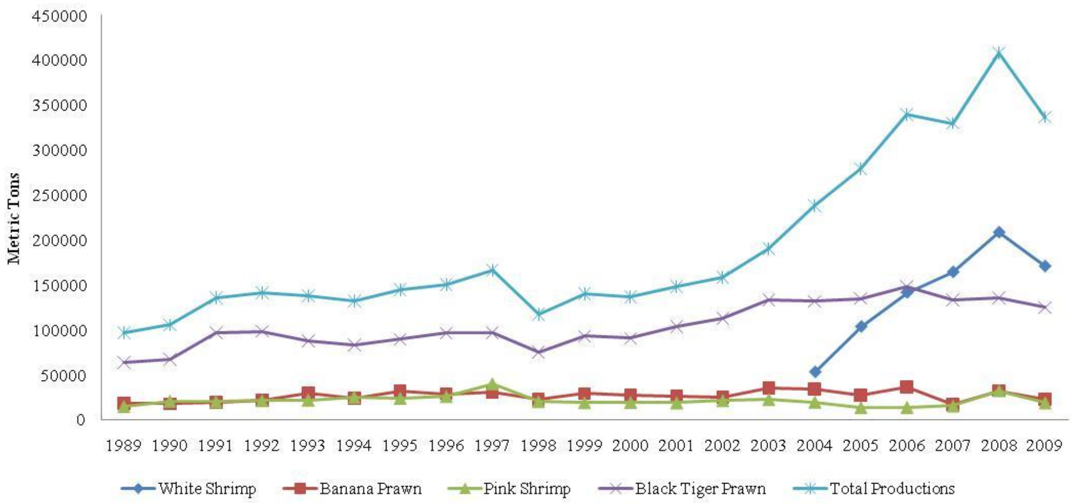

Figure 2.1 Indonesia Shrimp Production for Selected Species

Source: FAO, 2010

Shrimp farming in Indonesia is mainly export oriented. More than 55% of the national shrimp productions are exported, while about 45% are consumed in the local market. In 2009, the main destination of these exports are the United States (42.1%), Japan (25.5%), the European Union (15.7%) and 16.7% for others countries (Table 2.3). Black tiger is preferred in Japan, while the USA and the EU prefer white shrimp. Black tiger is exported to Japan's market as head-on, headless shell-on, peeled tail-on nobashi and PUD (peeled and cooked shrimp) (MMAF, 2010).

Table 2.3 Export of Shrimp Based on Volume and Value

Volume unit: Metric Ton; Value unit: US $ 000

Items	Years					Percentage (2009)
	2005	2006	2007	2008	2009	
Export Volume						
1. US	50,389	61,235	60,399	80,479	63,592	42.1
2. Japan	45,951	50,581	40,334	39,582	38,528	25.5
3. EU	27,180	35,232	28,845	26,825	23,689	15.7
4. Others	30,180	22,281	27,967	26,397	25,180	16.7
Total	153,900	169,329	157,545	173,283	150,989	
Export Value						
1. US	344,783	418,556	420,334	550,773	426,995	41.2
2. Japan	381,783	420,525	334,982	337,681	333,656	34.5
3. EU	152,625	196,430	178,195	117,855	145,597	15.1
4. Others	109,343	80,725	96,083	96,306	100,833	9.2
Total	988,198	1,115,963	1,029,935	1,102,615	1,007,081	

Source: MMAF, 2010

2.1.2 Shrimp Farming in Lamongan Regency

Lamongan Regency was one of the biggest producing of fisheries product in East Java Province. Farmers in lamongan regency cultivated milkfish (*Chanos chanos*) in brackish water pond for the long time before substituted to cultivated white shrimp.

White shrimp farming was starting in late 2000’s and spread into six villages along the northern coast of Java island, which are Labuhan Brengkok, Sedayu Lawas, Kranji, Tlogosadang, and Kandang Semangkon. In 2009, total brackish water pond area for shrimp cultivation was 1,745 ha (MMAF, 2010).

Based on annual reports issued by the Department of Marine and Fisheries, total farmers that were involved in white shrimp farming reached 683 farmers. Shrimp farmers in Lamongan Regency are small-scale farmers. A small-scale farmer typically has less than five ha in total brackish water pond area, and usually operated the farms activities by family members.

Shrimp farmers in Lamongan Regency produced white shrimp twice a year. The first crop started in March until August, and the second crop started in September and harvesting in February. In general, shrimp farmers in Lamongan Regency used intensive system in their shrimp cultivation. In 2009, total aquaculture production has been reported reach 3,606 metric tons, and dominated by white shrimp as the main commodity by 52.9%.

2.1.3 Problems in Shrimp Farming

The shrimp harvest failures are complex problems, which can be caused by internal and external factors. The internal factors include the problems related to management of brackish water pond. The factors consists of technical (site selection, brackish water pond design, insufficient quality of shrimp fry, degradation of environment, diseases, water pollution from human activity, management) and non-technical constraints (price, production cost, capital). The external factors are caused by unpredictable conditions, such as the impact of globalization (global market), disasters (tsunami, extreme weather, flood, and earthquake) and strict requirements to export from importing countries (Dyspriani, 2007).

In general, the main problems faced by shrimp farming in Indonesia are as follows;

1) Environmental degradation

The majority of shrimp farming in Indonesia uses extensive and semi-intensive systems which were susceptible to environmental influences. It is also related also to the design and layout of brackish water pond which use the same irrigation canal for water entrance and exit. The extensive systems of brackish water ponds that receive water from other sources have an impact to the deterioration of water quality in brackish water ponds. Sediment damage in brackish water pond also causes the shrimp mortality. Widiyanto, (2006) reported that the sediment damage due to the high amount of toxic pollutants (compound of ammonia, nitrite, sulfide acid and carbon), which are accumulated in brackish water ponds. The brackish water ponds needs treatment before used to avoid lower survival rate of the shrimp.

2) Shrimp disease

Spread of the disease has become a major problem in shrimp farming over the last few years. One of shrimp's characteristics is cannibals. The shrimp will eat the dead shrimp, which have died of disease. This behavior accelerates the infectious disease, which is spread into all brackish water ponds and causes massive mortality of shrimp.

The decline of water quality due to water pollution from outside brackish water ponds, and the accumulation of feed, shrimp faces, fertilizer in bottom of brackish water ponds, stress the shrimp. When shrimp is stressed, they loss their body resistance to viruses and it is very easy for them to become infected by diseases. The decline of water quality in brackish water ponds and the decrease of carrying capacity of the environment have stressed the shrimp become stress. It has accelerated the spread of diseases, caused slow growth of shrimp, and massive mortalities in brackish water ponds. The problem of diseases could not be solved until now, because the factors of the diseases are complex, and there is no proper way to combat the disease, except to maintain a good environment.

3) Disaster problems

Most of the shrimp farming in Indonesia is located in the coastal areas. These areas are close to problems of natural disasters such as tsunamis, earthquakes, floods and extreme weather. The earthquake in Aceh (December 2006), Pangandaran and Central Java (July 2006), along with floods and extreme weather in East Java are examples that have occurred in Indonesia. These disasters are unpredictable and have a negative impact not only for the society, but also to the damage of brackish water ponds in some central shrimp production areas. The disasters caused harvest failure and a loss of profit for the shrimp farmers. The facilities and infrastructures of brackish water ponds were also destroyed. It has affected the shrimp production.

4) Other factors.

Other factors are related to the operational management and socio culture condition of shrimp farmers. It includes technical constraints, higher shrimp operational cost while lower shrimp price, lack of knowledge and capital.

Technical constraints are related to the inability of shrimp farmers to apply appropriate cultivation system that affects the quantity and quality of shrimp. The operational cost to cultivate shrimp is relatively high, especially for those who use intensive system that needs more management inputs, while the shrimp price always fluctuates. The increasing price of fuel and oil, followed by the increasing the price of shrimp production facilities, such as formulated feed, shrimp fry, and fertilizer, led to the increase of shrimp production costs. The farmers also do not have enough information about the government policy related to shrimp farming.

2.2 Production and Efficiency Concepts

2.2.1 Production and Production Function

Coelli, *et al*. (1998); Debertin (2002) explains that the process of agricultural production is an activity in creating and adding the utility of goods or services by using labour, production inputs (seeds, fertilizers, and pesticides), capital and skills as an input. Then, the production function is the physical relationship between the dependent variables (Y) with an independent variable (X). Dependent variable (Y) is usually output and independent variable (X) in the form of input (Soekartawi, 2003; Rasmussen, 2011). Mathematically the production function is written as follows:

$$Y = f\{X_1, X_2, \dots, X_n\} \qquad 2.1$$

Where Y is representing output of production, and X are variables of input. Production functions are able to show the relationship between input and output directly. When the production function is known, then the price and cost information can be used to find the best combination of inputs in a production process.

Classical production function divided into three production areas. These areas are distinguished based on the elasticity of production, which is product changes resulting from changes in production factors (Beatti, *et al*., 1985). These areas are shown by region I, region II, and III regions in Figure 2.2

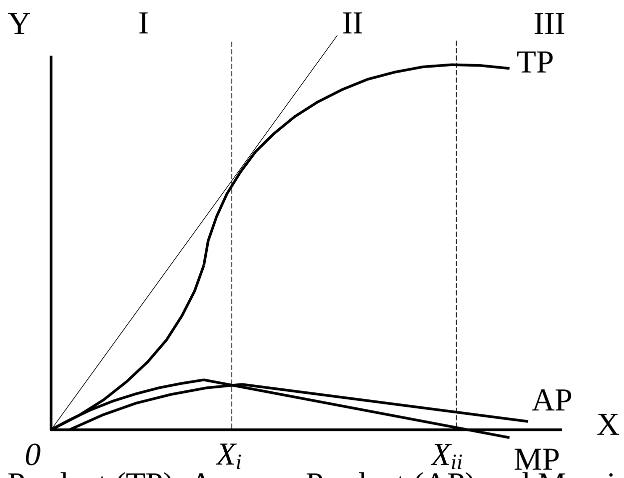

Figure 2.2 Total Product (TP), Average Product (AP) and Marginal Product (MP)

Source: Beattie, *et al*., (1985)

In the region I, which lies between 0 and X_i, has a value of elasticity of more than one, meaning that an additional unit of input used in region I, total production will increase at increasing rate. In this condition, the maximum benefit has not been achieved due to production can still be enlarged by using more production factors. Region II is between X_i and X_{ii} has a production elasticity values between zero and one, while region III has elasticity of production values less than zero. An additional unit of input used in these areas, total production will increase at decreasing rate and be decreasing respectively.

