STUDY OF TRADITIONAL SHRIMP FARMING; A CASE STUDY OF POND PRODUCTIVITY OF SEVERAL REGIONS IN INDONESIA

Handayani Boa[1,3*], Sasitorn Suwannathep[2], Bambang Indratno Gunawan[3], and Boosya Bunnag[4]

[1]*College of Multidisciplinary Sciences, King Mongkut's University of Technology Thonburi, Thung Khru, Bangkok 10140, Thailand*
[2]*School of Liberal Arts, King Mongkut's University of Technology Thonburi, Thung Khru, 10140, Thailand*
[3]*Faculty of Fisheries and Marine Sciences, Mulawarman University, Jalan Gunung Tabur, Kampus Gunung Kelua, Samarinda, East Kalimantan, Indonesia*

[4]*School of Bioresources and Technology, King Mongkut's University of Technology Thonburi, Bang Khun Thain, Bangkok 10150, Thailand*

*Corresponding Author: handayani.boa01@kmutt.ac.th

***Abstract*—*Traditional shrimp farming in Indonesia is still dominant aquaculture and the one of large contributions in fisheries sector, namely provinces from Kalimantan, Java, West Nusa Tenggara (NTB), Sumatera, and Sulawesi. Pond farmers still maintain the old ways of managing their shrimp farming, however some regions is found to apply sustainable shrimp farming with eco-friendly farm. In order to achieve sustainable income, the pond productivity is mainly calculated however pond productivities of those regions are not always correlated to the wider pond area and larger production. The objective of study is to explore traditional pond performance and its productivities in several provinces in Indonesia. The result shows that the shrimp farming is applying traditional method in pond management, water and soil quality is influenced by around the environment, the wide pond size/extensive pond, the opened pond, irregular pond shape, without feeds, built in the coastal areas and deltas as the brackish water pond, and harvest period after 4-6 months of cultivation. Seven provinces (South Sulawesi, West Java, East Java, Center Java, NTB, Southeast Sulawesi, and East Kalimantan provinces) in Indonesia contribute approximately 91% of total traditional shrimp farming production in Indonesia. Province with the second largest pond area in Indonesia is South Sulawesi province after North Kalimantan, however West Java is the biggest income of them compared, approximately IDR13.5 trillion. Government policy should facilitate improving environmental quality and sustainability in ponds in those regions.*

Keywords*—*Traditional shrimp farming; pond productivity in several provinces in Indonesia

Abstrak—Budidaya udang tradisional di Indonesia masih dominan budidaya dan salah satu penyumbang terbesar dalam sektor perikanan, yaitu provinsi dari Kalimantan, Jawa, Nusa Tenggara Barat (NTB), Sumatera, dan Sulawesi. Petambak tambak masih mempertahankan cara lama dalam mengelola tambak udang mereka namun beberapa daerah ditemukan menerapkan budidaya udang berkelanjutan dengan tambak ramah lingkungan. Untuk mencapai pendapatan yang berkelanjutan, produktivitas tambak terutama diperhitungkan, namun produktivitas tambak di wilayah tersebut tidak selalu berkorelasi dengan luas tambak dan produksi yang lebih besar. Tujuan penelitian adalah untuk mengetahui kinerja tambak tradisional dan produktivitasnya di beberapa provinsi di Indonesia. Hasil penelitian menunjukkan bahwa budidaya udang menggunakan cara tradisional dalam pengelolaan tambak, kualitas air dan tanah dipengaruhi oleh lingkungan sekitar, ukuran tambak yang luas/luas, tambak yang terbuka, bentuk tambak yang tidak beraturan, tanpa pakan, dibangun di daerah pesisir. dan delta sebagai tambak air payau, dan masa panen setelah 4-6 bulan budidaya. Tujuh provinsi (provinsi Sulawesi Selatan, Jawa Barat, Jawa Timur, Jawa Tengah, NTB, Sulawesi Tenggara, dan Kalimantan Timur) di Indonesia menyumbang sekitar 91% dari total produksi budidaya udang tradisional di Indonesia. Provinsi dengan luas tambak terluas kedua di Indonesia adalah Provinsi Sulawesi Selatan setelah Kalimantan Utara, namun Jawa Barat merupakan pendapatan terbesar di antara mereka, sekitar Rp13,5 triliun. Kebijakan pemerintah harus memfasilitasi peningkatan kualitas dan kelestarian lingkungan tambak di wilayah tersebut.

