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Changes in Managerial Decision on Pond Management to Adapt to Climate Anomalies in the Coastal Area of Pare-Pare Gulf, District of Pinrang

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Abstract. The climate anomaly was adapted through the adjustment of tiger shrimp stocking patterns and optimum use of locally endemic *Phronima Suppa* (PS) to suit the season. Thus, the batches period determined was adjusted to suit climate change dynamics, reducing the shrimp stocking density down to 10.000 – 15.000 per ha and applying PS so the shrimp became tolerant of any environmental stress and pathogen infection. The knowledge of adaptation to climate anomalies, a learning outcome of the field school, managed to increase the average production of tiger shrimp to 217 kg/ha with an average receipt of IDR 22.60 million/ha.

1. Introduction

Nowadays, climate anomaly phenomenon has been a global issue. Climate change occurs as a result of increasing accumulation of gas emission causing temperature rise through the Earth's atmosphere. The main indicator of climate change consists of changes in pattern and intensity of various climate parameters such as temperature, precipitation, humidity, cloud cover, and evaporation. This change causes extreme changes in rainfall and season patterns known as climate anomaly [1,2]. The temperature change happens in both local and global scale. In local scale, it affects the microclimate. The climate anomaly gives various effects locally [3,4,5]. It brings some consequences dealing with seasons timing. Thus, the seasons in Indonesia have been experiencing a shift either in commencement or in length.

Climate anomaly has such a significant impact on the existence of coastal community's resources and welfare. The abnormal climate changes lead to coastal environment degradation, pathogens outbreak, phytoplankton instability, and biota growth delay [6,5,7,8]. This greatly impacts the tiger shrimp farming success. Since any harvest failure will lead to an increase of poor population in coastal areas [1,9,4], there should be an innovation to anticipate and adapt to climate anomaly.

Since 1998, Pinrang, the district which has been determined as a shrimp farming center in Indonesia, has been experiencing harvest failures as a result of environmental stress and pathogen infection, particularly white spot syndrome virus (WSSV) and *Vibrio harvey***.** Climate anomaly has contributed to the failures as well as the increase of poor population in coastal areas in Indonesia [1,9,4,10]. Based on the data from the Badan Pusat Statistik Provinsi Sulawesi Selatan (2015), shrimp ponds area in the province of South Sulawesi has a total width of 85,500 ha and employs 156,000 workers [11]. Meanwhile, it is predicted that there are about 15 million people involved, directly and indirectly, in the shrimp farming and processing business in the country. The shrimp disease attack has killed productivity of around 39,022 ha in South Sulawesi. It is also predicted that the harvest failures have caused an annual loss of USD 33.4 million in the province and more than USD 300 million in the country [12].

The climate anomaly issue needs to be anticipated to increase the tiger shrimp production in Indonesia. The anomaly effect can be adapted through environmental quality improvement and pond managerial innovation. *Tasiwalie* and *Wiringtasi* are two coastal villages in the district of Pinrang having shrimp ponds with a total width of 634.45 ha impacted by the climate anomaly [13]. A field school, a systematic informal learning method by, from, and for farmers at field level [14], has been organized here as an attempt to adapt to the climate anomaly. This school was designed and conducted based on farmers' needs to result in changes in farmers' managerial behaviors.

2. Methods

The research was conducted in *Tasiwalie* and *Wiringtasi* village in Pare-Pare gulf coast, sub district of Suppa, district of Pinrang, South Sulawesi province, from March 2014 to June 2016. The data was collected through observations, interviews, and secondary data investigation. The parameters observed were climate, water quality, plankton, pathogen and the community's income. The farming business and income of the field school participants (A) was to be compared with that of those who did not attend the field school (B).