2.2.2 The Concepts of Efficiency

Performance of firms can be seen from the level of efficiency and productivity (Coelli, *et al*., 1998). According to Farrell (1957), efficiency can be divided into three types: 1) technical efficiency, 2) allocative efficiency, and 3) economic efficiency. Further, technical efficiency is reflects the ability of a firm to obtain maximal output from a given set of inputs, and allocative efficiency is reflects ability of a firm to use the inputs in optimal proportions, given their respective prices and the production system. These two measures are then combined to provide a measure of total economic efficiency.

2.2.3 Technical, Allocative and Economic Efficiency

Measurement of economic efficiency requires an understanding of the decision making behavior of the farmer. A rational farmer, producing a single output from many inputs, $X = X_1 \ldots\ldots X_n$, that are purchased at given input prices, $W = W_1 \ldots\ldots W_n$ and operating on a production frontier will be supposed to be efficient. But if the farmer is using a combination of inputs in such a way that it fails to maximize output or can use less inputs to attain the same output, then the farmer is not economically efficient. A given combination of input and output is therefore economically efficient if it is both technically and allocativelly efficient. The explanations above are illustrated in the Figure 2.3.

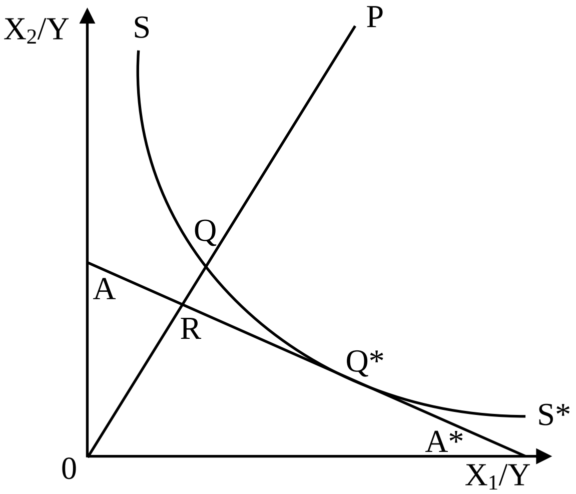

Figure 2.3 Technical and Allocative Efficiency

Sources: Farrell, (1957); Coelli, *et al*., (1998)

The line *SS** is an isoquant, representing technically efficient combinations of inputs, X_1 and $X_{2,}$ used in producing output *Q*. *SS** is also known as the best practice production frontier. *AA** is an isocost line, which shows all combinations of inputs X_1 and X_2 such that input costs sum to the same total cost of production. However, any farmer intending to maximize profits has to produce at *Q**, which is a point of tangency and representing the least cost combination of x_1 and x_2 in production of *Q*. At point *Q** the farmer is economically efficient.

To measurement of technical, allocative and economic efficiency, the same figure 2.3 is employed. Suppose a farm is producing its output illustrated by isoquant *SS** with input combination level of (X_1 and X_2) in figure 2.3. At this point *P* of input combination the production is not technically efficient because the level of inputs needed to produce the same quantity is *Q* on isoquant *SS**. In other words, the farm can produce at any point on *SS** with fewer inputs (X_1 and X_2) in this case at *Q*. The degree of technical efficiency of such a farm is measured as *OQ/OP*. *OQ/OP* is the proportional reduction of all inputs that could theoretically be achieved without any reduction in output.

In figure 2.3, *AA** represent input price ratio or isocost line, which gives the minimum expenditure for which a farm intending to maximize profit. The same farm using (X_1 and X_2) to produce output *P* would be allocatively inefficient in relation to *R*. Its level of allocative efficiency is represented by *OR/OQ*, since the distance *RQ* represents the reduction in production costs if the farmers using the combination of input (X_1 and X_2) was to produce at any point on *AA**.

The economic efficiency is measured as the product of *OQ/OP* and *OR/OQ*, which is *OR/OP*. This follows from interpretation of distance *RP* as the reduction in costs if a technically and allocatively inefficient farmer at *P* were to become efficient (both technically and allocatively) at *Q** (Coelli, *et al*., 1998)

2.2.4 Efficiency of Input Use

According to Doll & Orazem (1984), problem associated with the allocation of variable input are often referred to as the input–output relationship. The objective of the input–output relationship is to determine the quantity of the variable input that will be used in production to achieve economic efficiency. Economic efficiency refers to the combinations of inputs that maximize farm objective. Efficiency is defined in terms of two condition; necessary condition and sufficient condition.

Further explained that necessary condition is met in a production process when there is no possibility of producing the same amount of product with fewer inputs and no possibility of producing more product with the same amount of inputs. The necessary condition refers only to the physical relationship between input and output. The second condition that must be met to achieve the maximum profit is the sufficient condition. Sufficient condition is indicates the level of economic efficiency. Economic efficiency is achieved when the value of marginal product (*VMP*) equal with marginal factor cost (*MFC*), it means that any additional costs incurred for the factor of production could provide additional revenue in the same amount.

To determine the optimum amount of input use in production we can use the profit as a function on input. Mathematically it can be written as follows:

$$\pi = H.Y - (\textstyle\sum_{i=1}^{n} P_{X_i} X_i + TFC) \qquad 2.1$$

where:

π = Profit

H = Output price

Y = Output

X_i = Input

P_{Xi} = Input price

TFC = Total fixed cost

To maximize profit function with respect to the variable input, the first derivative would be set to zero as follows:

$$\frac{\partial \pi}{\partial x_i} = H \frac{\partial y}{\partial x_i} - P_{x_i} = 0 \qquad ; i = 1, 2, 3, \dots, n \qquad 2.3$$

$$H \frac{\partial y}{\partial x_i} = P_{x_i} \qquad 2.4$$

where

$\frac{\partial y}{\partial x_i}$: Marginal physical product (*MPP*)

Then, the equation 2.4 can rewrite as follows:

$$H.MPP_{x_i} = P_{x_i} \qquad 2.5$$

The left hand side from equation 2.5 is the slope of the total value product (*TVP*) or value of marginal product (*VMP*). According to Debertin (2002), profit maximization will occur when the slope of total value product (called value marginal product or *VMP*) equals to the slope of total factor cost (called marginal factor cost or *MFC*). If the price of input is assumed to be constant at *P*, then *MFC* equals with *P*. Then, the equation 2.5 can be written as follows:

$$VMP_{x_i} = P_{x_i} \qquad 2.6$$

The resource use efficiency emphasis is on marginal productivity due to its most economical and optimal way to maximize the net output in farming, and a resource is said to be efficiently used if its marginal product is equal to the cost of production. The value of marginal product (*VMP*) is the expected return from addition of one extra unit of input concerned as other inputs are held constant and when this is compared with the input price it will determine whether to increase the level of resource use or not. If the value of marginal product (*VMP*) is greater than the unit input price, it implies under utilization of the resource and this indicates the scope for raising output efficiently by increasing the use of that particular resource. On the other hand, if the value of marginal product (*VMP*) is less than the input price, it implies that the input concerned has been over-utilized and as such the output level cannot be increased by raising more of the resource.

2.3 Related Research

Various approaches to efficiency analysis have been used. According to Coelli, *et al*. (1998), there are four approaches to measuring the efficiency of production, which are Least Square (LS) econometric production model, Total Factor Productivity (TFP) indices, Data Envelopment Analysis (DEA) and Stochastic Frontier (SF). This research used the least square econometric production model approach in measuring the efficiency of production at white shrimp farms. The advantage of this method is to provide information about the role of different variables in influencing output. The resulting production function coefficients can be interpreted as contributing inputs to outputs.

There are several studies that have been performed related to shrimp farming and efficiency in production. Thongrak (1995) analyzed technical efficiency in intensive shrimp farming in southern Thailand. A deterministic parametric frontier approach used to measure technical efficiency among 75 shrimp farms. Four variables input, which are land, feed, shrimp fry, and chemical was used in this study. The result showed that some farmers were highly inefficient; i.e. efficiency indices were quite low, ranging from 0.21961 to 0.5, while the majority of shrimp farms have technical efficiency indices above 0.5. Farmer's level experience with shrimp culture has positive effect on technical efficiency while size of pond and feed conversion ratio have negative effects on technical efficiency, indicating that larger pond size and higher feed conversion ratio are more technical inefficient.

Inoni (2007) analyzed about allocative efficiency in pond fish production in Delta State Nigeria using linear production function. Multi-stage random sampling technique used to obtain data on social characteristics of the fish farmers, types and quantity of inputs used, pond size, output of fish, input and output prices, fish sales, production period, fish species cultured, and labour utilization. The ordinary least squares (OLS) technique was used to estimate the regression coefficients from linear production function. The research conclude that allocative efficiency of production resources employed in fish farming were 3.22, 0.0025, 0.00064, 0.00017, and 0.00025 respectively for pond size, feed resources, fingerlings, labour, and fixed costs. The indices indicate that apart from pond size which was under-utilized, all other resources were over-utilized implying inefficient resource allocations in fish farming in Delta State, Nigeria.

The same approach used by Kareen, *et al*. (2008) analyzed of technocal, allocative and economic efficiency of different pond systems, which are concrete and earthen pond systems using Cobb-Douglas production function with six variables of inputs (pond, feed, lime, labour, other materials, and fingerlings). The results of the analysis of the mean technical efficiency for both systems revealed that concrete pond system with 88% while earthen pond system was 89%. Similarly, the allocative efficiency results revealed that concrete pond system was 79% while earthen pond had 85%. Moreover, allocative efficiency results revealed that expenses on other costs and labour were found to be significant variables in concrete pond type while in earthen pond only cost of lime was found to be the significant factor. These results indicated that these variables contributed greatly to the allocative efficiency of fish farmers in the study area. The inefficiency sources model for concrete pond showed that only years of experience is the significant factor. Thus, a year of experience contributed significantly to the explanation of efficiency in concrete pond.

Measurement of efficiency of shrimp (*Panaeus monodon*) Farmers in Andhara Pradesh was studied by Reddy, *et al*. (2008). A total of 480 shrimp farmers were selected from 16 villages. Efficiency in shrimp production was measured by stochastic frontier method. Six variable used in the model, which are age, experience, education, land, stocking density, and training recieved. The results revealed that the variables of age, education, stocking density, and land had positive coefficienncts and are highly significant. It implies, with increase in the use of those inputs the yield will also increase. Trough not significant, experience and training has negative influence on efficiency, which may be due to the inappropriate training and experience, and lack of technical knowledge.