Kata kunci— Budidaya udang tradisional; produktivitas tambak di beberapa provinsi di Indonesia

I. INTRODUCTION

In many areas in Indonesia, pond farmers still preserve traditional ways of managing their ponds based on their respective environmental situation. Shrimp farming has developed over time, from a small traditional enterprise to industry. Shrimp farming is also called the ponds or *tambak*. This progress is correlated with high market demand and will then be commercially profitable. Indonesian shrimp production in the world market faces stiff competition from major competitor countries such as Ecuador, India, Bangladesh, China, Thailand, Vietnam and other countries which continue to supply the international market with more economical prices. Therefore, innovation and proper strategies of cultivation are developed continually to produce quality pond products that meet these markets.

In general, pond farmers have employed the ponds with installment of technology and the required size for improving of production but traditional ways are still selected by pond farmers because low costs, using skill and knowledge from pond farmer's family from generation to generation that is characteristic of most pond farmers of Indonesia, and in small/micro and medium enterprise scale. The shrimp farming or pond fisheries sector is generally managed traditionally, either monoculture or polyculture. This sector is really important because it has a large potential to contribute to the supply of food needs especially shrimp and fishes. The development and management of traditional ponds with due regard to the environment and the application of several technologies are considered to be a solution to increase sustainable shrimp production. Traditional shrimp farming in Indonesia that still apply extensive practices for the increase of production have to be abandoned and replaced by the application of better methods and less causing environmental damage as the concept, namely achieve as environment-based ponds. This concept supports international market demands that require certification of pond products exported.

Brackish water ponds in Indonesia divided on traditional, semi-intensive and intensive groups (BPS-StatisticsIndonesia, 2023). In general, the types of pond shrimp that are cultivated are Penaeus shrimp (shrimp from the Penaeidae family), and only two species of shrimp, namely Penaeus vannamei (white shrimp), and Penaeus monodon (tiger shrimp) are popular in Indonesia. Apart from seaweed, shellfish and crabs which are cultured in most of the brackish water ponds, milkfish is also found as the main cultivated species.

The largest area and production of shrimp farming in Indonesia is found in Kalimantan, Sulawasi, Aceh, Java and West Nusa Tenggara especially the area of traditional ponds however the number of vast ponds does not always correlate to its production and revenue. As mentioned by Indra et al. (2020) that pond area (in hectare) was negatively correlated shrimp production (inefficient). In addition, Boa et al. (2023) state that traditional shrimp farming also have to adopt integrating of mangrove and shrimp farming for sustainable shrimp farming production in the future because those shrimp farming are more feasible and profitable than ponds without mangroves. Although the Government of Indonesia has arranged cultivation ways in the pond and made the several guidelines through the law, regulation, decision, and decree, hence the scientific studies are needed to update the current situation in the fields in provinces, Indonesia. Such as the practical manual of Better Management Practices for Tambak Farming in Aceh, is aimed to be the pond farmers' guideline. According to Padiyar et al. (2011) that implement better management practices (BMP) in Aceh influences reduction of cost and raising benefit cost ratio.

The objective of study is to explore traditional shrimp farming performance and its productivities in several provinces in Indonesia. The assumption of the study is limited at representing several traditional shrimp farming in provinces of Indonesia with literature studies. Then, that is added by the data and information of ponds farmers and the relevant stakeholders to support the study.

II. METHODS

A. Study Site and Time

Several provinces in Indonesia are study sites to explore of the study, namely shrimp farming in provinces from Kalimantan, Java, West Nusa Tenggara (NTB), Sumatera, and Sulawesi as the largest pond cultivation regions in Indonesia. Data and information were collected and updated during January-June 2023.

