Feasibility and vulnerability of the preserved shrimp eco-farming park of Pinrang District

[1]Muhammad H. Fattah, [2]Sitti Rahbiah, [3]Basri Modding, [4]Sitti Marhamah

[1] Department of Coastal Management and Marine Technology, Post Graduate Program, Universitas Muslim Indonesia, Makassar, Indonesia; [2] Department of Agribusiness, Agriculture Faculty, Universitas Muslim Indonesia, Makassar, Indonesia; [3] Department of Management, Economics and Business Faculty, Universitas Muslim Indonesia, Makassar, Indonesia; [4] Pinrang District Fisheries Service, Pinrang, Indonesia. Corresponding author: M. H. Fattah, muhhattah.fattah@umi.ac.id

Abstract. Food and Agriculture Organization (FAO) piloted the Ecosystem Approach to Aquaculture (EAA) program, the first in Indonesia focused on black tiger shrimp (*Penaeus monodon*) in the Pinrang Shrimp Eco-farming Park; it was intended to be an effective solution to the tiger shrimp mass mortality. The poor managerial behavior of farmers caused an increase in contamination of pesticides, chemical fertilizers and pathogenic bacteria. Eco-shrimp products are produced through the application of the endemic microcrustacean *Phronima* sp. as natural feed. The study was conducted in Lanrisang Sub-District, Pinrang District, from August to October 2017. The synthesis of the area development model used the RAPPFISH Tool. The feasibility of the pond area during the rainy season and dry season is suitable (S2) however in the rainy season the value was 8.05 and it decreased to 7.15 during the dry season. Pathogenic infections (7.30) were the dominant factor causing vulnerability of the area compared to climate (4.51), water supply (4.11) and pollution (4.10). The area of tiger shrimp pond in Lanrisang Village and Waetuoe Village can be preserved as the Pinrang Shrimp Eco-farming Park. More attention is required for the fulfillment of the aspects of traceability and food safety o meet the provisions of the export market. The consistency of the feasibility level in the dry season is maintained through the improvement of the function of ponds canals and rivers in the continuous water supply to maintain temperature and salinity stability. The preserved area was followed up by the establishment of the Pinrang Shrimp Eco-farming Park in Lanrisang Village and Waetuoe Village. It is suggested to use *Phronima* sp. for premium black tiger shrimps because it can increase the production. Furthermore, the vulnerability of the preserved area can be mitigated by developing an early warning system for climate change.

Key Words: vulnerability, black tiger shrimp, *Phronima suppa*, pathogenic, climate.

Introduction. Black tiger shrimp (*Penaeus monodon*) products, which are exported to Japan, are categorized as premium shrimp based on a certification provided by Naturland Germany with the importing company Alter Trade Japan, Inc. (ATJ). The farming of black tiger shrimps in the Pinrang District encounters many challenges. One of which is the massive farming of whiteleg shrimp (*Litopenaeus vannamei*). The whiteleg shrimp farming was previously produced to secure Indonesian shrimp production because the tiger shrimp was infected by pathogens, especially White Spot Syndrome Virus (WSSV) and *Vibrio harveyi* since 1998 (Rukyani 2000; Fattah et al 2014). The development of both intensive and super intensive scales of whiteleg shrimp farming was potentially producing wastes from the massive use of artificial feeds. The contaminated artificial feed wastes could potentially contaminate tiger shrimps which led to rejection by importers from eco-shrimp countries category.

The development of eco-shrimp tiger species must be done in specific area and refer to certain criteria. The whiteleg shrimp farming could potentially become pathogens carrier for the tiger shrimp if they are in the same area. The development of tiger shrimp farming eco-shrimp type requires a specific area management system (Aguilar-Manajarrez et al 2017). The development is carried out on an inclusive basis so that contaminants can be eliminated from the environment and aquaculture activities.