2.1. El-Nino and La-Nina Analysis

Southern Oscillation Index (SOI) is an index value that indicates the difference in Sea Level Pressure (SLP) between Tahiti and Darwin, Australia [16]:

$$\mathrm{SOI} = 10\left[\frac{\mathrm{P_{diff}} - \mathrm{P_{diffay}}}{\mathrm{SD\ (P_{diff})}}\right] \tag{1}$$

Where : $\mathrm{P_{diff}}$ = the difference between Tahiti and Darwin in average monthly SLP
$\mathrm{P_{diffav}}$ = the average long-term $\mathrm{P_{diff}}$ in a given month
SD ($\mathrm{P_{diff}}$) = the long-term deviation standard of $\mathrm{P_{diff}}$ in a given month

La Nina phenomenon is characterized by the SOI index value of more than +10 (minimum 3 months), while the El Nino phenomenon is characterized by the SOI index value of less than -10 (minimum 3 months).

2.2. Plankton

The observation on plankton parameter included density, uniformity, and domination as described as follows;

2.2.1. Density. Plankton density was calculated through the modification of Lackley Drop Microtransect Counting (LDMC) formula based on APHA (1998) using microscope [17];

$$\sum \frac{ind}{I} = \frac{T}{L} \times \frac{P}{p} \times \frac{V}{v} \times \frac{1}{W} \tag{2}$$

Where : T = number of SRC boxes = 1,000
L = number of SRC boxes in one viewed field = 1
P = number of visible plankton individuals
p = number of observed SRC boxes = 100
V = concentrate volume in sample bottle = 100 ml
v = konentrat volume in SRC = 1ml

W = iltered water volume = 100 l

2.2.2. Uniformity. The plankton uniformity value was calculated based on the Indeks Shannon [18] formula;

$$H' = -\sum \left|\frac{ni}{N}\right| \ln \left|\frac{ni}{N}\right| \tag{3}$$

$$H_{maks} = \ln S \tag{4}$$

$$E = \frac{H\prime}{H_{maks}} \tag{5}$$

Where : E = uniformity index of plankton
H^1 = Shannon index
ni = number of individuals of the 1st species
N = number of individuals of the whole species
S = number of the whole species

*2.2.3. Domination***.** The domination value was calculated through the Simpson domination index [18];

$$d = (1 - c) \tag{6}$$

$$c = \frac{ni}{N} \tag{7}$$

Where : d = plankton domination index
c = Simpson index
ni = number of individuals of the 1st species
N = number of individuals of the whole species

2.3. Production

The cultivation performance was determined based on the tiger shrimp production employing the following formula;

$$P = \frac{W_t}{A} \tag{8}$$

Where : P = tiger shrimp production (kg/ha)
W_t = shrimp weight in farming plot (kg)
A = farming plot width (ha)

2.4. Income Analysis

Net income was calculated based on formula;

$$\prod = TR - TC \tag{9}$$

Where : $\prod$ = net income (Rp)
TR = total revenue (Rp)
TC = total cost (Rp)
$\prod > 0$ means profitable business

2.5. R/C-ratio Analysis

The R/C-ratio was conducted to determine feasibility level of the following formula;

$$\frac{R}{C} - ratio = \frac{TR}{TC} \tag{10}$$

Where : TR = total revenue
TC = total cost
R/C-ratio > 1 means profitable business deserving to be developed

3. Result and Discussion

The climate anomaly has impacted on water quality, plankton dynamics, shrimp production, and coastal community's welfare. These parameters are related to each other, influencing society's rationality in making a decision dealing with adaptation to the climate anomaly.

3.1. Climate Anomaly

Pinrang is a district with *Monsun* type of rain. It means that there is an obvious difference between wet season and dry season in this district. Normally, the wet season lasts from November to April and reaches its peak between December and February. Meanwhile, the dry season occurs from May to October and reaches its peak between July and September [19]. Table 1 shows the calculation result of normal rain in Suppa, Pinrang.

Table 1. Calculation of Normal Rain in Suppa, Pinrang (mm)

	Month											
Normal	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	230	184	274	253	150	118	102	34	81	110	238	342

Source : Result of BMKG data (2009 – 2015) processing

Based on the result of SOI value analysis, El Nino and La Nina occurred for three years, causing some climate anomaly in Pinrang (Table 2).