B. Data Collection Method

Primary and secondary data are employed for this study. The primary data is collected from several pond farmers and the related stakeholders (government staffs from office of Fisheries and Marine Science, and the relevant stakeholders) through a questionnaire and in-depth interviews that is intended to reinforce the study. The secondary data are collected from relevant statistical data of the related government and related private institution sources, the research reports, and published

relevant journals.

III. Results and Discussion

A. Overview of Traditional Pond and Its Performance

Based on interviews to pond farmers and the stakeholders in the study, they mention that traditional pond is included in the opened pond, extensive pond, and built on the land with traditional ways, as well as, irregular pond shape, large pond size, water intake depends on tidal action, without feeds, built in the coastal areas and deltas as the brackish water pond, and harvest period after 4-6 months of cultivation. Those shrimp farming features are employed from generation to generation, and pond farmers get the skill and knowledge from their family. According to Hoanh et al. (2006), in Bangladesh, India, Indonesia, Myanmar, the Philippines and Vietnam, extensive shrimp farming generally is conducted in tidal areas where water pumping is unnecessary. Shrimp farming with an irregular shape according to land boundaries are generally larger than five hectares and easily constructed by manual labor for cost reduction besides excavators. The wild seedlings which either enter the pond through the sluice by the tide or are purchased from the collector are usually stocked at a density not exceeding 2 seeds /m². Shrimp feed on natural foods that enter the pond regularly on the tide and are subsequently enhanced by organic or chemical fertilizers. If available, fresh fish or mollusks may be used as supplementary feed. Due to the low stocking densities, larger sized shrimp (>50 grams) are commonly harvested within six months or more. The yield is lowest in these extensive systems, at 50-500 kg/ha/year. Due to the increase in land costs and the shortage of wild seeds, almost no new extensive farms are being constructed today. After gaining experience in shrimp farming, many farmers have transformed their ponds into semi-intensive systems to gain higher incomes. Moreover, fry is wild fry from natural sources, built-in intertidal areas where water is exchanged by tidal action, the pond size typically is more than 10 ha, the trap and hold wild shrimp was at density of 1-3/m^2, and yield typically was less than 200 kg/ha/year.

In addition, the largest extensive pond type in the world is found in Indonesia, and perhaps the oldest largest scale cultural system. These ponds are built to culture milkfish and shrimp, where shallow water is needed to promote the growth of benthic algal mats, the natural food choice for milkfish and tiger shrimp in these ponds. Water depths range from 0.4 to 1.0 m. Ponds deeper than 0.5 m are less suitable because less light reaches the bottom, resulting in less growth of benthic algae. As greater interest and profits developed from shrimp culture, many of these farms supplemented natural shrimp seed with seed from hatcheries and from wild seed collectors (Bosma et al., 2012).

Shrimp farming performance in the pond has been arranged by a regulation of Ministry of Marine Affairs and Fisheries that no. 28/Men/2004. As well as, fish farming is arranged in President of Republic of Indonesia regulation, no.28/2017, in addition, about development of marine cultivation in Indonesia waters area is arranged in President of Republic of Indonesia decision, no.23/1982. The guidelines of the cultivation include site selection, layout design and construction, cultivation management, business pattern, maximum area of cultivation and business permits, then, is added preservation of germplasm related to fish resources and arrangements for entry and exit of prospective new fish broodstocks. The essential points of the cultivation address at the environment balancing, and impact to increase the income of fishermen/farmers, suffice the nutritional needs of the community, and expand employment opportunities.

The regulation of Ministry of Marine Affairs and Fisheries mentions that location of the cultivation is not built on critical mangrove lands and the path of geological formations of mining material. There are also requirements of water sources and water maintenance quality (Table 1 and 2), and soil standard quality for shrimp farming as shown in Table 1.