Aquaculture products produced at this time are directed to be able to provide food security guarantees ranging from the provision of raw materials to the final product of farming. It is to free them from the contamination of pesticides, drugs, and chemicals in accordance with international market regulations. Application of biosecurity technology was agreed by experts as an effective way to overcome the problem of the spread and infection of pathogens in tiger shrimp (Fattah & Busaeri 2002). The development of special areas for tiger shrimp farming is in line with the Pinrang District Government's Policy which encourages national tiger shrimp productivity improvement and becomes the center of tiger shrimp production in Indonesia.

The development of the Lowita Minapolitan Area in Suppa Sub-District is based on the Decision of the Regent of Pinrang No.523/149/2010 (Bupati Pinrang 2010) which has been successfully in increasing tiger shrimp production in Pinrang District. The improvement of pond governance by utilizing endemic organisms with the local name as Phronima suppa and the scientific name as *Phronima* sp., normalization of pond, canal and river policies, multi-stakeholder and multi-sector engagement have succeeded in increasing the performance of tiger shrimp farming in Pinrang District. To maintain the supremacy of Pinrang District as a national center of tiger shrimp production, it is necessary to expand the farming area through replication in other areas in order to increase the production of the district. The development of *Phronima* sp. since 2016 has been successfully replicated to Lanrisang Sub-District as a new area of aquaculture development known as the Pinrang Shrimp Eco-farming Park.

Sustainable development should be based on three main components namely economic, social, and environmental sustainability (Munasinghe 1993). Each component is interconnected in one system that is triggered by strength and purpose. The international community has raised an issue that 2020 is acknowledged as the Global Organic Era, the era of the consumption of food produced and processed organically, including in shrimp farming. Shrimp farming is recommended to help reduce greenhouse gas emissions. Therefore, the use of fertilizers, pesticides, and chemicals which has the potential to contribute to greenhouse gases should be reduced or even stopped.

The implication of the Global Organic Era issue is a change in the orientation of international consumers towards food products. Food products that are of interest to the international market are food products that are processed and produced organically so that future tiger shrimp development will lead to eco-shrimp type products. Shrimp eco-farming is defined as a shrimp cultivation system with a pest control system without using chemicals so that the product is produced without chemical residues. Food and Agriculture Organization (FAO) and the World Bank Group (Aguilar-Manajarrez et al 2017) recommend that the application of biosecurity techniques be widely applied to the region so that the Pinrang Shrimp Eco-Farming Park needs to be immediately preserved. The Pinrang Shrimp Eco-Farming Park is a new approach to the development of shrimp farming in Indonesia that adopts the New Global Shrimp Farming Paradigm which is a transformation from a conventional shrimp farming system to a new approach that refers to the Ecosystem Approach to Aquaculture (EAA) (Aguilar-Manajarrez et al 2017). The Pinrang Shrimp Eco-Farming Park is a form of application of area-based biosecurity as an effective approach in the revival process of tiger shrimp farming in South Sulawesi. This concept is expected to be able to preserve the increase in tiger shrimp production in Pinrang District in its role and function as the main center of tiger shrimp farming in Indonesia.

The development of the Pinrang Shrimp Eco-farming Park is specifically designed to increase the production of tiger shrimp in the region through improving its governance with the main goal of increasing the carrying capacity of the environment and land for the continuous availability of *P. suppa* as a potential natural feed, optimizing the quality of pond environment in accordance with the living requirements of tiger shrimp, and prevention of pathogenic infections, especially WSSV, and *V. harveyi* as an integral part of handling area vulnerability. The development of the Pinrang Shrimp Eco-farming Park is reserved in Lanrisang Sub-District and becomes a new development area and expansion of the Minapolitan Area located in Suppa Sub-District.

The aims of this study are (1) to analyze the feasibility of ponds in Lanrisang Sub-District to be preserved as a the Pinrang Shrimp Eco-farming Park, and (2) to analyze potential vulnerabilities in the management of eco-shrimp species.

Material and Method

Research location and time. The research was carried out in Lanrisang Sub-District, Pinrang District, South Sulawesi Province from August to October 2017. The research sites were scattered in Lanrisang Village and Waetuoe Village where the watersheds of Sumpangsaddang River and the Salopokkoe River have become the water source of the pounds (Figure 1).