Adinya, *et al*. (2008), examined production efficiency of catfish in Cross River State, Nigeria. They used data from 120 fish farmers and five input variables which are; fish pond size, labour, feed, adoption of improve technology, and education level. Three production functions have been used to measure the efficiency from catfish farming in research area, which is linear, Cobb Douglas and semi-log. The research indicate that catfish production was profitable but the farmers are not allocative efficient. The results of regression analysis showed that the marginal value products of fish pond size, labour and feed were ₦ 67,50, ₦ 178,13 and ₦ 728 respectively, while allocative efficiency for farm size, labour and feed were 0.09 (over-utilized), 2.85 (under-utilized) and 0.99 (over-utilized) respectively, there existed allocative inefficiency. In the other hand, there is a high potential for catfish farmers to increase their yields and income. This research also concluded that the farmer educational levels positively influence their level of efficiency in catfish production in the research area and adopting new technologies. Based on the findings of this research, they are recommended that fish farmers should expand fish farms, improving on production efficiency.

Krasachat (2009), analyzed technical efficiency of shrimp farms in Thailand under good agricultural practice system. The data envelopment analysis (DEA) approach and farm level cross sectional survey data of shrimp farms in the Eastern Region in Thailand are used to estimate technical efficiency scores. Then, a tobit regression isestimated and examined the effect of farm-specific socio-economic and management factors on farm efficiency. The empirical results suggest three important findings. First, the overall technical, pure technical and scale efficiency scores of some farms were considerably low. Second, there is confirmation that farm size and the differences in producers' experience in black tiger prawn production have influenced the overall technical and scale inefficiencies of shrimp farms while the difference in producers' participation in farm management training courses has different impacts on scale inefficiency in shrimp production in different farms. Finally, the empirical results also indicate that the difference in producers' education has different impacts on the overall technical, pure technical and scale inefficiencies in Thailand shrimp production in different farms.

Bhattacharya (2008), analyze technical efficiency between traditional and scientific shrimp farming in west Bengal using stochastic frontier method. The empirical results suggest high degrees of technical inefficiency among the shrimp farmers at household level. The scientific shrimp farmers have a higher technical efficiency than their traditional counterparts. This necessitates government policy initiatives and extension programs which will help the shrimp farmers especially the traditional ones of the state to utilize the best of their resources and enhance their production substantially. The government should also give adequate attention to small shrimp producers by providing them credit and other extension facilities.

A production function analysis of pond aquaculture in southern Ghana was studied by Asamoah, *et al*. (2012). They used Cobb-Douglas production function to determine the relationship between output with independent variables. This research used production data from six villages in southern Ghana. Four (feed, fertilizer, stocking rate, and labour) input variables used to measure the efficiency of input used in the production of fish. From the findings of the research, it can be conclude that stocking rate should be increased, since its *VMP* is greater than its price, whereas fertilizer and labor levels should be decreased to improve farm profitability. The result for labor further explains the negative coefficient obtained in the production function estimation. However, the size of the facility should be taken into account when increasing stocking rate, since these could be correlated.

In sum, according to the empirical results, the least square econometric production model has been used in the above studies. Through least square econometric production model, efficiency was measured by using econometric (ordinary least square) technique. Thus, the studies using this method had specific production functional forms such as log-linear, double-log, linear-log, *etc*. Furthermore, based on previous study and technical knowledge, four inputs variables used in this study, which are labour, fertilizer, feed and stocking density.

CHAPTER 3

Research Methodology

This chapter presents the research methodology. It consists of two main sections. The first section describes details of data and data collection. In the second section, analysis of primary data was explained in details.

3.1 Data and Data Collection

Data used in this research are both secondary and primary data. Details are described in the following sub-sections.

3.1.1 Secondary Data

Secondary data is the data that have been already collected and readily available from other sources. Secondary data used in this study consist of all information related to shrimp farming in Indonesia, theory of production, and efficiency, and related research. Secondary data were collected from archives of Minister of Marine Affairs, and Fisheries Republic of Indonesia, public documents, journals, articles, statistical agency and newspapers.

3.1.2 Primary Data

1) Study Area

Brondong district, located in northern Lamongan Regency, was purposively selected for this study area because it has been the major area of producing white shrimp in Lamongan Regency. Brondong district has six villages, which are Labuhan, Brengkok, Sedayu Lawas, Kranji, Tlogosadang, and Kandang Semangkon (Figure 3.1).

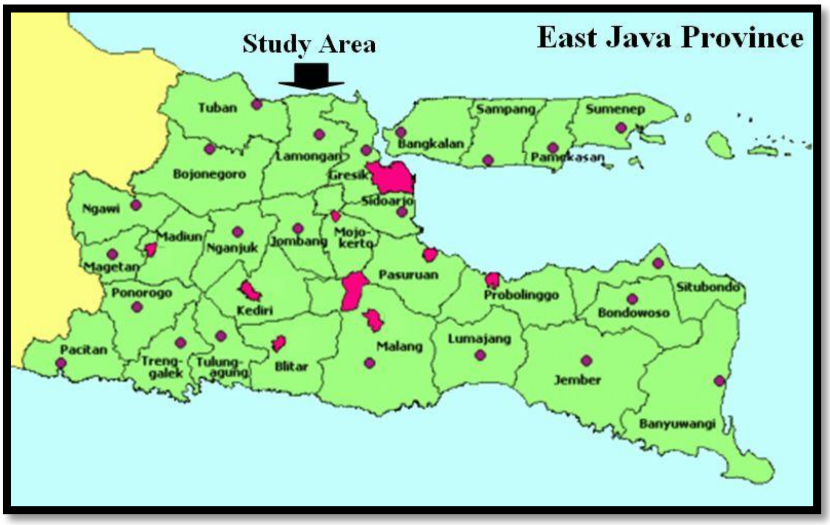

Figure 3.1 Study Area
Source: http://www.pelauts.com/peta/peta-kota-jawa-timur.html

2) Population and Sample

Populations of this study are the small-scale white shrimp farmers in the study area mention above, who have brackish water pond below five ha, and produce white shrimp using intensive system. In 2009, the total population were 683 white shrimp farmers.

Simple random sampling technique was used to select samples from the list of small-scale white shrimp farmers, published by Marine and Fisheries Department of Lamongan Regency. Moreover, to determine the sample size, Taro Yamane formula (Yamane, 1967) at 95% level of confidence was used.

$$n = \frac{N}{1+N(e)^2} \qquad 3.1$$

where:

n = Sample size

N = Population size

e = Level of error

By using this formula, with the level of error by 8%, a sample size of 125 shrimp farmers was obtained. Those samples were collected in November 2011 to January 2012.

3) Research Tools

Structured questionnaire was constructed to gather information from the sample white shrimp farmer. Questionnaire was divided into four sections; the first section contained questions related to small-scale white shrimp farmer's characteristics, the second section directed questions regarding to obtain data relating to white shrimp farming characteristics. The third section contained questions related to inputs use in the production of white shrimp farming such as the number of labours, amount of fertilizer, quantity of feed and stocking density of shrimp fry, shrimp yields price and the price of each input. The last section of the questionnaire related to problems in white shrimp farming. The questionnaire was shown in appendix.

4) Pretest the Questionnaire

Prior to data collection, the questionnaire was directed to 30 white shrimp farmers in the study area to check its appropriateness. Some adjustments have been made before using it.

3.2 Data Analysis

This study used both descriptive and quantitative analysis. Details were described in the following sub-sections.

3.2.1 Descriptive Analysis

For descriptive analysis, descriptive statistics such as frequency, mean, and percentages were used. To analyze the first and second objectives, related to small-scale white shrimp farmer's characteristics, white shrimp farming characteristics, white shrimp production, marketing and problems in white shrimp farming.

3.2.2 Quantitative Analysis

To determine the relationship between output of white shrimp and the selected input variables, data were analyzed using the Ordinary Least Square (OLS) multiple regression technique. The linear-log, double-log, and log-linear functional forms were used to determine which of the forms would best fit the relationship between output of white shrimp and the input as explanatory variables. Detail of model specification, estimation, and efficiency analysis were explained as follows.

1) Model Specification

The linear-log, double-log, and log-linear production function forms were used to determine which of the forms would best fit the relationship between output of white shrimp and the explanatory variables (labour, fertilizer, feed and stocking density). The functional form that has the highest R^2 and shows many statistical significant variables adopted in this research. The functional forms fitted specified equation below:

1.1) Log-linear

$$\log Y = a + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + e \qquad 3.2$$

1.2) Double-log

$$\log Y = a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + e \qquad 3.3$$

1.3) Linear-log

$$Y = a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + e \qquad 3.4$$

where:

Y = Output of white shrimp (kg per ha)

X_1 = Labour (man-days per production cycle)

X_2 = Fertilizer (kg per ha per production cycle)

X_3 = Feed (kg per ha per production cycle)

X_4 = Stocking density (fry per ha per production cycle)

b = Regression coefficient to estimate

e = Error term

Details definitions of the variables were used in the models are described as follows.

(1) Output (Y) refers to the total production of white shrimp from one brackish water pond, and measured in kilogram (kg) per ha per production cycle.

(2) Labour (X_1) is the amount of labour usage in shrimp production. It includes both family and hired labour. This variable was measured in man-days per ha per production cycle.

(3) Fertilizers (X_2) includes all fertilizers used in shrimp production, measured in kg per ha per production cycle.

(4) Feed (X_3) is the quantity of formulated feed usage in shrimp production, measured in kg per ha per production cycle.

(5) Stocking densities (X_4) is the number of white shrimp fry which was applied in shrimp production, measured in fry per ha per production cycle.

2) Model Estimation

The data obtained were analyzed using the ordinary least square (OLS) multiple regression technique to determine the relationship between output of white shrimp and the selected variables. Based on Gujarati (2004) some tests conducted on the model, which are:

(1) Coefficient of determination (R^2)

The coefficient of determination is indicating goodness of fit of the regression. The *R Square* (R^2) test used to determine the percentage variation of the dependent variable that explained by variations of the independent variable. R^2 measured by the following equation:

$$R^2 = 1 - \frac{SS_{err}}{SS_{tot}} \quad 3.5$$

where

R^2 = Coefficient of determination

SS_{err} = The sum of squares of residuals

SS_{tot} = The total sum of squares

The value of R^2 is between zero and one. If the coefficient determinant equal to zero, it means that, the independent variable had no effect on the dependent variable. If the value of the coefficient determinant getting closer to one, it means that, more independent variables affect the dependent variable.

(2) Testing the assumption of ordinary least square.

The various tests performed to ensure the model met the criteria of *Best Linear Unbiased Estimator* (BLUE), which are:

(2.1) Normality

The linear regression assumes that any residual from regression model has spread to follow the normal distribution. In this research, the Kolmogorov-Smirnov test used to measure the normality of residual.