Table 1 STANDARD OF WATER AND SOIL QUALITY FOR SHRIMP FARMING BY REGULATION OF MINISTRY OF MARINE AFFAIRS AND FISHERIES

Parameter	Water Sources	Water Management	Soil
Salinity (ppt)	5-35	15-25	-
pH	7.0-9.0	7.5-8.5	6.0-8.0
Alkalinity (ppm)	>50	120-160	-
H_2S (mg/l)	0.001	0.01-0.05	-
Organic matter	<55 ppm	28.5-31.5 ppm	<9.0%
Total phosphate (ppm)	0.05-0.5	0.05-0.10	-
BOD (Biological Oxygen Demand) (ppm)	<25	-	-
COD (Chemical Oxygen Demand) (ppm)	<40	<55	-

TSS (Total Suspended Solid) (ppm)	25-500	30-40	-
Pb (Plumbum) (ppm)	0.001-1.157	0.01-0.05	-
Hg (Mercury element) (ppm)	0.051-0.167	-	-
Cu (Copper element) (ppm)	<0.06	-	-
Organochlorine (ppm)	<0.02	-	-
Texture	-	-	Clay (60-70%) and sand (30-40%)
Structure	-	-	Compact
Infiltration potency (cm/minute)	-	-	<1
Coelom (m)	-	-	>1

Source: Ministry of Marine Affairs and Fisheries (no. 28/Men/2004), Indonesia

Table 2 PARAMETER OF OPTIMAL WATER QUALITY DURING MAINTENANCE OF VANNAMEI SHRIMP

Parameter	Maintenance water
pH	7.5-8.5
pH range	<0.5
Alkalinity (ppm)	100-200
TAN (Total ammonia nitrogen) (ppm)	<10
DO (Dissolved oxygen) (ppm)	>4
Water brightness (cm)	30-40
Water color	Green-brown
Salinity (ppt)	24-35
Temperature ºC	24-29
Total suspended solid (ml/L)	2-6
Bacteria density (CFU/ml)	10^4-10^5
Vibrio bacteria density	<5% of total bacteria
AHPND, IMNV, WSSV, EHP	negative

Source: Standard Operational Procedure of Ministry of Marine Affairs and Fisheries, Indonesia, Brackish Water Cultivation Center of Situbondo, 2020

Furthermore, characteristics of extensive pond has been discussed in research by Fast & Lester (1992) in Table 3. The research informs about the annual production per hectare, stocking rate, seed source, maximum standing crop, feed (no supplement), nuisance species (abundant), selected pond system (polyculture), water exchange rate, water exchange mode, aeration, pond size, pond shape, water depth, survival, dike construction, the annual crops, labour needs, management, disease problems, and potential profit. So, similar with pond inputs in West Bengal as shown in Table 4, normally, extensive ponds are without feeds, and stocking density of seed is very low, amounting to < 2 seed/m^2. Farmers in West Bengal also use without pumping and paddle wheel.

Table 3 CHARACTERISTICS OF EXTENSIVE POND

Characteristics	
Production (ton/ha/yr)	<0.1 to 0.3
Stocking rate (m^2/crop)	0.1 to 1
Seed source	wild
Maximum standing crop (g/m^2)	< 25
Feed	natural (no supplement)
Feed conversion (kg feed/kg shrimp)	0
Nuisance species	abundant
Polyculture	common
Water exchange rate (%/day)	< 5%
Water exchange mode	tidal or pump
Aeration and aerators	natural water exchange
Pond size (in ha)	>5
Pond shape	irregular
Water depth (m)	0.4 to 1
Survival (%)	< 60
Dike construction	earthen
Crops/yr	1-2
Labour needs (persons/ha)	< 0.15
Management	minimal attention
Diseases problems	minimal
Potential profit	very low

Source: Fast & Lester (1992)

Table 4 TECHNICALLY CRITERIA FOR SHRIMP FARMING IN WEST BENGAL

Characteristics	Extensive
Stocking density	< 2 seed/ m^2
Feed (artificial pellets)	No
Usual feed conversion ratio	-
Liming	Yes
Fertilizers	100-150 kg/ha
Pesticides	Yes
Other inputs	Corn, Rice bran, etc.
Paddle wheel	No
Pumping	No

Source: Bhattacharya, (2010)