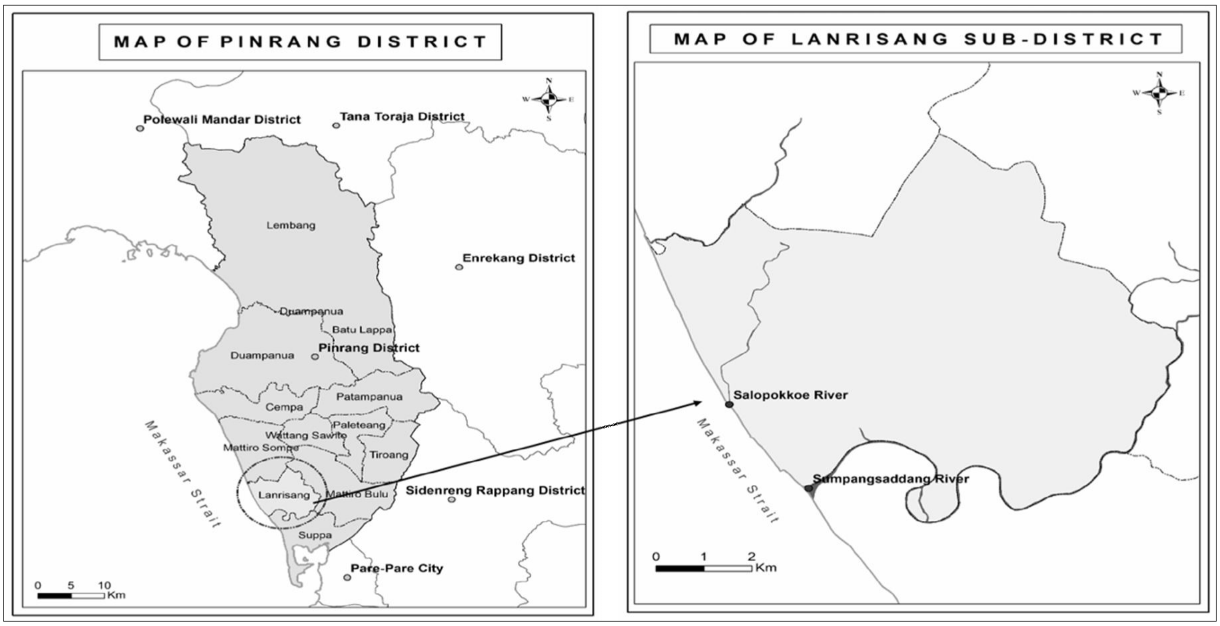

Figure 1. The location of Sumpangsaddang River watersheds and Salopokkoe River watersheds, in Pinrang District, Indonesia.

Data collection techniques. The research was conducted in two stages namely; (1) Identification of the feasibility of prospective reserve locations for the Pinrang Shrimp Eco-farming Park and (2) Collection of biophysical data, interviews, and focus group discussions (FGD) as well as the collection of aspirations related to the potential vulnerability of the area and the model of management of pond areas in the Pinrang Shrimp Eco-farming Park. Sampling was carried out at twelve locations. Interviews were conducted with respondents consisting of farmers (15 people), fisheries instructors (3 people), buyers (2 people), relevant agencies (7 people), and World Wide Fund for Nature (WWF) staff (1 people) purposively. The interview uses a questionnaire in the form of a structured questionnaire.

Feasibility analysis. Pond suitability is based on relevant biotechnical parameters. The suitability class is divided into four classes as presented in Table 1.

Based on the weighting and scoring values of the parameters depicted in Table 1, it can be determined the value of pond suitability classes: Highly Suitable (S1): 8.17 - 10.00; Suitable (S2): 6.28 - 8.16; As Conditional (S3): 4.39 - 6.27; and Permanently Unsuitable (N): 2.50 - 4.38.

Vulnerability. Vulnerability analysis is based on observations and measurements of biophysical aspects and interviews with multi-stakeholders. The measurement results are carried out to determine the vulnerability attributes that will be confronted with the aspirations of multi-stakeholders. The data obtained were then analyzed using the RAPPFISH Tool.

