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Review of Shrimp (*Litopenaeus vannamei* (Boone, 1931)) Farming in Indonesia: Management Operating and Development

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ABSTRACT

Indonesia is an archipelago with a coastline of about 81,000 km and has enormous cultivation potential. The area that's the potential for aquaculture is estimated at 15.59 million hectares, consisting of 2.23 million hectares of freshwater cultivation land, 1.22 million hectares of cultivated land in brackish waters, and 12.14 million hectares of marine areas. Nowadays, only 10.1% freshwater, 40% of brackish water, and 0.01% of the marine area potentially suitable for cultivation are being used. However, land use for shrimp farming until 2017 has only reached 20% of the total potential. It is still very open to developing land for the extensification of shrimp farming. Shrimp is one of the non-oil and gas export commodities that play a crucial role. Besides the high price, shrimp also has a large market in various countries. Although the industry suffered disease outbreaks and environmental problems, Vannamei shrimp farming has recently seen a rapid expansion in Indonesia due to superior varieties and disease resistant shrimp. Vannamei shrimp is a new variety that's some advantages, including more resistance or resistance to disease and low environmental quality, high stocking density, shorter rearing time, which is around 90-100 days per cycle. This study provides some necessary background for Vannamei shrimp farming in Indonesia. It focuses on the operating characteristics of shrimp farming in brief. Emphasis is placed on the impact of shrimp farming on the environment. Promising strategies for reducing nutrient release from shrimp farming are analyzed. Effective management measures to resolve or mitigate the adverse environmental effect of shrimp farming development have now become necessary and urgent. The sustainability of shrimp farming depends on many factors including the completeness of policies and regulations, good ecology, superior breeding and various kinds of

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cultivation technology and government support, advances in technology digitization and cooperation between industries shrimp farming.

***Keywords*:** Indonesia, Farming, Management, Shrimp, Litopenaeus vannamei

1. INTRODUCTION

Indonesia is an archipelago with a coastline of about 81,000 km and has enormous cultivation potential. Nationally, the area that's the potential for aquaculture is estimated at 15.59 million hectares, consisting of 2.23 million hectares of freshwater cultivation land, 1.22 million hectares of cultivated land in brackish waters, and 12.14 million hectares of marine areas. Nowadays, only 10.1% freshwater, 40% of brackish water, and 0.01% of the marine area potentially suitable for cultivation are being used [1].

Aquaculture is one of the necessary sectors for fisheries in Indonesia because it can contribute to national food security, income, and employment development and foreign exchange earnings. Aquaculture has a role as an alternative source of income for coastal fishing communities. It also contributes to reducing pressure on marine natural resources. Recently, the development of aquaculture in Indonesia has been accelerating and is considered a necessary sector in supporting rural economic development [1, 38-42].

Aquaculture can be implemented in freshwater, brackish water, and seawater using various facilities and production methods. Cultivation systems range from extensive to intensive depending on stocking density, level of input, and management level. Brackish water cultivation is quite popular in Indonesia. One of them is shrimp farming. Shrimp farming plays an important role in contributing to the country's foreign exchange in Indonesia [2].

Shrimp farming has increased rapidly in the last decade, and cultured shrimp continues to dominate the international seafood market [3]. In addition, Indonesia has become the fourth largest shrimp exporter, after India, Ecuador, and Argentina [4]. The average volume of shrimp exports on the world market during this period was 91.7 thousand metric tons per year. The average world shrimp export volume growth rate is around 6.75% per year [5].

Table 1. Volume and Value of Indonesian Fisheries Exports by Commodities, 2018 [6].

No	Commodities	Value (USD)	Ton
1	Shrimp	1,302,330,215.54	147,164.7
2	Tuna – Skipjack - Mackerel	499,951,755.15	116,909.4
3	Squid – Cuttlefish - Octopus	371,250,811.57	103,408.4
4	Crab	370,144,098.01	21,577.3
5	Seaweed	213,461,393.07	154,367.2
6	Other commodities	766,948,739.91	258,538.4

So far, shrimp has become Indonesia's leading export for fisheries commodities [7]. In 2018, for example, it can be seen on the volume of exports and their export value is recorded to be the highest compared to the export volume and export value of other fishery commodities (occupying 4th in 1st place). The export value of shrimp in that year reached USD 1,302,330,215.54 and the export volume reached 147,164.69 tons. This can be seen from the data as shown in Table 1.