In the Mahakam Delta shrimp farming case, East Kalimantan province, most pond farmers decide applying polyculture system for income at their traditional ponds (Susilo et al., 2018), which put tiger shrimp and milkfish as the cultured main species of pond inputs, as well as those pond farmers employ polycutural pond with mangroves (Boa et al., 2023). Polyculture pond system adoption by pond farmers in the Mahakam Delta is inseparable from the influence of family size, demographic factor, education level, economic factor, benefit and cost of enterprise (Susilo et al., 2019). Then, pond farmers' motivation to apply this polyculture system in 8.1-10.1 ha of pond size is the best preference decided (Sidik et al., 2014). Likewise, traditional ponds case in South Sulawesi province that is one of the brackish water pond farming centers in Indonesia and has a relatively large area of brackish water pond reaching 107,509 ha of a total area of 667,083 ha. Also, dominant soil textures of its brackish water include sandy loam, loamy sand, clay loam and silty clay loam, hence soil management needs by drying, submerging, flushing, and liming for increasing of the quality of ASS (acid ulfate soil) (Mustafa et al., 2020). Meanwhile, the farmers in West java have applied their ponds management through the production of tiger shrimp between treatment in rice-fish farming system and using salinity-tolerant rice lines, where the management was able to adapt to high-salinity land (with a conductivity of 10.21 dS/m) (Hendrajat et al., 2020).

After 1994 was conducted a survey, the crop failure in East Java and South Sulawesi are caused mainly by disease outbreaks (i.e., degradation of the environment) and is exacerbated by drought (Surtida, 2000). Further, greater production in traditional ponds in Southeast Sulawesi is also influenced by the wider pond area (Muthalib et al., 2017). While, in the fact of history, the ponds in East Java case was an inverse relationship between production and organic matter accumulating at bottom of the pond (Hariati et al., 2008). Therefore, in addition to focusing on pond management in this case, it is very important to pay attention to the quality of water and soil because it affects the production of traditional ponds.

B. Traditional Shrimp Farming Productivity in Several Regions, Indonesia

1. Shrimp farming Production

Seven provinces with largest production and traditional shrimp farming in Indonesia are South Sulawesi, West Java, East Java, Center Java, NTB, Southeast Sulawesi, and East Kalimantan provinces, successively. In 2022, at traditional ponds in South Sulawesi produces 1.22 million ton, following West Java, East Java, Center Java, NTB, Southeast Sulawesi, and East Kalimantan provinces are 321, 198, 1.50, 0.95, 0.77, and 0.75 thousand ton, respectively (Table 5). Data from BPS-Indonesia in 2023 mentions that total production of traditional shrimp farming is approximately 2.35 million ton. It means that production of South Sulawesi provides 49% of total traditional pond production in Indonesia, as well as, these seven provinces contribute approximately 91% of total traditional pond production in Indonesia.

Distribution of its production is showed by Figure 1 that traditional shrimp farming production from South Sulawesi is prominent. Comparison among South Sulawesi, East Kalimantan and West Java provinces, traditional pond production from South Sulawesi is 16 times higher than East Kalimantan, and also 3.8 times higher than West Java. The ponds in South Sulawesi province are in Kabupaten Selayar, Bulukumba, Bintaeng, Jeneponto, Takalar, Gowa, Sinjai, Maros, Pangkajene, Barru, Bone, Wajo, Pinrang, Luwu, Luwu Utara, Luwu Timur, Kota Makassar, Kota Parepare, and Kota Palopo.

Table 5 PRODUCTION OF TRADITIONAL SHRIMP FARMING IN THE 7 BEST PROVINCES, INDONESIA

No.	Province	Production (ton)
1	West Java	321,404
2	Center Java	149,835
3	East Java	198,375
4	West Nusa Tenggara (NTB)	94,539
5	East Kalimantan	75,437
6	South Sulawesi	1,222,411
7	Southeast Sulawesi	77,037