(2.2) Heteroskedasticity

The Ordinary Least Squares (OLS) is assuming that the variance of the error term is constant for all observations or homoskedasticity. To ensure these conditions, Glejser test used in this research.

(2.3) Multicollinearity

Multicollinearity is a situation in which one or more independent variables have relationships with other independent variables. It means that one or more independent variables are a linear function of other independent variables. To detect multicollinearity, Klein's Method used by comparing the value of (r^2), X_1, X_2,..., X_n) with the value of (R^2Y), X_1, X_2,..., X_n).

If the value of (R^2Y), X_1, X_2,..., X_n) > (r^2), X_1, X_2,..., X_n) means there are no symptoms of multicollinearity and if the value of (R^2Y), X_1, X_2,..., X_n) < (r^2), X_1, X_2,..., X_n) means there are multicollinearity.

(3) Testing Hypotheses

(3.1) *F* test

F test was used to examine simultaneous influences of independent variables on dependent variable. According to Gujarati (2004), formula for the *F* test is as follows:

$$F_{statistic} = \frac{R^2/(K-1)}{(1-R^2)(n-K)} \qquad 3.6$$

Where

R^2 = Coefficient of determination

K = The total number of variables

n = Number of samples

(3.2) Student (*t*) test

The *t* test was used to test the significance of the effect of each independent variable on the dependent variable. This test aims to measure the relationship among the independent variables, which are labour, fertilizer, feed and stocking density, and the dependent variable, which is the output of white shrimp.

Formula for the *t* test is as follows:

$$t_{statistic} = \frac{b_i}{S_e b_i} \quad 3.7$$

Where

b_i = Value of regression coefficient

S_e = Standard error of regression coefficient

3. Efficiency Analysis

According to Debertin (2002), profit maximization will occur when the slope of total value product (called value of marginal product or *VMP*) equals to the slope of total factor cost (called marginal factor cost or *MFC*). If the price of inputs is assumed constant at P_x, then *MFC* equals with P_x. To answer the fourth objective, the level of efficiency inputs used in white shrimp production calculated by comparing the value of marginal product (*VMP*) of each input with price of inputs (P_x).

The explanation above is interpreted as follows:

(1) If the VMP_x/P_x equal one means that, at the price level prevailing in the time of the research, the use of factors of production (input X) was located at an optimum level or efficient.

(2) If the VMP_x/P_x greater than one means that the use of factors of production is still not efficient, to achieve optimum level of input X should be increased.

(3) If the VMP_x/P_x smaller than one means inefficient use of factors of production or already exceeds the optimum level, so particular input should be reduced in production process.

All the price information used in the analysis was the average price on the first crop in 2011, which was obtained from small-scale shrimp farmers as respondent.

CHAPTER 4

Results and Discussions

This chapter presents the results and discussion of study. This chapter was organized in four sections; the first section presents a broader view of socio-economic characteristics of shrimp farmers, the second section contains information related to white shrimp farming characteristic and problems in shrimp farming, the third section shows the result of production function analysis, and the last section presents the efficiency analysis.

4.1 Socio-economic Characteristics of White Shrimp Farmers

4.1.1 Age of the Farmers

The small-scale white shrimp farmers in the study area have age between 26 to 72 years, with an average of 43.8 years. It is notable in Figure 4.1 that 38.4% farmers are in the age group less than 40 years. Furthermore, the farmers who have age between 40 to 50 attaining 28.8% and the rest in the age group more than 50 by 32.8%. Overall, more than 67.2% of small-scale white shrimp farmers fall into the productive age group of 26 – 50 years.

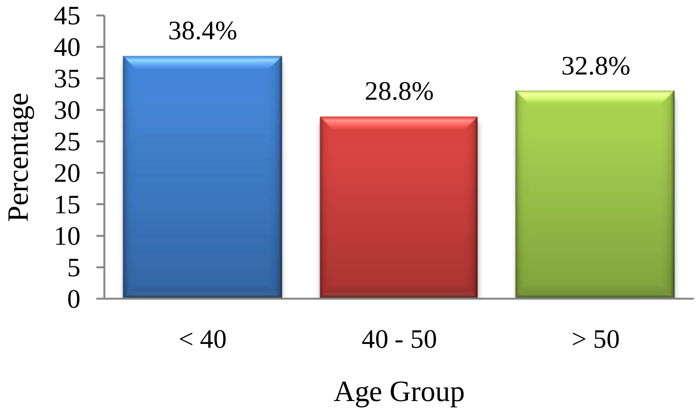

Figure 4.1 Age Distribution of Shrimp Farmers

4.1.2 Household Size

On average, one household had 3.7 family members (Table 4.1), but the size ranged from one to eight. In study area, more than 46.4% of shrimp farmers have the small household. Small household consisted of a husband or wife couple with one child, while 53.6% of shrimp farmers have medium to large household with at least four family members. Generally in study area, large households comprised of up to three generations living together in the family. This is a characteristic of Javanese ethnic, in which the elderly parents who cannot take care of themselves, joined with their children.

Table 4.1 Distribution of Household Size

Family Member (People)	Number of Farmers (n = 125)	Percentage
< 4	58	46.4
4 - 6	65	52.0
> 6	2	1.6
$\bar{x}$	3.7	

4.1.3 Education Level of Farmers and Experience in Shrimp Farming

One of the crucial aspects concerning the farmers' decisions about their production is educational level and experiences in white shrimp farming. It is expected that educational level and experience in white shrimp farming will help improve their ability to improve farms productivity, and efficiency.

On an average, education level of shrimp farmers was 9.3 years of schooling, but ranged from one year's schooling to 16 years of schooling. Shrimp farmers in the study area that have the senior high school certificate and the university degree (more than nine years schooling) reached 40.8% and 53.6% between seven to nine years of schooling or junior high school, while the rest in-group less than seven years schooling or elementary school by 5.6% (Figure 4.2). In Indonesian education system, it took six years to complete the elementary school, three years for junior high school. Then, required three and around four years for complete senior high school and university degree, respectively.

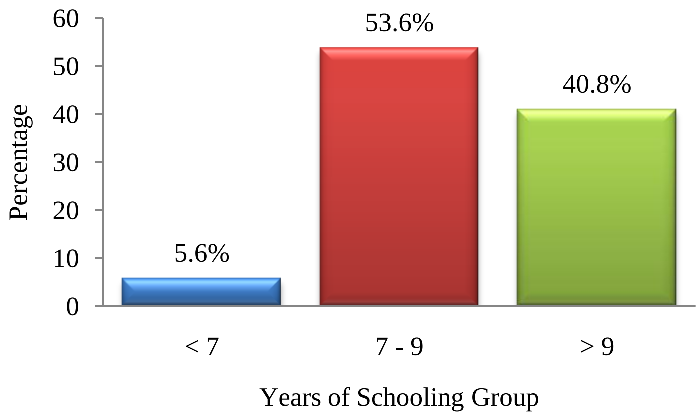

Figure 4.2 Year of Schooling of Shrimp Farmers

Table 4.2 shows the farmers' experiences in white shrimp farming. The minimum experience in white shrimp farming was one year and the maximum was 11 years, with the average was six years in white shrimp farming. The results revealed that 47.2% of the farmers had experiences less than six years. Furthermore, 39.2% of the farmers indicated that they had experiences between six to nine years, while 13.6% had experiences more than nine years.

Table 4.2 Years of Experience in Shrimp Farming

Experience (Years)	Number of Farmers (n = 125)	Percentage
< 6	59	47.2
6 – 9	49	39.2
> 9	17	13.6
$\bar{x}$	6	

4.1.4 Occupation of Shrimp Farmers

In the study area, fish farming has become hereditary occupation. They have been cultivating milkfish for the long time before white shrimp farming started in 2000. Most of the respondent (80%) stated that the white shrimp farming has become their main occupation, while the remaining farmers considered shrimp farming as their supplementary occupation (Table 4.3).

Table 4.3 Occupation of Shrimp Farmers

Occupation	Number of Farmers (n = 125)	Percentage
Shrimp farming as their main occupation	100	80
Shrimp farming as their supplementary occupation	25	20

4.1.5 Land Holding of Shrimp Farmers

The distribution of land holding was shown in Figure 4.3. The majority of the farmers, 72.8%, occupied land below one ha. The rest, 20.8%, and 6.4% occupied land between one to two ha, and above respectively. In addition, shrimp farmers in study area had land 0.78 ha on average.

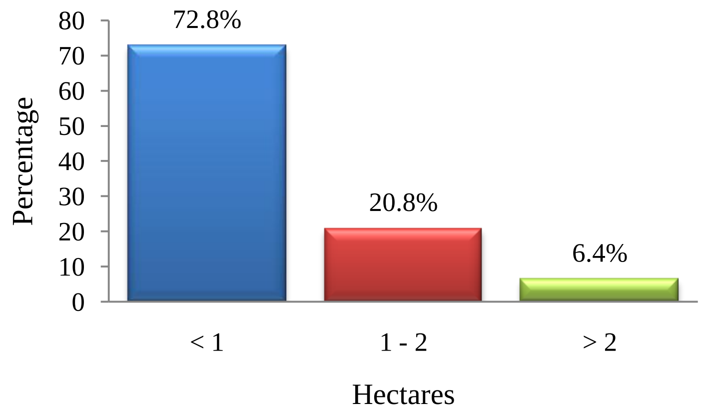

Figure 4.3 Land Holding of Shrimp Farmers

4.1.6 Sources of Capital and Access of Credits

Most shrimp farmers stated that shrimp farming is the legacy of their family. They have been cultivating milkfish for long time before started to produce white shrimp. According to the results of survey (Table 4.4), only 33.6% of interviewed shrimp farmers had access to credit services. The main credit sources were bank and credit institutions, cooperatives, and other sources by 76.1%, 14.2% and 11.9% respectively.

Shrimp farmers used credits for several purposes. These were; purchasing additional shrimp fries (40.5%), rent brackish water pond (26.2%), purchasing shrimp feed (21.4%) and buying water pumping and paddle wheel (11.9%). These farmers used credits for shrimp investment due to they saw potential profit.