In Indonesia, shrimp farming has long been practiced by pond farmers because shrimp is a prime aquaculture commodity in the fisheries sector that can increase foreign exchange through exports of fishery commodities. The high demand for shrimp at home and abroad makes Indonesia the largest shrimp sender in the world because Indonesia has an extensive area and natural resources that support the development of shrimp farming.

Indonesian farmers generally cultivate tiger prawns (*Penaeus monodon*) with problems such as constraints on high production costs and the vulnerability of these shrimp to disease. The farmer tries to cultivate other shrimps as a substitute for tiger prawns. One of the efforts to increase shrimp productivity is by introducing new, disease-resistant, superior varieties of shrimp. In addition, it also aims to enrich and add to the alternative types of cultivated shrimp that have the potential to be developed. In connection with this, a new shrimp variety has been released namely, the vannamei shrimp (*Litopenaeus vannamei*) that is believed can increase the enthusiasm of aquaculture to become prospective again.

Vannamei shrimp has officially been released as superior varieties and is disease resistant and expected can increase the chances of doing aquaculture again. In addition, it also aims to enrich and add to the alternative types of cultivated shrimp that have the potential to be developed.

The eastern Pacific white shrimp, *Litopenaeus vannamei* (Boone 1931) is an increasingly popular and necessary culture shrimp species following the massive decline in tiger prawn production (Penaeus monodon Fabricius 1798) caused by a worldwide outbreak of white spot syndrome disease. In South-East Asia. Tiger prawns are attacked by many diseases, including the White Spot Syndrome Virus (WSSV) and Yellow Head Virus (YHV) [8]. As a result, vannamei shrimp has been introduced to most Southeast Asian countries in recent years. *Litopenaeus vannamei* has been cultivated widely in Asia, North America, South America, and the Pacific Islands because of its high survival, rapid growth in intensive culture systems, and disease tolerance [9]. In connection with this, a new shrimp variety has been released namely, the vannamei shrimp (*Litopenaeus vannamei*) that is believed can increase the enthusiasm of aquaculture to become prospective again.

Many studies convey what shrimp farming activities in Indonesia are like in terms of management and operations. Most of the study is related to the problems that arise in some or several shrimp ponds. This study aimed to analyze the development of shrimp farming in terms of management and operational characteristics in Indonesia.

2. HISTORY OF SHRIMP FARMING IN INDONESIA

Shrimp is one of the non-oil and gas export commodities that play a crucial role. Besides the high price, shrimp also has a large market in various countries, one of importing countries for Indonesian shrimp is Japan. The demand for Indonesian shrimp by Japan is increasing year

to year. It is very beneficial because it can increase the country's foreign exchange and increase the income of pond farmers and trigger the emergence of efforts to develop shrimp production.

In 1980, Indonesian shrimp exports experienced a decline due to Presidential Decree No. 39 of 1980 concerning the prohibition of trawling [10].

In Indonesia, brackish water cultivation began in the 1400s [11]. This sustainability has made it the main activity for coastal communities that produce fish and some natural shrimp to be raise in cultivation media in mangrove forests. Eventually, the farmers removed the mangroves and constructed dykes. They produce fish and shrimp without using pellet feed, just using the algae of the ponds. This "traditional, extensive technology" continued for centuries, present in the modern era among small farmers [12].

After a long gradual development for nearly seven centuries, in the 1960s-1980s shrimp farming suddenly occurred, there was a massive decline in Indonesia. Such sudden economic transformations and technological changes have been common in many sectors in the past century. The departure of aquaculture modernization is due to several reasons.