Table 2. Southern Oscillation Index Values in 2009 – 2015

	Month											
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009	09.04	14.08	00.02	08.06	-7.4	-2.3	01.06	-5.0	03.09	-14.7	-6.0	-7.0
2010	-10.1	-14.5	-10.6	15.02	10.00	01.08	20.05	18.08	24.09.00	18.03	16.04	27.01.00
2011	19.09	22.03	21.04	25.01.00	02.01	00.02	10.07	02.01	11.07	07.03	13.08	23.00
2012	09.04	02.05	02.09	-7.1	-2.7	-10.4	-1.7	-5.0	02.06	02.04	03.09	-6.0
2013	-1.1	-3.6	10.05	00.03	08.04	13.09	08.01	-0.5	03.09	-1.9	09.02	00.06
2014	12.02	-1.3	-13.3	08.06	04.04	-1.5	-3.0	-11.4	-7.6	-8.0	-10.0	-5.5
2015	-7.8	00.06	-11.2	-3.8	-13.7	-12.0	-14.7	-19.8	-17.8	-20.2	-5.3	-9.1

Source : Result of BMKG Data (2008 – 2015) Processing (El Nino = Red, La Nina = Blue)

Both El Nino and La Nina influence rainfall amount and cause season anomaly. A quite long El Nino occurred in 2010 and 2015. Meanwhile, La Nina took place in 2010 and 2011. The El Nino was marked by a dry season lasting for minimum three months. The longest El Nino happened for six months in 2015. The longest La Nina occurred in 2010, marked by a six-month rainy season, four months longer than usual. This climate anomaly has been occurring in Pinrang for three years. The most extreme climate anomalies occurred in 2010 as El Nino and La Nina came up simultaneously. The first three months of the El Nino phenomenon lasted from July to the end of the year, followed by the phenomenon of La Nina. Climatic conditions in 2009, 2012 and 2014 tended to be normal although in certain months symptoms of El Nino and La Nina occurred. Symptoms of El Nino occurred in 2012 and 2014, and in 2013 those of La Nina did. In 2009, symptoms of both came up.

La Nina has increased rainfall in the coastal areas of Pinrang. The highest increase of rainfall (431 mm) occured in January 1999, while the highest increase from normal rainfall took place in October

2010, reaching the level of 342,5% [19]. This has made rainy season in the coastal areas of Pinrang one until four months longer. The longest rainy season occured in 2010. This rainy season lasted in all months of the year but August.

3.2. Water Quality

The parameters influencing dynamics in coastal areas are salinity, dissolved oxygen, temperature, ammonia, and nitrite. The measurement results of each parameter in the research location were distinguished according to the seasons (Table 3);

Table 3. Average Value of Water Quality Parameters

Parameter	Wiringtasi Village		Tasiwalie Village		Eligible Range of Water Quality according to literature
	Dry	Wet	Dry	Wet	
Salinity (ppt)	32.7	18.9	24.7	7.9	15.0 – 25.0 (Poernomo, 1979)
Dissolved oxygen (ppm)	6.14	4.86	5.61	6.61	≥ 5.00 (ManikdanMintardjo, 1980)
Temperature (° C)	34.80	33.98	34.48	33.30	26.00 – 32.00 (Tiensongrusmee, 1980)
Degree of acidity (pH)	8.10	7.96	7.71	7.75	7.00 – 8.50 (Tiensongrusmee, 1980)
Ammonia (ppm)	-	0.44	-	0.39	≤ 0.10 (Poernomo, 1979)
Nitrite (ppm)	-	0.09	-	0.40	≤ 0.01 (Poernomo, 1979)

The main aspect to notice in managing tiger shrimp ponds is water quality parameter [22] since it highly influences shrimp health. The parameters of salinity, temperature, and ammonia in the coastal areas of Pare-Pare gulf are beyond the eligible range according to literature (Table 3). This condition has caused low-level growth, survival, molting frequency, and pathogen organism population increase. Change in water quality along this gulf coast was influenced by the climate anomaly. The water quality sampling described in Table 3 was conducted in the middle of a quite long El Nino and La Nina.