Table 1

Matrix and score matching parameter for pond farming suitability

Parameter	*Weight*	*Categories and scores*							
		S1	*Score*	*S2*	*Score*	*S3*	*Score*	*N*	*Score*
Slope (%)	0.20	0-3	4	3-6	3	6-9	2	> 9	1
Distance from the beach (m)	0.10	200-300	4	300-400	3	< 200	2	> 4000	1
Distance from the river (m)	0.10	0-1,000	4	1,000-2,000	3	2,000-3,000	2	-	1
Soil type	0.10	Alluvial beach	4	Alluvial	3	Regosol	2	Regosol	1
Height (m)	0.15	0-3	4	3-6	3	6-9	2	> 9	1
Drainage	0.10	Flooded	4	Flooded	3	Unflooded	2	Unflooded	1
Geology	0.10	Loose sediment	4	Loose sediment	3	Solid sediment	2	Solid sediment	1
Salinity (ppt)	0.30	12-20	4	20-30	3	5-12; 30-45	2	< 5; > 45	1
Temperature (^oC)	0.30	25-32	4	23-25	3	32-34	2	0-23	1
Dissolved oxygen (ppm)	0.30	6-7	4	3-6	3	1-3	2	< 1; < 8	1
pH	0.30	8.1-8.7	4	7.6-8.0; 6.1-7.6	3	8.8-9.5; 4.0-4.5	2	9.6-11.0; < 4.0	1
Phosphate (PO_4) (ppm)	0.10	0	4	0.10-0.25	3	0.26-0.45	2	> 0.45	1
Ammonia (NH_3) (ppm)	0.10	0	4	0.10-0.25	3	0.26-0.45	2	> 0.45	1
Nitrite (NO_2) (ppm)	0.05	0	4	0.10-0.25	3	0.26-0.45	2	> 0.45	1

Source: Modifications of Asbar (2007); Boyd (1990); Poernomo (1992).

Result and Discussion

Pond feasibility level. The ponds feasibility was influenced by the dry or rainy seasons (Tables 2 and 3).

The rainy season feasibility level. Based on the weighting and scaling parameters in Table 2, the land suitability class value in the rainy season (8.05) is in the Highly Suitable Category (S1). A number of parameters did not reach optimal conditions namely the distance from the coast (1,000 m), the distance from the river (300-1,600 m), salinity (7-22 ppt), phosphate (0.05-0.10 ppm), ammonia (0.05-0.10 ppm), and nitrite (0.05-0.10 ppm).

Table 2

Ponds feasibility during the rainy season

Parameter	*Weight*	*Measurement results*	*Scores*	*Value*
Slope (%)	0.20	0.03	4	0.80
Distance from the beach (m)	0.10	1,000	2	0.20
Distance from the river (m)	0.10	300-1,600	3	0.30
Soil type	0.10	Alluvial beach	4	0.40
Height (m)	0.15	1.2-1.4	4	0.60
Drainage	0.10	Flooded	4	0.40
Geology	0.10	Loose sediment	4	0.40
Salinity (ppt)	0.30	7-22	2	0.60
Temperature (^oC)	0.30	27-31	4	1.20
Dissolved oxygen (ppm)	0.30	5.4-8.9	4	1.20
pH	0.30	6.14-9.73	4	1.20
Phosphate (PO_4) (ppm)	0.10	0.05-0.10	3	0.30
Ammonia (NH_3) (ppm)	0.10	0.05-0.10	3	0.30
Nitrite (NO_2) (ppm)	0.05	0.05-0.10	3	0.15
Total	2.50			8.05