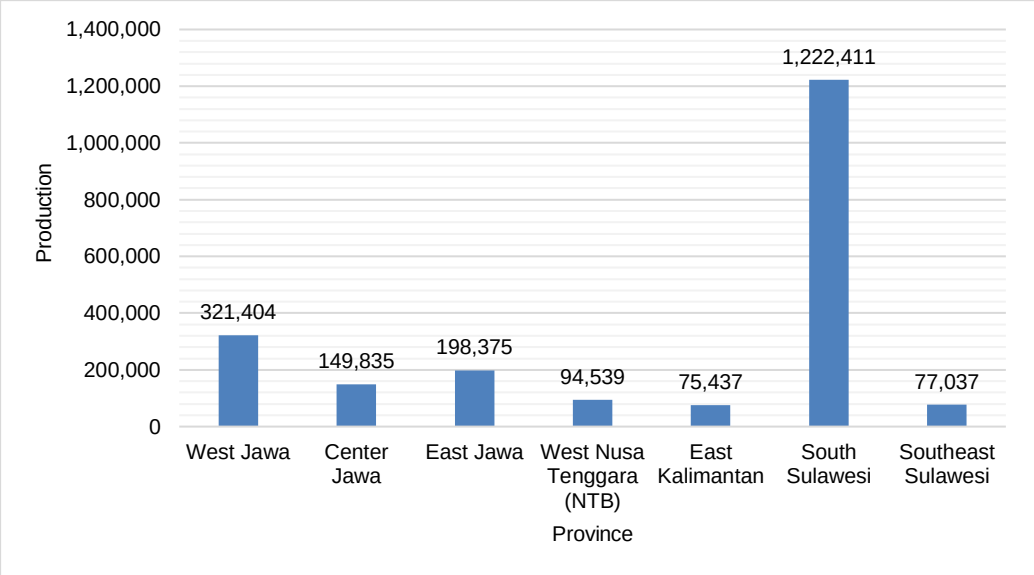

Figure 1. Distribution of Traditional Pond Production in the 7 best Provinces, Indonesia in 2022 (ton)

Furthermore, production of traditional shrimp farming per crop in East Java was around 300 kg/ha (Hariati et al., 2008), then in Central Java, volume of milkfish is around 700 kg/ha, and the average shrimp harvest was 186 ± 133 kg/ha where pond farmers are using LEISA (Low External Input Sustainable Aquaculture) principles (Widowati et al., 2021) for eco-friendly farm, although also found some locations were made quite close to the beach, without a green belt in Cilacap regency, Central Java (Utami et al., 2021). Production of traditional shrimp farming in the Mahakam Delta are 47 kg/ha for tiger shrimp, and 185 kg/ha for milkfish (Boa et al., 2023).

2. Shrimp Farming Land Area

The area of ponds in Indonesia for cultivation from 2013-2016 was 0.65, 0.67, 0.72 and 0.67 ha respectively. The trend of pond area is relatively constant for 4 years, even tends to decrease. Based on data from the Ministry of Maritime Affairs and Fisheries (KKP) in 2021, the area of Indonesian ponds was 785,088.28 ha in 2021, where those include fish-shrimp ponds, salt ponds, and the other cultivation in brackish water area.

Then, North Kalimantan is the province that has the largest shrimp farming in Indonesia. There were 118,195.885 ha after 2012 recorded. The province with the second largest pond area is South Sulawesi, namely 113,548.44 ha, following East Kalimantan with a pond area of 105,524.14 ha. The area of ponds in East Java and West Java is 74,903.34 ha and 62,313.03 ha, respectively.

In addition, Aceh recorded an area of 55,376.33 ha (BPS-StatisticsIndonesia, 2023a). So, traditional ponds employ large pond size in cultivation, like in East Kalimantan, as mentioned by Boa et al. (2023), that the largest pond sizes reach approximately 25 ha/pond (called extensive ponds).

3. Shrimp Farming Income or Value

Traditional pond income from seven provinces is displayed by the value as shown in Table 6. South Sulawesi provides the highest production of seven provinces of the study, but income of traditional pond of West Java is the highest value, amounting to IDR13.5 trillion. Then, the income of traditional pond from South Sulawesi, East Java, NTB, Central Java, Southeast Sulawesi, and East Kalimantan are IDR7, 5.2, 3.5, 2.5, 2.3, and 2.2 trillion, respectively. Distribution of traditional pond

value of West Java at Figure 2 shows that West Java's ponds value is almost twice South Sulawesi's ponds value. It means that the increase of traditional pond's production is not always linear toward its value rise because those values are influenced by its product prices as well. Overall, traditional pond in West Java province contributes to the highest increase of traditional pond total income in Indonesia, amount 32%. Based on data and information of BPS-West Java in 2022, those shrimp farming spread in Majalengka, Indramayu, Subang, Karawang, Bekasi, Pangandaran, and Cirebon region.