Table 4.4 Access to Credit Services of Shrimp Farmers

Items	Number of Farmers (n = 125)	Percentage
Access to credit service	42	33.6
Sources of Credit		
1. Bank and credit institutions	31	73.8
2. Cooperatives	6	14.2
3. Others sources	5	11.9
Purpose of Credit		
1. Purchasing additional shrimp fries	17	40.5
2. Rent shrimp pond	11	26.2
3. Purchasing shrimp feed	9	21.4
4. Add water pumping and paddle wheel	5	11.9

4.2 White Shrimp Farming Characteristics

4.2.1 Number of Shrimp Pond

The results in Table 4.5 revealed that shrimp farmers had at least two ponds, on average. Majority of farmers had number of shrimp pond between one to two (83.2%). In addition, only 16.8% of farmers had pond more than two. Overall, the average shrimp pond size is 0.42 ha. This is a small size for shrimp pond. Most of shrimp farmers in study area are small farmers; they have limited resources and technology to manage their ponds. A smaller pond size allows them to maintain water quality and health of white shrimp easier. Moreover, a smaller pond size requires fewer paddle wheels, means less investment cost is needed.

Table 4.5 Number of Shrimp Pond

Number of Pond	Number of Farmers (n = 125)	Percentage
1 - 2	104	83.2
3 - 4	11	8.8
> 4	10	8.0

4.2.2 Shrimp Pond Design

There was no standard design for a shrimp pond in the study area. The design for the pond depends on experiences of the farmers, financial capabilities and the environmental condition at the pond location. Most of the ponds in the study area are rectangular (77.6%) with the mud in the bottom of the pond (95.2%). Furthermore, the dikes that built around the shrimp pond made from clay, *Acropora* coral, and concrete by 51.2%, 44.0%, and 4.8% respectively (Table 4.6).

Table 4.6 Shrimp Pond Design

Items	Number of Farmers (n = 125)	Percentage
Form of Shrimp Pond		
1) Rectangular	97	77.6
2) Foursquare	28	22.4
Bottom of Shrimp Pond		
1) Mud	119	95.2
2) Concrete	6	4.8
Dikes of Shrimp Pond		
1) Clay	64	51.2
2) *Acropora* coral	55	44.0
3) Concrete	6	4.8

In the study area, the brackish water pond for white shrimp farming has a depth ranging between 90 to 110 cm and depth of the platform is 60 to 80 cm. A typically design of brackish water pond in study area shown in Figure 4.4.

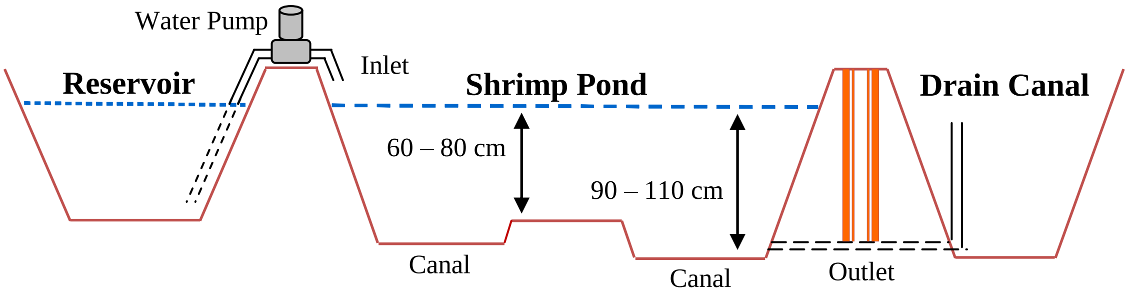

Figure 4.4 Shrimp Pond Design

4.2.3 Land and Pond Preparation

Before brackish water pond was stocked with white shrimp fries for a new production cycle, the excessive wastes that accumulated in the brackish water pond during the previous production cycle was disposed by using the drying method. All farmers in the study area, who have pond with mud at the bottom (119 farmers), used this method due to cheaper and more effective method of eliminating undesirable species in brackish water pond from the previous production.

The pond was drained and left to dry in the sun for a period of 10 to 30 days. During the process of drying the brackish water ponds, other activities were undertaken by farmers. These include repair of dikes, inlet - outlet of water and recondition of canal (Figure 4.5).

Figure 4.5 Land and Pond Preparation

4.2.4 Application of Fertilizer in Shrimp Cultivation

In shrimp farming, farmers in study area used several kind of fertilizer for different purposes. To increase pH (alkalinity) of pond sediments, and to avoid disease in the next production cycle, lime (Calcium carbonate or ($CaCO_3$)) and dolomite (Calcium magnesium carbonate or [$CaMg(CO_3)_2$]) was used. Moreover, to stimulate the plankton bloom in pond, shrimp farmers ware apply fertilizer such as; urea, and bran.

The result in Table 4.7 revealed that the majority (73.6%) of shrimp farmers used fertilizer (lime, dolomite, urea, and bran) between 5,000 to 10,000 kg per ha. A large amount of fertilizer (lime and dolomite) used to increase the alkalinity of the pond during land and pond preparation, due to unfavorable environmental conditions. Moreover, the price of fertilizer in the first crop in 2011 was IDR 47,400 per kg on average.

Table 4.7 Amount of Fertilizer Applied

Amount of Fertilizer (kg per ha)	Number of Farmers (n = 125)	Percentage
< 5,000	29	23.3
5,000 – 10,000	92	73.6
> 10,000	4	3.2
$\bar{x}$	6,400	

4.2.5 Stocking of Shrimp Fries

One of the key success factors in shrimp farming is the optimal stocking density and the management thereafter. White shrimp fries usage in the study area was *Specific Pathogen Free* (SPF)[1]. The results showed that 72.8% of shrimp

[1] *Specific Pathogen Free* (SPF) is a term used for labouratory animals that guaranteed free of particular pathogens.

farmers got their shrimp fries from private hatchery (Central Proteinaprima, Charoen Pokphand Group) in Rembang, Central Java Province, at size PL 8 to PL 10, while the remaining got their shrimp fries from public hatchery in Gondol, Bali Province, at size PL 15 (Table 4.8).

Table 4.8 Sources and Size of Shrimp Fries

Items	Number of Farmers (n = 125)	Percentage
Sources of Shrimp Fries		
1) Rembang, Central Java Province	91	72.8
2) Gondol, Bali Province	34	27.2
Size of Shrimp Fries		
1) PL 8	28	22.4
2) PL 10	54	43.2
3) PL 15	43	34.4

To eliminate stress during shipment, acclimatization of white shrimp fries to the water pH and temperature of the shrimp pond rendered on arrival (Figure 4.6). In the study area, acclimatization has been done by float the plastic bag of white shrimp fries in the shrimp pond until it has reached equilibrium. The plastic bags of shrimp fries opened one by one and brackish water added gradually to an equal volume. After 30 minutes of acclimatization, shrimp farmers released the fries directly into the pond by distributing them throughout the area of the brackish water pond.

Figure 4.6 Stocking of Shrimp Fries

The amount of shrimp fries applied in shrimp cultivation varies from ponds to ponds. It was determined by pond size and capital of shrimp farmers. Thirty six percent of shrimp farmers used shrimp fries less than 750,000 fry per ha, while 36.0% of farmers used shrimp fries between 750,000 – 1,000,000 per ha, and the rest of farmers used shrimp fries more than 1,000,000 fry per ha per production cycle (Table 4.9). Furthermore, an average price of shrimp fries in the first crop in 2011 was IDR 55 per fry.

Table 4.9 Amount of Shrimp Fries

Amount of Shrimp Fries (fry per ha)	Number of Farmers (n = 125)	Percentage
< 750,000	36	28.8
750,000 – 1,000,000	45	36.0
> 1,000,000	44	35.2
$\bar{x}$	931,750	

In white shrimp production with intensive system, a stocking density more than 50 shrimp fry per m^2 are normally recommended. In the first crop of 2011, shrimp farmers used stocking density 93 fry per m^2 on average.

4.2.6 Water Quality Management

In intensive shrimp production, management of brackish water quality is very important. Degradation of water quality could affect the growth and survival of white shrimp. In general, shrimp farmers in study area monitored several indicators to judge the water quality; these are Dissolved Oxygen (DO), pH, salinity and turbidity.

1) Dissolved Oxygen (DO)

The amount of dissolved oxygen in the brackish water is very important for the shrimp's health. Low DO will reduces white shrimp immunity against disease and decrease their growths. Shrimp farmers in study area used several ways to maintain the DO level in the pond, these are; 1) placing the paddle wheels in right position in a pond to add oxygen to brackish water and get good water circulation; 2) controlling plankton density to an optimum level and; and 3) minimizing of uneaten formulated feed.

2) pH

The pH of brackish water indicates its fertility of brackish water pond. Brackish water with pH ranging from 6.0 to 9.0 is generally regarded as suitable for white shrimp production. Growth of white shrimps was retarded if pH falls below 5.0. In the study area, pH of brackish water pond ranged from 7.5 to 8.5. Most of farmers tried to control pH of brackish water within the optimum range and limit pH fluctuation by using lime or dolomite to neutralize the acidity and taking care of excessive plankton growth by brackish water exchange.

3) Salinity

Due to high evaporation rate in the study area, salt concentration in brackish water gradually increased. To reduce risk of slower white shrimp growth due to high salinity, the farmers had to change the brackish water regularly. Usually, the farmers replaced brackish water twice a day, morning and afternoon. Amount of brackish water that replaced was different depending on the condition of the brackish water pond. When study conducted, the salinity of brackish water pond in study area varies between 0.00001 to 0.00025 milligrams per liter (mg/l).

4) Turbidity

The color of brackish water mainly resulted from suspended particles of plankton. The turbidity level of brackish water was strongly influenced by the density and species of plankton. Shrimp farmers used a secchi disk to measure turbidity of brackish water. A secchi disk is a black and white disk that lowered into the brackish water until it can no longer see. That depth (secchi depth) is then recorded as a measure of the transparency of the brackish water (inversely related to turbidity). Shrimp farmers usually measured the turbidity level of brackish water every day, in the morning. Turbidity levels of brackish water in the study area during data collection ranged from 30 to 60 cm and the brackish water dominated by *green algae* or *diatoms* and slightly *blue green algae* and *dinoflagellates*.

4.2.7 Feed and Feeding

Shrimp farmers in study area used formulated feed in their shrimp cultivation. On an average, shrimp farmers used 23,850 kg formulated feed per ha. As shown in Table 4.10, 53.6% of farmers used formulated feed between 15,000 to 25,000 kg per ha, and 40.0% of farmers used formulated feed more than 25,000 kg per ha. In the other hand, only 6.4% used formulated feed less than 15,000 kg per ha. In addition, the price of fertilizer in the first crop in 2011 was IDR 13.350 per kg on average.