The parameters of the distance from the coast and the distance from the river were permanent and had an impact on the dynamics of water quality, especially salinity. The pond area in Lanrisang Village was in the Sumpangsaddang River watershed so that it received an abundant supply of freshwater during the rainy season. Salinity of Sumpangsaddang River in the rainy season was 9.00-17.00 ppt whereas Salopokkoe River was 8.00-22.00 ppt with the optimum range of 12.00-20.00 ppt. The data indicated that salinity fluctuation in the Salopokkoe River was wider and exceeded the minimum and maximum standards. Some ponds in Waetoue Village were far from the Saloppokoe River so that event tough in the rainy season the salinity was higher than the optimum standards. In addition, the water supply capacity of Saloppokoe River was smaller because the size was smaller and the end of the river was blocked. Phosphate levels (0.05-1.00), ammonia (0.05-1.00), and nitrite (0.05-1.00) in the entire aquaculture area were higher than the recommended range. Sampling was carried out after several periods of application of organic fertilizer so that it contributed to the increase in phosphate, ammonia, and nitrite levels.

The dry season feasibility level. The weighting and scoring parameters in Table 3 produce land suitability class values in the dry season (7.15) in the Suitable Category (S2). A number of parameters did not reach the optimal score, namely the distance from the coast (1,000 m), the distance from the river (300-1,600 m), salinity (9.00-39.00 ppt), temperature (22.70-38.00^oC), pH (7.50-9.88), phosphate (0.05-0.10 ppm), ammonia (0.00-0.05 ppm), and nitrites (0.00-0.05 ppm).

Table 3

Ponds feasibility during the dry season

Parameter	*Weight*	*Measurement results*	*Scores*	*Value*
Slope (%)	0.20	0.03	4	0.80
Distance from the beach (m)	0.10	1,000	2	0.20
Distance from the river (m)	0.10	300-1,600	3	0.30
Soil type	0.10	Alluvial beach	4	0.40
Height (m)	0.15	1.2-1.4	4	0.60
Drainage	0.10	Flooded	4	0.40
Geology	0.10	Loose sediment	4	0.40
Salinity (ppt)	0.3	9-39	2	0.60
Temperature (^oC)	0.3	22.7-38.0	2	0.60
Dissolved oxygen (ppm)	0.3	4.7-14.4	4	1.20
pH	0.3	7.50-9.88	3	0.90
Phosphate (PO_4) (ppm)	0.1	0.05-0.10	3	0.30
Ammonia (NH_3) (ppm)	0.1	0-0.05	3	0.30
Nitrite (NO_2) (ppm)	0.05	0-0.05	3	0.15
Total	2.50			7.15

The pond area in Lanrisang Village received a continuous supply of freshwater from the Sumpangsaddang River. The continuous supply of fresh water from the Sumpangsaddang watershed causes the salinity range in the rainy season to be 9-17 ppt and in the dry season it changes to 8-35 ppt, beyond the optimum range. Climate anomalies that have been taking place since 2015 at the study site have caused seasonal differences to cause vulnerability. In the dry season, there was still a chance of rain which would cause drastic temperature fluctuations, causing stress to the shrimp in the pond. The temperature range in rainy session was 28.5-30.5 in the Salopokkoe River watershed. Limited fresh water supply caused an increase in salinity in rainy session (8-22 ppt) and dry session which exceeded the optimum level. It was not measured due to the absence of water in the ponds. The dynamics of water quality in the dry season tended to trigger an increase pH (7.50-9.85) in Sumpangsaddang River watershed and 7.5-8.5 in Salopokkoe River watershed.

Based on the dynamics of water quality during the study (Table 4), temperature and salinity parameters fluctuated during the rainy season and the dry season. Phosphate, ammonia, nitrate, and pH parameters tended to be stable. The temperature in the dry season tended to be more volatile compared to the rainy season. The same condition was found in the salinity parameter. Pond water salinity in the dry season was more volatile than in the rainy season. The temperature in the rainy season and dry season was still in the optimum range. Salinity in the dry season was beyond the optimum range so that it was the main cause of the decline of the pound feasibility value from 8.05 in the rainy season to 7.15 in the dry season. However, the overall feasibility level of the pond in the dry season was still in the suitable category (S2).

Potential vulnerabilities. Potential vulnerability in the harvesting of the Pinrang Shrimp Eco-farming Park is influenced by climate, pollution, water supply, and pathogen dimensions (Table 5 and Figure 1). The social, policy, technology, price and market dimensions, institutional, legal, and stakeholder support have no potential to cause vulnerability.