The salinity level influences the levels of dissolved oxygen and phosphate impacting the lives of waters organisms. Black tiger shrimp grow well at salinity level of <15.0 ppt with no sudden salinity change. A good salinity range for shrimp growth is 10.0 – 35.0 ppt with optimum range of 15.0 – 25.0 ppt [23]. The waters osmosis stress on optimum salinity should be in the same condition or close on body cell osmosis stress so there is no energy wasted for salt regulating in shrimp cells. That salinity in Tasiwalie village in dry season and the lowest tide period reaches the level of 42.3 ppt has inhibited black tiger shrimp growth.

Adequacy of dissolved oxygen ensures shrimp survival in ponds. Low level of oxygen leads to balance loss and death. Dissolved oxygen can be used as indicator of organic materials contamination in waters. Most of waters organisms cannot directly utilize free oxygen from the air. The average level of dissolved oxygen in Pare-Pare gulf waters, particularly in Wiringtasi village, in wet season is beyond the tolerance limit of shrimp growth. Black tiger shrimp grows normally at oxygen level of ≥ 5.00 ppm [6, 24].

Almost all waters organisms, including shrimp, is so sensitive to environmental temperature changes. A temperature change of 5.00 °C occurring suddenly causes stress and death in ponds [25,26]. The average temperature of waters in Wiringtasi village is 34.80°C in dry season and 33.98°C in wet season, while that of waters in Tasiwalie village is 33.30°C in rainy season and 3.48°C in dry season. The optimum temperature for black tiger shrimp growth ranges between 29.00°C and 31.00 °C [27,23]. The rise of temperature in Pare-Pare gulf is an impact of global climate change.

The average level of ammonia in the coastal areas of the two villages in low tide condition in wet season is 0.30 ppm and 0.28 ppm. In high tide condition, the average level is 0.44 ppm in Wiringtasie and 0.39 in Tasiwalie. The free ammonia content is toxic and dependent on pH, temperature, and salinity of waters. The pH factor plays the most important role in expressing ammonia's toxic nature. Rise of pH will increase free ammonia content. At critical level, ammonia influence inhibits growth, decreases fecundity, and decreases biota resistance to disease [28,29,7]. The toxic level of free ammonia usually occurs at a concentration of 0.60 – 2.00 ppm [25, 30, 24].

Excess nitrite compounds will decrease shrimp blood's ability to bind oxygen. Nitrite will react more strongly to the lymphocytes, increasing level of mortality. High concentration of ammonia and nitrite compounds inhibits excretion process of ammonia and nitrite, accumulating in shrimp body. The concentration of nitrite permitted in the pond waters should be less than 0.01 ppm [22].

3.3. Plankton

The zooplankton found either in the waters of Wiringtasi and Tasiwalie is relatively low with only nine genera as described in Table 4. In the coastal areas of Pare-Pare gulf in the two villages, nine plankton genera are available, while *nauplius,zoea,* and fish larvae are not. The *Onychocamptus, Echinochamptus, Tortarus, Apocyclops, Acartia*, and *Temora* types can be found in Wiringtasi with *Acartia* sp type as dominant plankton. The plankton in Tasiwaliehas the same type as that found in Wiringtasi. *Schmackeria* sp is the dominant type in Tasiwalie.

In general, black tiger shrimp hatcheries in district of Pinrang use *Artemia salina*, an imported feed [13]. The plankton used as natural feed for this kind of shrimp consists of Diatom (*Chaetoceros sp* and *Skeletonema sp*), Branchipoda (A*rtemia salina*), Cladocera (*Moina sp* and Daphnia *sp*) and Rotifer (*Brachionus sp*) types [31,32,33,34]. These types of plankton were not discovered in this research. The zooplankton composition in Pare-Pare gulf waters is relatively low. Plankton diversity index is influenced by climate and waters management factors. The climate anomaly and cultivation management influence the progress of plankton in type, abundance, and stability in black tiger shrimp.