Table 4.10 Amount of Formulated Feed

Amount of Formulated Feed (kg per ha)	Number of Farmers (n = 125)	Percentage
< 15,000	8	6.4
15,000 – 25,000	67	53.6
> 25,000	50	40.0
$\bar{x}$	23,850	

All shrimp farmers in study area used *Irawan*[2] as their white shrimp formulated feed. This brand has various formulas (Irawan 681 V, 682 V, 683 V, 683-SP V, 684-S V, 684 V) which were adjusted for age and size of white shrimp (Table 4.11). Formulated feed is an important factor in white shrimp farming, especially in intensive system. White shrimp requires nutritionally balanced good quality feed for healthy growth. White shrimp feed should contain essential nutrients like protein, fat, fiber, vitamins and minerals for faster growth. If good quality feed has been given, sufficient, and environmental condition favor, the farmers can expect good harvest of shrimp. If good quality feed has been given, sufficient, and environmental conditions favor, it is certain that the growth rate of shrimp as expected by farmers.

Table 4.11 Size and Contents of Nutrient of Shrimp Feed

Unit: Percent

Feed Code	Size (mm)	Crude Protein	Moisture	Fat	Fiber
Irawan 681 V	0.4 * 0.7	30	12	5	4
Irawan 682 V	0.7 * 1.0	30	12	5	4
Irawan 683 V	1.0 * 2.3	30	12	5	4
Irawan 683-SP V	1.8 * 2.0	30	12	5	4
Irawan 684-S V	1.8 * 4.0	28	12	5	4
Irawan 684 V	2.0 * 5.0	28	12	5	4

In the study area, amount of feed given to white shrimp was adjusted to the standard feed conversion ratio (FCR)[3] based on age and size of white shrimp. On an average, feed conversion ratio of shrimp farms in study area was 1.6; it means that 1.6 kg of formulated feed was needed to produce 1 kg of shrimp live weight. The result in Figure 4.7 revealed that the majority of shrimp farms had FCR between 1.5 to 2.0 (76.8%).

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[2] *Irawan* is a brand of shrimp feed produced by Central Proteinaprima (*Charoen Pokphand Group)*

[3] Feed Conversion Ratio (FCR) is a measure of the amount of feed needed to produce a unit weight of shrimp

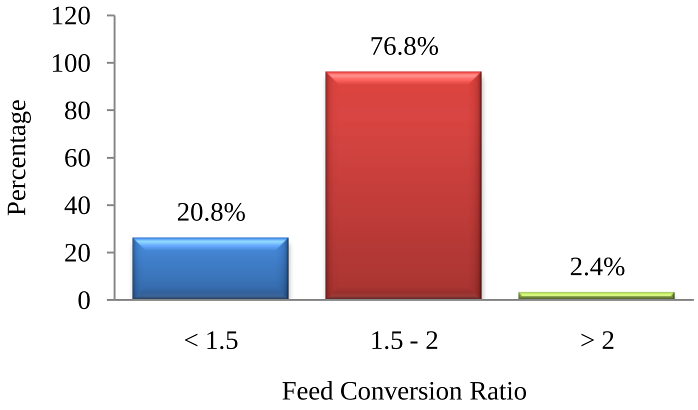

Figure 4.7 Feed Conversion Ratio

The common method to measure the level of feed consumption of white shrimp was visual observation method (Figure 4.8). This method employed using feeding tray, which distributed throughout the brackish water pond. Five to ten percent of the feeding ration placed at the feeding trays while the rest spread into brackish water pond. After one to two hours, the feeding tray was lifted by farmers to observe the level of feed consumption. The disadvantage of this method is that it very subjective, depending upon the farmers’ experience and skill in white shrimp farming. Based on the observation of feed consumption in feeding tray, farmers have made some adjustments to determine the amount of feed to be provided for the next feeding.

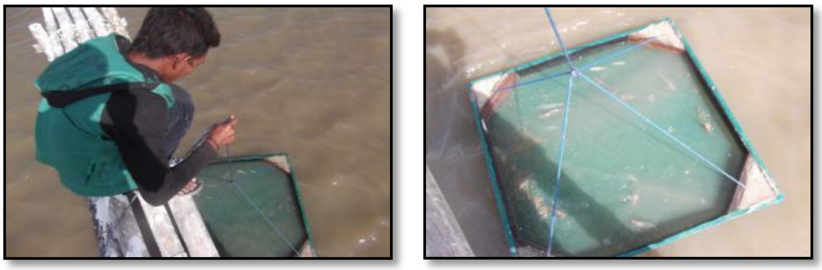

Figure 4.8 Visual Observation Method

Table 4.12 shows some adjustments that usually made by shrimp farmers in the study area to determine the appropriate amount of formulated feed usage for the next feeding.

Table 4.12 Adjustment of Feed Consumption

Observation	Adjustment
No residual feed	Increase amount of feed by 50%
Residual feed around 0 to 10%	Increase amount of feed by 25%
Residual feed around 10 to 25%	Increase amount of feed by 10%
Residual feed around 25 to 50%	No change
Residual feed around 50 to 75%	Decrease amount of feed by 25%
Residual feed around 75 to 100%	No feed for the next feeding

4.2.8 Labour Used in Shrimp Farming

The number of labour used in white shrimp farming was depending on the pond size and stocking density. During the cultivation time, the household labour mainly worked fulltime from the beginning until the end of shrimp cultivation including maintenance activities, feeding, and shrimp health check. Moreover, hire labour used only for land preparation and harvesting.

The result in Table 4.13 revealed that 36.8% of shrimp farmers used labour between 170 to 190 man-days, and 34.4% of shrimp farmers used labour more than 190 man-days. In addition, only 28.8% of farmers used labour less than 170 man-days per production cycle per ha. On average, the wage of labour in the first crop in 2011 was IDR 64,700 per day.

Table 4.13 Labour Used in Shrimp Farming

Used Labour (Man-days per ha)	Number of Farmers (n = 125)	Percentage
< 170	38	28.8
170 - 190	46	36.8
> 190	43	34.4
$\bar{x}$	188.3	

4.2.9 Shrimp Disease

White shrimp disease was the major obstacle in white shrimp farming in the study area. White shrimp diseases such as *White Spot Syndrome Virus* (WSSV) and *Infectious Myonecrosis Virus* (IMV) caused great losses due to the white shrimp should harvested early. These diseases have infected the white shrimp between the ages of 35 to 85 days, recorded 17 brackish water ponds infected by these viruses at the last production cycle. Treatment could not carry out effectively when white shrimp disease occurred in a brackish water pond. Practicing good farm management or prevention are the best ways to avoid disease.

4.2.10 Harvesting and Marketing Practices

The white shrimps will be harvested when reaching the marketable size (40 to 70 heads per kg). Harvesting maybe done completely at one time or partially depending on market demand. Normally, harvesting was undertaken by using a bag net installed at the drainage gate of the pond, while partial harvesting was done by using a selective harvesting net. Harvesting of white shrimps has only been done when shrimps are not molting, due to newly molted white shrimp have soft shell and fetch lower price.

The step after harvesting was grading. Shrimp farmers graded shrimp according to its size. For example, wholesaler prefers a bigger size (40 or 50 heads per kg), retailers preferred a smaller size shrimp (60 and 70 heads per kg). For the smallest size, shrimp are usually consumed by themselves (Table 4.14).

Table 4.14 Average of Shrimp Size

Shrimp Size (Heads per kg)	Number of Farmer (n = 125)	Percentage
< 40	8	6.4
40 – 50	57	45.6
> 50	60	48.0

Shrimp farmers sold fresh shrimp to two groups of buyers, namely the wholesalers and retailers. As shown in Table 4.15, 8.8% of farmers only sold shrimp to wholesalers and 28.0% of farmers only sold their produce to retailers, while 63.2% of farmers sold shrimp to both group of buyers (wholesalers and retailers).

Table 4.15 Marketing Practices

Item	Number of Farmer (n = 125)	Percentage
Wholesalers	11	8.8
Retailers	35	28.0
Both of wholesalers and retailers	65	63.2

4.2.11 Shrimp Production and Productivity

In the study area, most farmers produced white shrimp twice (two crops) a year. The first crop started in March for land preparation until August, while the second crop started in September and harvesting in February (Figure 4.9). In a production cycle, it took 110 to 130 days.

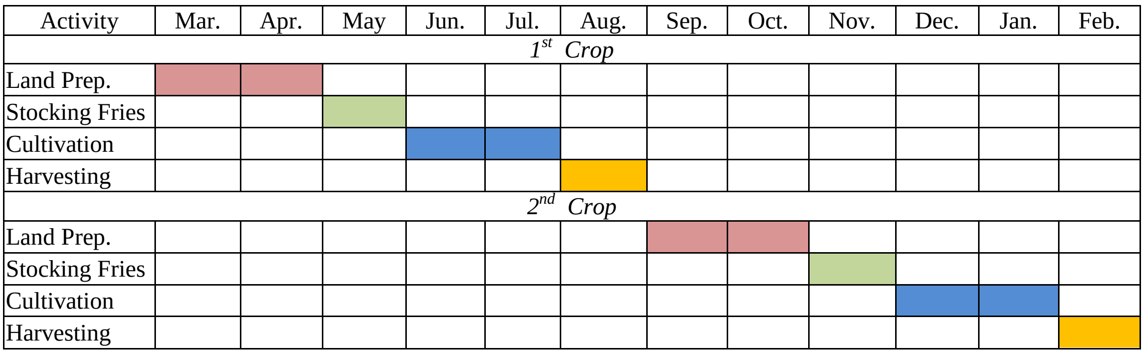

Figure 4.9 Seasonal Calendar of Shrimp Production

The amount of white shrimp produced from brackish water pond per production cycle varies from places to places. It was determined by pond size, stocking density, natural mortality, level of management and size of white shrimp when it was harvested. Based on the results of the study, the average amount of white shrimp harvested was 13,116 kg per ha (Table 4.16). The results further showed that most farmers (63.2%) produced white shrimp between 10,000 to 20,000 kg per ha. In addition, an average price of white shrimp was IDR 46,375 per kg in the first crop of 2011.

Table 4.16 Shrimp Yield and Prices

Item	Number of Farmers (n = 125)	Percentage
Shrimp Yield (kg per ha)		
1. < 10,000	32	25.6
2. 10,000 – 20,000	79	63.2
3. > 20,000	14	11.2
$\bar{x}$	13,116	
Shrimp Price (IDR per kg)		
1. < 45,500	3	2.4
2. 45,500 – 47,000	94	75.2
3. > 47,000	28	22.4
$\bar{x}$	46,375	

4.2.12 Problems in Shrimp Farming

The problems faced by shrimp farmers relating to various aspects in white shrimp production were presented in Table 4.17. The main problem in white shrimp production was shrimp disease. About 27.6% of shrimp farmers stated that at least one of their brackish water ponds infected by *White Spot Syndrome Virus* (WSSV) or *Infectious Myonecrosis Virus* (IMV) in the last production cycle. Lack of capital to improve their production was the second problem faced by shrimp farmers (19.4%). Surprisingly, most of shrimp farmers in the study area did not have access to credits; this was due to various reasons such as lack of knowledge, restrictive procedure, lack of collateral and high interest rate.