Table 4

Water quality base season of the preserved Shrimp Eco-farming Park of Pinrang District

Watershed	*Rainy season*						*Dry season*				
	Temp.	*Salinity*	*PO_4*	*NH_3*	*NO_2*	*pH*	*Temp.*	*Salinity*	*PO_4*	*NH_3*	*pH*
Sumpangsaddang											
A1	29	13	0.1	0.05	0.05	7	24.9	9	0.05	undetected	10.25
A2	29	17	0.1	0.05	0.05	7	23.95	16	0.01	0.03	9.49
A3	29.5	15	0.08	0.05	0.05	6.14	25.3	8	0.05	0.03	9.85
B1	28	15	0.05	0.05	0.05	6.93	25.1	14	0.05	undetected	7.9
B2	29	7	0.05	0.05	0.05	7.11	32.4	35	0.05	0.05	8.8
B3	28	9	0.05	0.05	0.05	7.5	24.4	18	0.05	undetected	8.5
The range	28.0–29.5	9–17	0.05 -0.1	0.05	0.05	6.14-7.5	23.95-32.4	8-35	0-0.05	undetected-0.03	7.90-9.85
Salopokkoe											
C1	29	14	0.08	0.05	0.05	7.5	27	28	0.05	0.05	7.8
C2	28.5	12	0.08	0.05	0.05	13.7	26.6	30	0.05	0.05	7.9
C3	29	22	0.1	0.05	0.05	9.7	26.4	36	0.08	0.05	8.5
D1	29.5	21	0.08	0.05	0.05	7.11	27.8	not measured*	not measured*	not measured*	8.2
D2	29.5	11	0.08	0.05	0.05	9.73	27	38	0.06	0.05	8.5
D3	30.5	8	0.08	0.05	0.05	7.42	29.1	20	0.08	0.05	7.5
The range	28.5-30.5	8-22	0.08-0.10	0.05	0.05	7.11-13.70	26.4-29.1	not measured-38	not measured-0.08	not measured-0.05	7.5-8.5

* it was not measured due to the absence of water in the ponds.

Table 5

The vulnerability management of the preserved Shrimp Eco-farming Park of Pinrang District

No	*Dimension*	*Vulnerability generators*	*Amount (percentage)*
1	Climate	Rain and drought occur beyond prediction and have an impact on salinity that is outside the tolerance threshold of tiger shrimp to temperature and salinity.	10 (47.62)
2	Pollution	Temporary pollution occurred which caused massive death;	8 (38.10)
		The environment and shrimp pond area are free from pollution.	8 (38.10)
3	Water supply	Raw water according to the living requirements of tiger shrimp in a certain period.	11 (52.38)
4	Pathogen	Pathogens are massive and infect since the second month of the farming period.	16 (76.19)
5	Social	Free of social conflict and theft of shrimp and fish.	19 (90.48)
6	Policy	Specific and relevant policies.	18 (85.71)
7	Technology	Specific and relevant technology.	17 (80.95)
8	Price and market	Price levels and markets attractive.	20 (95.24)
9	Institutions	Institutions have not accommodated the aspirations and needs of all members.	15 (71.43)
10	Legal aspect	Specific and effective legal instruments.	12 (57.14)
11	Stakeholder supporting	Government and related stakeholder support is effective.	21 (100.00)