Table 4. Abundance, Diversity, Uniformity, and Domination of Plankton

Sampling Location	Plankton Type	Number of Planktons (ind/L)	Biological Index Diversity Index	Uniformity Index	Domination Index
Wiringtasi Village	*Onychocamptus* sp	4	0.5363	0.7740	0.5555
	Echinocamptus sp	16	2.1452	3.0960	2.2220
	Tortarus sp	4	0.5363	0.7740	0.5555
	Apocyclops sp	20	1.7539	1.9656	0.8579
	*Acartia*sp	44	1.3194	1.9035	1.1101
	Temora sp	8	0.6365	0.9183	0.5555
Tasiwalie Village	*Onychocamptus* sp	8	1.8469	0.9491	0.1734
	Schmackeria sp	44	2.6895	2.9181	1.3055
	Acartia sp	16	1.2135	1.7507	1.3088
	Apocyclops sp	8	0.6931	1.0000	0.5000
	*Tortarus*sp	4	0.3218	0.4642	0.7221

3.4. Pathogen

The pathogen type infecting black tiger shrimp and vaname cultivated in Pare-Pare gulf coast consists of *Epistylis* sp, *Vibrio* sp, *Vibrio damsella*, *Zoothamnium* sp, and WSSV types. Table 5 describes relationship among aquaculture biota, water quality, and pathogen prevalence.

Table 5. Aquaculture Biota, Water Quality, and Pathogen Prevalence

Year	Shrimp Type	Water Quality Temperature (°C)	Salinity (ppt)	DO (ppm)	pH	Brightness (%)	Water depth (cm)	Pathogen
2010	Black Tiger	33.00.00	23.00	05.00	07.00	70	-	*Epistylis* sp *Vibrio* sp *Vibrio damsella*
2011	Black Tiger	-	-	-	-	-	-	*Zoothamnium* sp
2013	Black Tiger	32.00.00	0,2569444	07.32	07.50	30	60	*Zoothamnium* sp
2015	Vaname	26.00.00	26.50.00	0,3604167	0,3819444	30	70	WSSV

Source :Hasanuddin Fish Quarantine, Makassar (BBKIHM) (2016)

Table 3 and table 5 indicate that water quality in the ponds in the research location is not optimum and tends to be at the upper threshold of tolerated limit of black tiger. This condition has triggered pathogen outbreak and infection in cultivated shrimp. Based on the result of research by Fattah *et al.* (2014a); Kou *et al.* (1998), WSSV infection has occurred in black tiger cultivated in the coast of Pare-Pare gulf [35,36]. Table 5 shows an assumption that the VSSW transmission occurs horizontally between black tiger and vaname.

The water quality change in the coast of Pare-Pare gulf is influenced by the climate anomaly (Table 1, 2, and 3). The impact of the climate change on pathogen prevalence is described in Table 6.

Table 6. Climate Anomaly and Pathogen Prevalence

Pathogen and Climate Anomaly (Year) **2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Normal	El Nino and La Nina	La Nina	Normal	Normal	Normal	El Nino
Epistylis sp	*Epistylis* sp			*Epistylis* sp		
Vibrio sp	*Vibrio* sp		*Vibrio* sp	*Vibrio* sp		
	Vibrio damsella					
Zoothamnium sp		*Zoothamnium* sp		*Zoothamnium* sp	*Zoothamnium* sp	*Zoothamnium* sp WSSV