(1) In the 1960s and 1970s, traditional shrimp farming technology began to change with the introduction of new technologies from Japan and Taiwan, for example, mass production in post-larval shrimp hatcheries for ponds and the use of formulated shrimp feed;

(2) In the middle 1970s, the government encouraged the adoption of P. monodon (tiger prawns) for aquaculture due to its high market value and demand in Japan (whose economy boomed in the 1980s led to a surge in shrimp imports [13], and the US; P. monodon grew to become the main species in the 1980s [14] The impetus for aquaculture compared to capture fisheries for shrimp was caused by overfishing which led to the banning of coastal trawlers in 1980. In addition, the government invested in aqueducts and P. monodon hatchery in the 1980s [15];

(3) In the mid to late 1980s, the government encouraged by regulation and land grants the emergence of "nucleus-estate, small-scale out-growers scheme" (NESS) that shrimp companies enter into contractual agreements with small farmers, supplying the water, electricity, finance, and technical assistance. It led to 350 medium to large enterprises involved in 1990. In addition, many other actors emerged along the shrimp value chain - a large number of feed mills, hatcheries, and cold stores [14]. The government has also liberalized foreign investment in shrimp farming, for example, open doors for the Charoen Pokphand. One of the large agribusinesses in Asia, to open up the largest shrimp production scheme in the world [16]. Results 1–3 above represent the growth of shrimp culture, up to 250,000 ha in 1988.

In 1990, intensification with densification of P. monodon cultivation led to the outbreak of the White Spot Syndrome Virus (WSSV) that drained P. monodon cultivation for a decade [17]. To be countered this trend, the government was impotent to import the parent *P. vannamei* in 2000; In 2001, the government issued a KEP.41 / MEN / 2001 "Releasing Vannamei Shrimp as a Superior Variety of Shrimp", which assists the production and distribution of these species.

The government and shrimp companies believe that *Penaeus vannamei* is resisted to WSSV and has other advantages over *P. monodon* namely, increased awareness of its high stocking density, better feed conversion rates, higher average daily growth rate, tolerance of high stocking density greater than salinity and air temperature ranges, and production outputs of more consistent quality and size.

Vannamei shrimp were considered initially to be resistant to disease. However, in its development, vannamei shrimp are also attacked by WSSV (*White Spot Syndrome Virus*), TSV

(*Taura Syndrome Virus*), IMNV (*Infectious Myonecrosis Virus*), vibrio, EMS (*Early Mortality Syndrome*), and the latest disease, namely AHPND (*Acute Hepatopancreatic Necrosis Disease*). For this reason, it is necessary to do prevention and control with the application of environmentally friendly cultivation [18].

3. MANAGEMENT OPERATING AND CHARACTERISTICS

Since the 1980s, Indonesian shrimp production has continued to increase at the expanse of large aquaculture areas and intensification of production. The consequence of diseases and environmental degradation associated with this development, there is currently 250,000 ha of abandoned ponds in Indonesia [19].

In Indonesian waters, there are some freshwater shrimp species, which are very potential for cultivation. The types of shrimp that cultivated widely in Indonesia are namely vannamei shrimp (*Litopenaeus vannamei*) and tiger prawns [20]. Vannamei shrimp is a new variety thats some advantages, including more resistance or resistance to disease and low environmental quality, high stocking density, shorter rearing time, which is around 90-100 days per cycle [21].

Based on data from the Ministry of Marine and Fisheries, the potential for land for the development of brackish water cultivation (ponds) in Indonesia reaches around 2,964,331.24 hectares. However, land use for shrimp farming until 2017 has only reached 20% of the total potential, which is around 605,908,818 hectares, it is still very open to developing land for the extensification of shrimp farming [6]

3. 1. Stock

In general, the stock must meet several criteria, including age, total length, activity, not variation, survival rate, and disease-free. The age of postlarvae (PL) is about 10-13 days by a length total of at least 10 mm. The stock is active against the current and does not cluster. The survival rate of stock that subject to a stress test with formalin 100 mg / l is at least 75%. The stock is uniform, do not vary to prevent cannibalism. The stock also must be free from several types of diseases such as white spot syndrome virus (WSSV), Taura syndrome virus (TSV), IMNV, and IHHNV. And hatcheries in Indonesia still rely on imported broodstock, although domestic broodstock and selective breeding techniques ensure better shrimp survival, reduce disease risk, and position hatcheries to focus on faster-growing and be large PL breeding. However, because they considered having better quality than Indonesian broodstock, hatcheries buy imported broodstock [22].