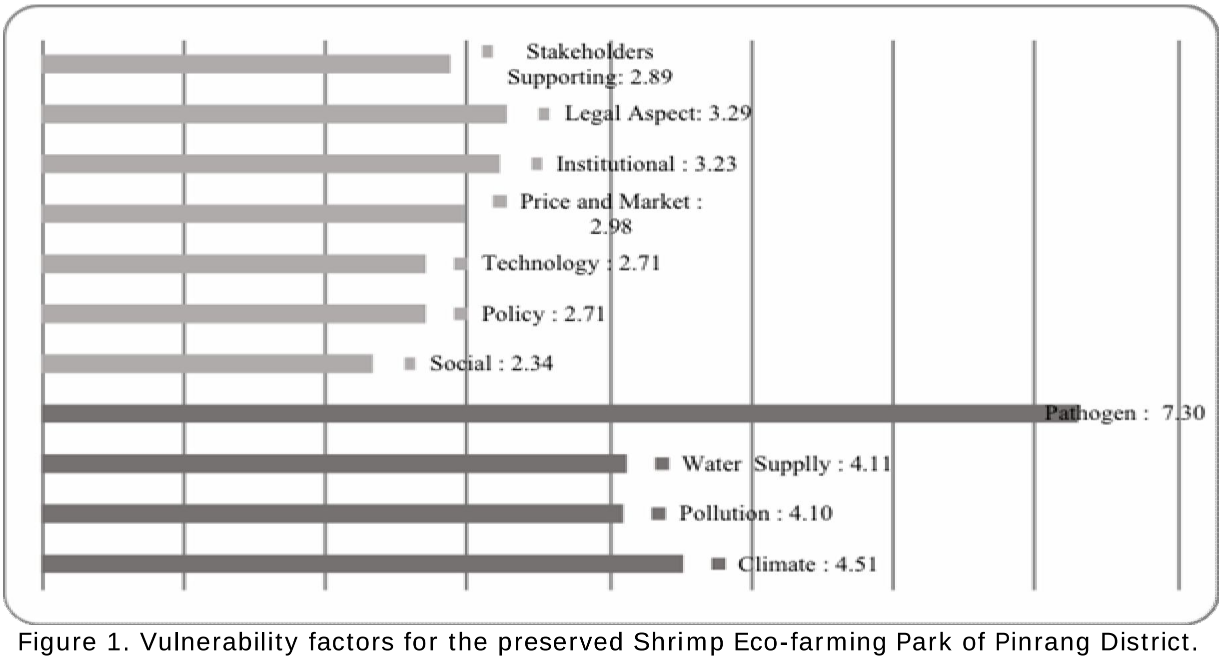

Figure 1. Vulnerability factors for the preserved Shrimp Eco-farming Park of Pinrang District.

Climate anomalies have caused irregular season periods. The rainy season and dry season occur unpredictably, making the anticipation of temperature and salinity fluctuations even more difficult (Table 5 and Figure 1). These conditions trigger a decrease in the tolerance of shrimp to environmental changes and pathogen infections.

Pollution occurs at several locations in the upstream area. Potential pollution comes from the waste of rice planting activities. During the application period, pesticides and fertilizers cause residues to enter the pond canal, causing temporary pollution in the aquaculture areas in the Salopokkoe River watershed (Table 5). A total of 52.38 percent of respondents stated that the suitability of raw water for shrimp life is periodic due to rice planting activities in certain periods. As many as 38.10 percent of respondents said that the aquaculture area in the Sumpangsaddang River watershed was free of pollution. Massive pathogen infections generally occur in the second month of the cultivation period as stated by 76.19 percent of respondents. The results of the vulnerability analysis are presented in Figure 1.

Anticipating pathogenic infections, especially WSSV and *V. harveyi*, is suggested by 52.63 percent through improved land preparation and pest and disease control with a bio-security system. It is expected to overcome the spread and threat of pathogen infection vertically and horizontally. Vertical distribution can occur from the female broodstocks to the eggs and larvae it produces. It is line with a study where 30 samples of shrimps, 6 female broodstock shrimps were infected with virus (2 IHHNV virus and 4 MBV virus) (Anshary et al 2014). The results of the examination of tiger shrimp larvae found viruses in all larval rearing tanks especially the MBV and IHHNV viruses and no WSSV and HPV viruses were found. Pathogen interventions can tackle the horizontal spread of pathogens between ponds and governance area using the zone management approach (Aguilar-Manajarrez et al 2017).