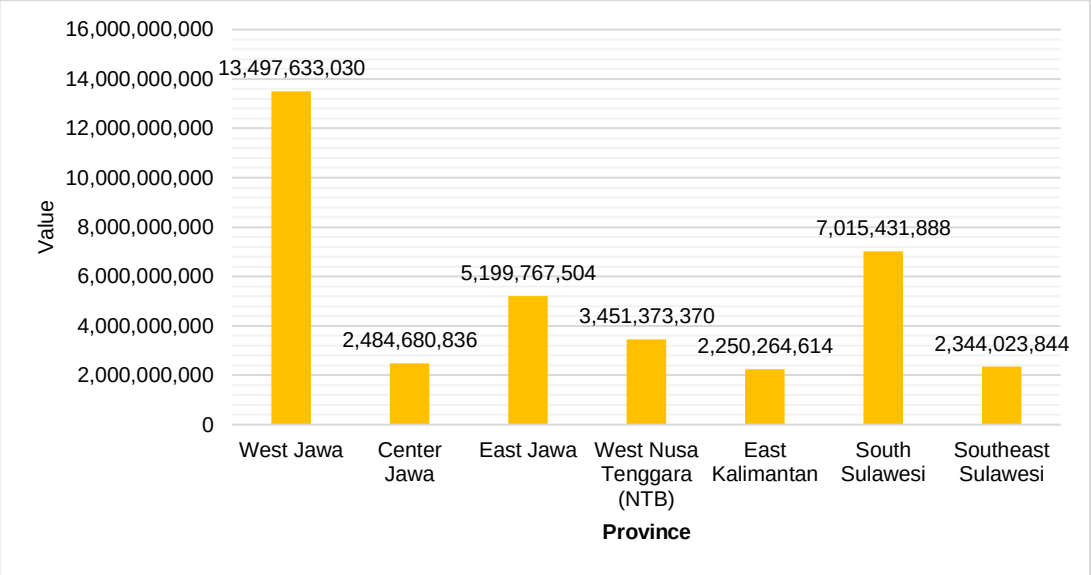

Figure 2. Distribution of Traditional Shrimp Farming Value in the 7 best Provinces, Indonesia in 2022 (000 IDR)

Table 6 VALUE OF TRADITIONAL SHRIMP FARMING IN THE 7 BEST PROVINCES, INDONESIA

No.	Province	Value (trillion IDR)
1	West Java	13.5
2	Center Java	2.5
3	East Java	5.2
4	West Nusa Tenggara (NTB)	3.5
5	East Kalimantan	2.2
6	South Sulawesi	7.0
7	Southeast Sulawesi	2.3

IV. CONCLUSION AND RECOMMENDATION

Most traditional ponds performances in several regions in Indonesia are inherited by hereditary pond farmers' family with applying traditional ways in management and using the large ponds. South Sulawesi, West Java, East Java, Center Java, NTB, Southeast Sulawesi, and East Kalimantan provinces successively contribute as the biggest pond production, amounting to 91% of total traditional pond production in Indonesia. Province with the second largest shrimp farming area in Indonesia is South Sulawesi province after North Kalimantan. However, the high production and large pond size are not linear to the increase of production value because in the fact, West Java is the biggest income of them compared, approximately IDR13.5 trillion. The study recommends including the economic and environment aspects and marketing chance in the study for future especially study about internationally pond products standard for shrimps because shrimps' market dominantly is aimed for export. When pond product follows international standard of export, hence there is indicated the increase of product price then affect earning of income or value. As well as Government policy should facilitate improving environmental quality and sustainability in ponds in those regions.

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DISCLOSURE

The authors declare no conflict of interest.