The stocking of shrimp farming facilities with stocks of domesticated shrimp that are free from certain diseases (“Specific Pathogen Free" or SPF) and / with stocks that are resistant to some disease agents (SPR) is perhaps the most necessary component of a biosecurity program.

The example provided by the domestic SPF stock development of *Litopenaeus vannamei* has helped make biosecure shrimp farming viable. Its development and other SPF stocks, diagnostic methods for developing specific diseases and disease-causing agents, have been an important milestone in the development of the international shrimp farming industry in recent years. Routine monitoring (surveillance) of shrimp stocks in a biosecurity culture facility is the component important of a biosecurity plan, having a contingency plan for disease control and eradication if it occurs in the physical and managerial components of the biosecurity facility and the disease occurs [23].

3. 2. Disease

When vannamei Shrimp came to Indonesia, this species has been cultivated successfully on a large scale since 2003. However, in early 2006, there were reports from Indonesian shrimp farmers about high mortality in *P. vannamei* cultivation [24]. Disease attack is one of the causes of unsuccessful production, including in shrimp culture. The most dangerous viral disease attacks and causing many losses for shrimp farmers in Indonesia are virus attacks (WSSV, TSV, YHV, IMNV, and IHHNV).

Table 2. Disease reported in *Litopenaeus vannamei*.

Disease	Type	Syndrom	Reported in	Reference
Infectious myonecrosis virus (IMNV) disease	Virus	Significant mortality in grow-out ponds and is characterized by acute onset of gross signs: focal to extensive whitish necrotic areas in the striated muscle, especially of the distal abdominal segments and the tail fan. The white necrotic areas redden, similar to the colour of cooked shrimp. The outbreak results in elevated mortality that was initially associated with a chronic Persistent low-grade path of death.	in East Java, Bali, and West Nusa Tenggara provinces	[25]
White spot syndrome virus (WSSV)	Virus	The necessary viral pathogen of the shrimp can replicate in this polychaete. The WSSV infection can identify if the vannamei shrimp has clinical signs of white spots on the carapace.	in the Peudada sub district of Bireun District of Aceh Province	[26] [27]
Acute hepatopancreatic necrosis disease (AHPND)	Virus	Non-specific mortality during the first 50 days of culture.	*has not yet been encountered*	[28]

Disease	Type	Syndrom	Reported in	Reference
Vibriosis outbreak	Bacterial	The clinical signs of shrimps affected by vibrio were pale hepatopancreas, weak of telson, the dark and reddish colouration of smooth, patches of red colour in part of the body on the carapace, pereiopods, pleopods, and telson.	Kendal District, Indonesia	[29]
White feces disease (WFD)	Bacterial	The cause of this disease is thought to be due to the abundant population of Vibrio bacteria in the cultivation medium	in East Lampung Regency, Indonesia	[30]
Protozoan ectoparasites	Parasites	In this condition, the shrimp becomes stressed because it is influenced by changes in fluctuations in water quality conditions, especially temperature, and maintenance which contains a lot of leftover feed. As a result, there is a buildup of organic matter that will increase the ammonia level so that the dissolved oxygen level in the water will decrease.	Pasuruan, East Java, Indonesia	[31]

3. 3. Feed

Feed is the most necessary factor in intensive shrimp farming. It can absorb 60% -70% of the total cost of shrimp production. The composition of protein, carbohydrate, fat, e.t.c. should be adjusted to the shrimp needs, to achieve optimum growth and survival. Efforts need to make that always reduce feed costs through efficient use of feed so that shrimp can grow optimally and feed is waste to a minimum. One of the efforts made to control overfeeding is through feed management, namely by regulating feed ration properly.

The accuracy of feeding will stimulate the growth and development of vannamei shrimp optimally so that productivity can increase. Pellet feeding starting from the stocks is spreading until the shrimp are ready for harvest. The size and amount of feed given must do carefully and

precisely so that the shrimp are not underfeeding or overfeeding. The feed amount must adjust to the total biomass of shrimp, but when the price of feed needs increases due to the impact from the weakening of the rupiah exchange rate, the resulting production costs will also increase.