Climate anomaly makes the dynamics of the rainy and dry seasons difficult to predict and has implications for the vulnerability of tiger shrimp farming due to temperature and salinity fluctuations. Changes in temperature and salinity > 5 ppt per day will cause shrimp stress and death (Poernomo 1979). The majority of respondents (36.84 percent) want the importance of accuracy of climate data and information as the main instrument of adapting climate anomalies. Biased climate data and information will cause errors in adapting to climate anomalies and are vulnerable to harvest failure. Another 36.84 percent suggested the importance of aquaculture planning in accordance with climatic conditions and water dynamics. The accuracy of aquaculture planning is determined by the accuracy of climate data and information published by the Meteorology and Geophysics Agency (BMKG) and the expansion of access to community information through the Social Media Features of the Phronima "SUPPA" Field School. An integrated early warning system development is needed in anticipating the phenomenon of climate anomalies and the dynamics of environmental changes and ponds in the Pinrang Shrimp Eco-farming Park.

The managing of the Phronima "SUPPA" Field School succeeded in broadly disseminating the development of a new paradigm of shrimp farming including adaptation to the vulnerability of climate anomalies, degeneration of the aquaculture environment, and pathogen infections and trends in global tiger shrimp market demand. Field schools have made important contributions in overcoming regional vulnerability, disseminating technology to supply *Phronima* sp. as best natural food, and increasing production of premium tiger shrimp. The application of *Phronima* sp. succeeded in increasing the production of tiger shrimp size 40 to 217.89 kg ha^{-1} for 47 days the average farming period was higher than 40.50 kg ha^{-1} produced in ponds without the application of *Phronima* sp. with an average farming period of 112.50 days (Fattah et al 2017).

Water supply caused the quantity and quality of pond water below to standard (Table 5) so that 52.63 percent of respondents expected regular and integrated monitoring of raw water and farming media. As many as 68.42 percent of respondents in the pollution dimension expected to monitor the use and distribution of chemicals, pesticides, antibiotics, and chemicals as well as support for the application of friendly black tiger shrimp farming. Finally, 36.84 percent of respondents were expecting the existence of specific legal instruments to support the development of the Pinrang Shrimp Eco-farming Park.

Conclusions. The feasibility of the pond area during the rainy season (8.05) is Highly Suitable (S1) and decreased to be Suitable (S2) during in the dry season (7.15). The area of tiger shrimp farms in Lanrisang Village and Waetuoe Village can be preserved as the Pinrang Shrimp Eco-farming Park. Pathogenic infections (7.30) are the dominant factor causing vulnerability of the area compared to climate (4.51), water supply (4.11) and pollution (4.10).

Permanent attention is still needed to the fulfillment of the aspects of traceability and food safety to meet the provisions of the export market. The consistency of the feasibility level in the dry season is maintained through the improvement of the function of ponds canal and rivers in the continuous supply of raw water to maintain temperature and salinity stability. The area reserve is followed up by the establishment of the Pinrang Shrimp Eco-farming Park in Lanrisang Village and Waetuoe Village. The supply of Phronima sp. is optimized to increase the production of premium black tiger shrimp and mitigate the vulnerability of the area by developing an early warning system.

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Authors:
Muhammad Hattah Fattah, Department of Coastal Management and Marine Technology, Post Graduate Program, Universitas Muslim Indonesia, Jl. Urip Sumoharjo No. 225, Makassar 90232, South Sulawesi, Indonesia, e-mail: muhhattah.fattah@umi.ac.id
Sitti Rahbiah, Department of Agribusiness, Agriculture Faculty, Universitas Muslim Indonesia, Jl. Urip Sumoharjo Km 5, Makassar 90231, South Sulawesi, Indonesia, e-mail: sittirahbiah.busaeri @umi.ac.id
Basri Modding, Department of Management, Economics and Business Faculty, Universitas Muslim Indonesia, Jl. Urip Sumoharjo Km 5, Makassar 90231, South Sulawesi, Indonesia, e-mail: basri.modding@umi.ac.id
Sitti Marhamah, Pinrang District Fisheries Service, Jl. Jenderal Sukawati, Pinrang 91212, South Sulawesi, Indonesia, e-mail: marhamahpinrang@gmail.com

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