The third problem was low price of white shrimp in harvesting time due to oversupply of white shrimp in the market. Low quality of shrimp fry was the fourth problem. In general, shrimp farmers use *Specific Pathogen Free* (SPF) shrimp fries. Lack of knowledge in shrimp farming and poor environmental management has triggered the spread of disease. Moreover, there are several other problems faced by shrimp farmers, such as low price of white shrimp, water pollution from human activities, high production costs, and inappropriate pond design.

Table 4.17 Problems in Shrimp Farming

Problems *	Number of Farmers (n = 125)	Percentage
Disease	60	48.0
Lack of Capital	42	33.6
Low Price of White Shrimp	35	28.0
Insufficient Quality of White Shrimp Fry	29	23.2
Water Pollution from Human Activities	26	20.8
High Production Costs	17	13.6
Inappropriate Pond Design	8	6.4

* : One farmer can respond more than one answer.

4.3 Production Function Analysis

The multiple regression analysis carried out to examine the determinants of factors effecting output in aquaculture farms by small-scale farmers in Lamongan Regency. The results showed that linear-log functional form has the highest R^2 value. However, this function also has highest standard error of regression and problem of multicollinearity so that the resulting regression coefficients to be biased. At last, the double-log functional form came out best; this functional form also passes the test of normality, heteroskedasticity and multicollinerity.

The results of the regression analysis of factors influencing output of white shrimps are show on Table 4.18. The coefficient determination (*Adj* R^2 = 0.840) of double log functional form indicated that 84% of variation in output of white shrimp is explained by the independent variables, while the rest 16% of the variation was due to other variables that did not include in the model. The overall regression result was significant as $F_{Statistic}$ value of 164.9585 and significant at $\alpha = 0.01$. This provides evidence that the combination of labour, fertilizer, feed and stocking density had an impact simultaneously on output of white shrimp in the study areas.

Table 4.18 Estimated of Double-Log Functional Form

Variable	Coefficient	$t_{statistic}$	Probability
Constant	-10.121	-10.146	0.0000
Log X_1 (Labour)	1.653	10.923	0.0000
Log X_2 (Fertilizer)	0.106	1.783	0.0770
Log X_3 (Feed)	0.589	7.643	0.0000
Log X_4 (Stocking density)	0.302	4.447	0.0000
$F_{Statistic}$	164.958		0.0000
R^2	0.846		
R^2 *Adj.*	0.840		

As shown in Table 4.18, the double-log functional form showed that all inputs positively related to the output of white shrimp. The estimated coefficients are positive; the coefficients of labour, fertilizer, feed, and stocking density are 1.653, 0.106, 0.589 and 0.302 respectively. Furthermore, labour, feed, stocking density significantly affects the output of white shrimp at $\alpha = 0.01$, while fertilizer at $\alpha = 0.1$. Thus, it can be inferred that for 1% increase in the use of labour from its present average level of 188.3 man days to 190.1 man days, with all other things held constant, output of white shrimp will increase by 1.6% that is by 209.9 kg per ha.

Increasing by 1% in the use of fertilizer from its present average level of 6,400 kg to 6,464 kg, with all other things held constant, output of white shrimp will increase, by 0.1% that is by 13.1 kg per ha.

Moreover, increase by 1% in the use of feed from its present average level of 23,850 kg to 24,088 kg, output of white shrimp will increase by 0.5%, that is by 65.6 kg per ha, with all other things held constant. For stocking density, increase by 1% from its present average level of 931,750 shrimp fry per ha to 941,067 shrimp fry per ha, with all other things held constant, will increase output of white shrimp by 0.3%, that is by 39.3 kg per ha.

4.4 Efficiency Analysis

The value of marginal product (*VMP*), marginal factor cost (*MFC*) ratios of resources in the white shrimp production present in Table 4.19. The marginal product (*MP*) for each input was calculate by multiply the average product and elasticity (coefficient of regression) of each input from double-log production function that mention above. In addition, the output concept used in the production function was derived from average size of white shrimp. Based on findings of the study, it can be conclude that aquaculture farm resources were not efficiently utilized for shrimp production in study area. Most of the resource such as labour, feed and stocking density were under-utilized implying that white shrimp farmer are not optimal in allocating their resources.

Table 4.19 Estimated of Efficiency Analysis

Variable	*MP*	P_Y (IDR)	*VMP* (IDR)	*MFC* (IDR)	Allocative Efficiency Ratios	Decision
Labour	112.9	46,375	5,235	64,700	80.9	Under-utilized
Fertilizer	0.238		11,060	47,400	0.2	Over-utilized
Feed	0.352		16,337	13,350	1.2	Under-utilized
Stocking Density	0.005		215	55	3.9	Under-utilized

The allocative ratio for labour, fertilizer, feed, and stocking density was 80.9, 0.2, 1.2 and 3.9 respectively. By these results, labour, feed and stocking density were under -utilized having allocative efficiency ratios greater than one while fertilizer with allocative efficiency ratio below one were over-utilized. Lack of capital is one factor that led to the shrimp farmers failed to use inputs in optimal proportions.

Further, the result explained that with other inputs held constant, increasing labour by one unit would increase total value product by IDR 5,235. For another inputs, increasing feed and stocking density by one unit would increase total value product by IDR 16,337 and IDR 215, respectively. On the other side, fertilizer was employed above the optimum level, implying that fertilizer is been over-utilized as indicated by its allocative efficiency ratio of 0.2. The reason behind over utilization of fertilizer inputs was attributed by the use of lime ($CaCO_3$) and dolomite [$CaMg(CO_3)_2$] in large quantities to increase the pH of mud in bottom of pond. Therefore, to improve efficiency in shrimp production, the shrimp farmers should reduce fertilizer in their production.

CHAPTER 5

Conclusions and Recommendations

This chapter begins with the study conclusions where the study objectives and fact findings are summarized. Based on the fact findings, recommendations are then highlighted.

5.1 Conclusions

The main objectives of this study were to: 1) study the socio-economic characteristics of small-scale white shrimp farmers; 2) study the existing conditions of small-scale white shrimp farming of the farmers, consisting of white shrimp farming characteristics, production, marketing and problems in white shrimp farming; 3) examine the main factors affecting shrimp production; 4) measure the efficiency of input use in shrimp production. Data was collected from 125 small-scale white shrimp farmers through the period of November 2011 and January 2012. Data was analyzed using the ordinary least square (OLS) multiple regression technique. The level of efficiency inputs used in white shrimp production was calculated by comparing the value of marginal product (VMP) of each input with the prices of inputs (P_x).

The results revealed as follows.

1) The white shrimp farmers whose age less than 40 years constituted the majority. Overall, 67.2% fall into the productive age group of 20 – 50 years. Most of white shrimp farmers (53.6%) had the large household with at least four family members. In the study area, more than 80% of farmers stated that

the shrimp farming has become their main occupation, while the remaining stated as supplementary occupation.

The shrimp farmers in the study area that have the senior high school certificate and the university degree (more than nine years of schooling) reached 40.8% and 53.6% between seven to nine years of schooling or junior high school, while the rest in-group less than seven years schooling or elementary school by 5.6%. The results of the analysis revealed that 47.2% of white shrimp farmers had experience less than six years. However, 39.2% of the white shrimp farmers disclosed that they had experience between six to nine years, while 13.6% revealed that they had experience more than nine years.

2) The majority of the farmers (72.8%) occupied land below one ha. while 20.8%, and 6.4% occupied land between one to two ha, and above respectively. On an average, shrimp farmers in study area had land 0.78 ha. Furthermore, only 33.6% of shrimp farmers have access to credit services.

3) Majority of shrimp farmers had number of shrimp pond between one to two (83.2%). In addition, only 16.8% of farmers had pond more than two. Overall, the average shrimp pond size is 0.42 ha. In addition, most of the ponds in the study area are rectangular (77.6%) with the mud in the bottom of the pond (95.2%). Furthermore, the dikes that built around the shrimp pond made from clay, *Acropora* coral, and concrete by 51.2%, 44.0%, and 4.8% respectively.

Most of shrimp farmers (73.6%) used fertilizer between 5,000 to 10,000 kg per ha. A large amount of fertilizer (lime and dolomite) used to increase the alkalinity of the pond during land and pond preparation, due to unfavorable environmental conditions. The amount of shrimp fries applied in shrimp cultivation varies from ponds to ponds. It was determined by pond size and capital of shrimp farmers. Thirty six percent of shrimp farmers used shrimp fries less than 750,000 fry per ha, while 36.0% of farmers used shrimp fries between 750,000 – 1,000,000 per ha, and the rest of farmers used shrimp fries more than 1,000,000 fry per ha per production cycle

Shrimp farmers used formulated feed in their shrimp cultivation. On an average, shrimp farmers used 23,850 kg formulated feed per ha. The findings of study showed that 53.6% of farmers used formulated feed between 15,000 to 25,000 kg per ha, and 40.0% of farmers used formulated feed more than 25,000 kg per ha. In the other hand, only 6.4% used formulated feed less than 15,000 kg per ha. Furthermore, the results of study revealed that 36.8% of shrimp farmers used labour between 170 to 190 man-days, and 34.4% of shrimp farmers used labour more than 190 man-days. In addition, only 28.8% of farmers used labour less than 170 man-days per production cycle per ha.

Generally, farmers produced white shrimp twice (two crops) a year. The first crop started in March for land preparation until August, while the second crop started in September and harvesting in February. The amount of white shrimp produced from brackish water pond per production cycle varies from places to places. It was determined by pond size, stocking density, natural mortality, level of management and size of white shrimp when it was harvested. Based on the results of the study, the average amount of white shrimp harvested was 13,116 kg per ha.

The main problem in white shrimp production was shrimp diseases. About 48% of shrimp farmers stated that at least one of their brackish water ponds infected by *White Spot Syndrome Virus* (WSSV) or *Infectious Myonecrosis Virus* (IMV) in the last production cycle. Lack of capital to improve their production was the second problem faced by shrimp farmers (33.6%). The third problem was low price of white shrimp in harvesting time due to oversupply of white shrimp in the market. Low quality of shrimp fry was the fourth problem. In general, shrimp farmers use *Specific Pathogen Free* (SPF) shrimp fries.