3. 4. Farming Environment

Shrimp farming, particularly in Java, Sumatra, and Sulawesi, has resulted in extensive ecological degradation due to the large area required and its competition with mangrove forests in coastal areas. Extensive deforestation in Sumatra and Kalimantan also impacts fire air quality, rainfall patterns, and freshwater quality [32]. As a result, land concessions created negative feedback for the aquaculture industry due to deteriorating ecosystems. So, despite large carbon emissions, the argument for zero tolerance of further land concessions is overwhelming and essential to the success of the aquaculture industry. Meanwhile, most of the systems evaluated have the potential for intensification, but this needs to do with minimal negative trade-offs, such as deforestation of the Amazon for soybean production [33].

3. 5. Governmental management

The government regulates shrimp farming in the KEP. 28 / MEN / 2004 regarding general guidelines for shrimp culture in ponds. Guidelines for shrimp farming through pond regulations stipulated in this Ministerial Regulation are for:

(1) Using technical and land that suitable for shrimp farming areas;

(2) a good applied strategy for stocking;

(3) Using certified shrimp larvae post for cultivation;

(4) Application of sterilized shrimp pond water system;

(5) Using all registered and certified shrimp farm production inputs;

(6) Avoiding the use of antibiotics and banned chemicals;

(7) Biosecurity Application.

But the government does not strictly regulate shrimp farming. Disposal of agricultural waste into offshore waters is untreated and thus affects the ecosystem. Some pools are not well designed in an environmentally friendly way. Disposal of chemicals or drugs in cultivation is often misused or overused due to poor management.

3. 6. Farmers' knowledge

The rapid development of the shrimp farming industry has attracted investment from other industry. However, the educational background and technical skills of farmers are not necessarily able to meet these demands. The development of shrimp farming can take advantage of technology 4.0 through automation of the production system and digitalization of marketing so that the supplies chain is more efficient and the profits of farmers increase. In addition, shrimp farming in ponds has potent to absorb labour and create new farmers because the technology is easy to apply and can be harvested quickly so that the shrimp farming business is very prospective and promises big profits. Cultivation of vannamei shrimp (Litopenaeus

vannamei) in Indonesia has role importance in economic growth, labour absorption, and the welfare of coastal communities in Indonesia [8].

3. 7. Biosecurity

Biosecurity, as applied to shrimp farming, can be defined as the practice of removing specific pathogens from aquaculture stocks in broodstock, hatcheries, and ponds or from entire regions or countries for disease prevention purposes. Make the biosecurity programs a functional concept in shrimp farming. The relevant risks must identify and appropriate biosecurity measures implemented to reduce these risks. Examples of biosecurity measures implemented could include the basics such as selection when the objective is to locate new shrimp farming facilities in areas where certain diseases are not enzootic. Agricultural facility standard operating procedures can adapt to minimize the risk of disease entry and spread within the facility through concepts such as pretreatment of all water sources, and "zero" water reduction or exchange [23].

4. SHRIMP FARMING SYSTEM

Shrimp farming has developed quite rapidly both from technology input and cultivation methods. This development is inseparable from the increase in knowledge and the increasingly limited cultivated land along the coast. Shrimp farming in the future must be environmentally friendly to ensure its sustainability.

4. 1. Shrimp Cultivation System Based on Input Technology

Based on technology input, shrimp farming systems are divided into three categories, namely:

1) extensive or traditional ponds;
2) semi-intensive ponds;
3) intensive / super intensive ponds.

The more intensive the cultivation system, the less dependence on natural food. Traditional/extensive ponds are very dependent on natural food. Only a little additional feed provided so that the carrying capacity of the land is very limited. In this system, there is no water sterilization treatment and biosecurity applications. The density of the stock is not more than five individuals/m^2. While in intensive systems, the main source of feed is artificial/commercial feed, the role of natural feed is very small. The more intensive the cultivation system, the greater the technology input as well as the management input. The input technology includes equipment such as aerators/waterwheels, water pumps, machines. generators and others as well as supporting equipment such as laboratories [34].

The application of management in intensive systems is very concerned, such as good aquaculture practises (GAP) applications and structure standard operating procedures (SOP) and biosecurity. The carrying capacity of the ponds increases so that the very high stocking density can reach more than 100 individuals / m2 with a productivity of more than 10 tons per hectare. However, in intensive system shrimp farming, disease outbreaks often occur because of the high density of distribution followed by an increase in the resulting organic waste. A bad

environment will stimulate the growth of pathogens and stress the shrimp that results in decreased immunity of shrimp [34].

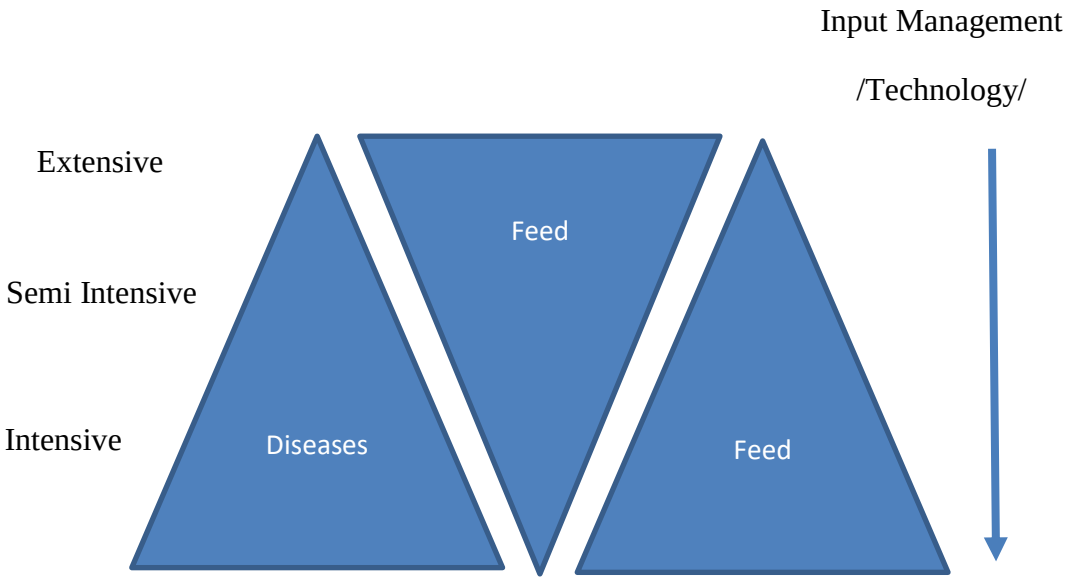

Figure 1. Differences in shrimp farming systems based on technological input [34]

4. 2. Application and Development of Shrimp Cultivation System in Indonesia

The implementation and development of the shrimp farming system have undergone several changes, one of which is the input technology as explained in Table 3.

Table 3. Implementation and Development of Shrimp Cultivation System in Indonesia.

Location	Cultivation System	Application and Development	Reference
in Gresik, East Java, Indonesia	Super Intensive	Develop a hybrid zero water discharge (ZWD) - recirculating aquaculture system (RAS) system to improve water quality, as well as the growth, survival, and productivity, of the super-intensive white shrimp culture under low salinity conditions at semi-mass and the industrial level.	[35]
in Rembang Regency, Central Java, Indonesia	Intensive	System detection of bacterial abundance and community composition to avoid rearing failure due to stress, disease, or mass mortality, and to achieve optimum shrimp production	[36]

in Probolinggo District, East Java, Indonesia	Intensive	Silvofishery system that integrates mangroves into a pond as a potential solution to excellent water quality to ensure its growth rate and production	[37]

5. CONCLUSIONS

Shrimp is one of the non-oil and gas commodities that have economically important, especially for vannamei shrimp (*Litopenaeus vannamei*). However, land use for shrimp farming until 2017 has only reached 20% of the total potential. It is still very open to developing land for the extensification of shrimp farming. There are several important factors of Management Operating and Characteristics in shrimp farming such as stock, disease, feed, farming environment, governmental management, farmer knowledge and bicosecurity. Based on technology input, shrimp farming systems are divided into three categories, namely: 1. extensive or traditional ponds; 2. semi-intensive ponds; 3. intensive / super intensive ponds. The application of management in intensive systems is very concerned, such as good aquaculture practices (GAP) applications and structure standard operating procedures (SOP) and biosecurity.

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