4) The results of the regression analysis of factors influencing output of white shrimps showed that double-log functional form had the best fit in explaining the relationship between output of white shrimp and inputs used, the coefficient determination ($Adj\ R^2$ = 0.840) indicated that 84% of variation in output of white shrimp is explained by the independent variables, while the rest 16% of the variation was due to other variables that did not include in the model.

   The estimated coefficients are positive; the coefficients of labor, fertilizer, feed, and stocking density are 1.653, 0.106, 0.589 and 0.302 respectively. Furthermore, labor, feed, stocking density significantly affects the output of white shrimp at $\alpha = 0.01$, while fertilizer $\alpha = 0.1$.

5) From the findings of study, it can be conclude that aquaculture farms resources were not efficiently utilized for shrimp production. The allocative ratio for labor, fertilizer, feed, and stocking density was 80.9, 0.2, 1.2, and 3.9 respectively. By these results, labor, feed and stocking density were under-

utilized having allocative efficiency ratios greater than one while fertilizer with allocative efficiency ratio below one were over-utilized.

5.2 Recommendations

Based on the results presented in this thesis, a contribution to evaluation of improved intensive shrimp farming in Lamongan Regency was made.

5.2.1 Recommendations to Shrimp Farmers

1. The main problem in shrimp farming in study area is shrimp disease. The risk of shrimp disease, especially at the seed stage is a very important factor that directly affects the economics performance of shrimp farmers. Maintaining a good environment and improvement of shrimp fry quality to reduce risk at this stage is the best solution for attaining better shrimp yields.
2. Most of shrimp farmers in study area lack adequate capital resources to invest on improved shrimp production, such as purchasing shrimp fry, formulated feed, water pumping, and paddle wheels. In addition, there was possibility to develop the shrimp farming in study area. Therefore, shrimp farmers recommended using the existing credit services to expand their farms.
3. The third problem facing by shrimp farmers was low price of white shrimp in harvesting time. The different planting time among farmers can reduce the risk of oversupply and decline of shrimp price when harvesting. Moreover, the fourth problem was quality of shrimp fry. Lack of knowledge about shrimp farming, particularly regarding the acclimatization of shrimp fries caused of failure in cultivation. Following the manual book is the best way to reduce risk in shrimp farming.

4. Based on findings of study, shrimp farmers are inefficient in the use of the availability factors of production. This implies that production could increased by increasing the use of particulars inputs such as; feed and stocking density. Otherwise, fertilizer on white shrimp aquaculture farms was employed above the economic optimum level. To improve efficiency in shrimp production, white shrimp farmers should reduce fertilizer applied in their production.

5.2.2 Recommendations to the Government

1. The policy implication of findings in this study is that government should give support, such as training about new technology in shrimp farming, prevention and treatment of shrimp diseases, simplify access to credit, providing information about input and output prices relating with white shrimp production and price intervention to avoid lower shrimp price when harvesting.
2. Moreover, government should give support to the extension officers frequently visiting the farmers. This expected to improve their skill in white shrimp farming and solving their technical problems.
3. Finally, it is suggested that the government may formulated an appropriate policy to invest in study and development project for enhancing the yield of white shrimp.

5.2.3 Recommendations for Further Study

For further study, it is recommended that more relevant variables should be considered in white shrimp farming. In addition, other alternative methods for in depth analysis of production efficiency such as DEA (Data Envelopment Analysis) or SF (Stochastic Frontier) production function should be used.

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APPENDIX

Name : …………….…………….

Date : ..…………..……………..

Place : …………….…………….

QUESTIONNAIRE

Production Efficiency Analysis for White Shrimp (*Panaeus vannamei*) Aquaculture Farms in Lamongan Regency, East Java Province, Indonesia

The objectives of this research are:

5) To study the socio-economic characteristics of small-scale white shrimp farmers (who use intensive systems) in Lamongan Regency, the East Java Province, Indonesia.
6) To study the existing conditions of small-scale white shrimp farming of the farmers, consisting of white shrimp farming characteristics, production, marketing and problems in white shrimp farming.
7) To investigate the main factors affecting production of small-scale white shrimp farming of the farmers in study area.
8) To measure the efficiency of input use in the production of white shrimp farms in the study area.

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This questionnaire is a tool for collecting data used for the thesis research. This questionnaire is divided into 4 sections, such as:

Section 1 : Questions related to white shrimp farmers characteristics

Section 2 : Questions about white shrimp farming characteristics.

Section 3 : Questions related to the inputs use in the white shrimp production

Section 4 : Questions about problems in shrimp farming and government policies in shrimp farming

QUESTIONNAIRE

Production Efficiency Analysis for White Shrimp (*Panaeus vannamei*) Aquaculture Farms in Lamongan Regency, East Java Province, Indonesia

Information of Respondent:

1. Name :
2. Address : Village :
   Sub District :
   District :
   Telephone :

Section 1: White 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? No:
   (a) Male: (b) Female:
6. Please, fill the following table with the information regarding your family members

Family member	Age	Education levels	Occupation

7. Number of family members who assist in the white shrimp production process?
8. 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

9. Shrimp farmer is your main occupation? Yes / No
10. If Yes, do you have secondary occupation?
    If No, what is your main occupation?
11. How much land (total) do you have?
    No. of hectares : Hectares
    Divided into (pond) : Ponds
12. Land uses:

Ponds	Hectare	Land uses

13. On average, how much your monthly income? IDR
14. On average, how much your monthly expense? IDR

15. Do you have any debt (formal* or informal**) for your farm? Yes / No
    * : Source of debt from bank or other formal institution (i.e. Cooperation, etc.)
    ** : Source of debt from non-formal institution (i.e. Family, Neighbors, etc.)
16. If Yes, how much? IDR
17. Can you give me information the source s of your debt?

18. What are the main objectives of your debt? (i.e. increase the number of water pumping, increase the number of aerator, maintenance of brackish water pond, etc)

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Section 2: White Shrimp Farming Characteristics

1. Who taught you about the white shrimp cultivation?
2. How many years your experience in shrimp farming?
3. Did an extension officer visit your farm? Yes / No
4. If Yes, how many times per month?
5. If visited, what message did they carry?
6. If they did not come, did you try to look for advice from extension agents? Yes / No
7. Before the shrimp farming started, did you perform maintenance of brackish water pond? Yes / No
8. If Yes, can you explain in what form (in detail)?

9. How about the bottom construction of your brackish water pond?
10. Where you got water for your brackish water pond?
11. The replacement of brackish water done regularly? Yes / No
12. If Yes, how many times a week?
13. Where you got the shrimp fry?
14. How about the quality of shrimp fry?
15. Do you provide special treatment for shrimp fry? Yes / No
16. If Yes, in what form (in detail)?

17. When the shrimp fry stocking into the brackish water pond?
18. What the type of shrimp feed are provided?
    (a) Crumble (b) Pellet (c) thers:................................
19. In the last production, do you use artificial feed? Yes / No
20. If Yes, you made or bought it?
21. If you made it, can you explain about the composition?

Kinds	Composition	Unit

22. How many times you give feeding per day?
when?
23. Do you try to growing plankton or detritus as natural feed in your brackish water pond? Yes / No
24. If Yes, How you do that?
25. How many water pumping and aerator that you used in 1 plot of brackish water pond?
(a) Water pumping: (b) Aerator:
26. Shrimp health checks done regularly? Yes / No
27. If Yes, how many times a week?
28. Do you test the salinity, pH, oxygen levels in water and temperature regularly? Yes / No
29. If Yes, how many times a week?
(a) Salinity: (b) pH: (c) Oxygen levels: (d) Temperature:
30. What disease that infected in your white shrimp in the last production cycle and in what age?

Types of shrimp disease	Infected at shrimp age

31. How you solve this disease problem?

Types of shrimp disease	Solutions

32. At what age shrimp harvested (month)?
33. When harvested, what size of shrimp? Shrimp/kg
34. How many of total production harvested per specific pond?

Number of Ponds	Production
1	
2	
3	

35. When you harvest the shrimp from the brackish water pond?
(a) Morning (b) Mid day (c) Afternoon (d) Others………….
36. How much survival rate for white shrimp in your last production cycle?
37. For the last production cycle, where did you market it?
(a) Traders came to water pond (b) Sell to local market
(b) Sell to firm (d) Others………………………………………
38. What price per kilogram of shrimp? ± IDR
39. Can you give me information about the payment system?

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Section 3: The Inputs use in the White Shrimp Production (for selected pond)

✓ **Labour**

Labor (*LBR*) includes both family and hired labor utilized for pre and post aquaculture operations, and harvesting. It will be measured in labor-days used for white shrimp production per hectare per production cycle.

1. How many days did the labour take in each activity in once production cycle and how many wages are paid? (only in 1 pond)

Activities	**Family Labour**		**Hired Labour**		**Wages (man / days)**
	Amount	**Man days**	**Amount**	**Man days**	
Land Prep.					
Pre Cultivation					
Operation					
Post Cultivation					
Harvesting					
Marketing					

✓ **Fertilizers**

Fertilizers (*FTR*) include all of fertilizers used by the aquaculture farm households for white shrimp production and will be measured in kilogram (kg) per hectare per production cycle.

1. What type of fertilizer did you use in 1 pond and how much?

Types	**Usage (kg)**	**Price (IDR)**

✓ **Feed**

Feed (*FED)* is the quantity of formulated feed applied to the white shrimp production, measured in kilogram (kg) per hectare per production cycle

1. What type of feeds did you use in 1 pond and how much?

Types	**Usage (kg)**	**Price (IDR)**

✓ **Stocking Densities**

Stocking densities (*STD*) is quantities of white shrimp fry applied to the white shrimp production, measured in fry per hectare per production cycle.

1. How much stocking densities in 1 pond?

Plots of Brackish Water Pond	Fry / ha	Price of Shrimp Fry (IDR)

Section 4: Problems in Shrimp Farming and Government Policies in Shrimp Farming

1. What your main problems in shrimp farming?
   (You can select more than one)

Internal Problems

Technical

(a) Wrong site selection

(b) Wrong in brackish water pond design

(c) Insufficient quality of shrimp fry

(d) Degradation of environment

(e) Disease

(f) Water pollution from human activity

(g) Management

(f) Others:

Non Technical

(a) Shrimp prices are too low

(b) Production cost is too high

(c) lack of business capital

(d) Others:

External Problems

Unpredictable conditions

(a) Disasters

(b) Strict requirement to export from importing countries

2. Related with question number 1, how did you solve those problems?
   (Please explain in detail)

3. What policies that the Government has done in support of your shrimp farming?
   (Please explain in detail)

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