Source : Result of BMKG (2016) and BBKIHM (2016) Data Compilation

The climate anomalies over these seven years has been followed by the pathogen prevalence in tiger shrimp and vaname. The longest La Nina in 2010 triggered the highest pathogen outbreak epidemics of three pathogen types (Table 6). The La Nina phenomenon, which began with the longest El Nino in the early years, led to explosive growth of three kinds of pathogens; *Epistylis* sp, *Vibrio* sp, and *Vibrio damsella*. The El Nino phenomenon triggered the outbreak of *Zoothamnium* sp and WSSV pathogenic types. *Zoothamnium* sp phenomenon grows in any climate condition. The symptoms of El Nino occurring in 2012 and 2014 triggered Zoothamnium sp and *Vibrio* sp, and in 2013 the symptoms of La Nina triggered *Epistylis* sp, *Vibrio* sp, and *Zoothamnium* sp. In 2009, the combination of El Nino and La Nina symptoms triggered *Epistylis* sp, *Vibrio* sp, and *Zoothamnium* sp. The findings of *Zoothamnium* sp in any climate condition indicate that pond management at the level of farmers has not been fully in accordance with the instructions of best management practice. The symptoms of La Nina in 2013 mainly affected the water quality parameters of salinity waters of the Pare-Pare Gulf in the range of 7.75 - 7.90 ppt (Table 3) and 5.7 ppt (Table 5) in wet season, triggering the *Zoothanmiums* p development.

3.5. Adaptation to Climate Anomalies

The climate anomaly impact should be anticipated by upgrading community's knowledge of the climate changes, improving environmental management, applying environmentally-friendly shrimp cultivation technology, and applying the *Phronima Suppa* endemic organism. The development of community's capacity is done through the organizing of the "Phronima Suppa" field school. The managerial decision improvement has been committed in the aspect of management target function, while the functions of planning, decision making, and observation have not made any significant changes [37,39]. In this research, the production of pond with the phronima (B) was compared with that of pond without the phronima (A) as described in Table 6.

Table 6. Survival and Production in Pond with PhronimaSuppa

Application	Pond Width (ha)	Cultivation Period (days)	Stocking Density (seeds) Shrimp	Stocking Density (seeds) Milk Fish	Shrimp Survival (%)	Production (kg) Shrimp	Production (kg) Milk Fish
Without Phronima Suppa Application (A)							
Average	1.25±0.52	112.50 ± 21.21	14,687.50 ± 6,870.94	1,962.50 ± 1,047.36	17.20 ± 7.34	50.63 ± 24.27	337,50± 180.77
With Phronima Suppa Application (B)							
Average	1.31±0.37	47.00 ± 2.12	18.555,56± 247.60	-	61,54 ± 10,36	285.44 ± 88.02	-

The implementation of the field school learning outcomes with the application of phronima suppa (B) has increased black tiger shrimp production to 285.44±88.02 kg/1.31 ha or 217.89 kg/ha for 47 days growing season, higher than the production of pond without phronima suppa (A) which is only 50,63±24,27 kg/1,25 ha or 40,50 kg/ha for 112.50 days growing season. The application of phronima suppa employed an operational standard which was different from the conventional method used by the control group (A) consisting of eight farmers. The nine farmers applying the phronima (B) posted PL-12 black tiger shrimp in the transition pond for 30 days before the stocking into the growing pond and reduced the shrimp stocking density down to 10.000 – 15.000 per ha. The posting by group B produced black tiger shrimp adaptive to environmental stress caused by the climate anomaly.

The application of phronima suppa in ponds areas infected by WSSV and *V. Harvey* managed to result in a harvest of black tiger shrimp with a survival level of 65.00 %, while the pond which did not use the phronimaonly resulted in a survival level of 10.00 % [38]. Phronima suppa can provide nutrients needed by black tiger shrimp, form immune stimulant, and improve environmental quality of aquaculture [33]. The application of phronima suppa is predicted to result in immune stimulant towards environmental stress so shrimp become more tolerant of extreme climates. The survival level of shrimp provided with phronima suppa is higher although the ponds area is not free of WSSV and *V. harvey* yet. The development of modular aquaculture method and the continuous supply of phronima suppa will increase production.

The receipt value through the application of phronima suppa (B) is higher. The result of R/C-ratio analysis also indicates that B (8.48) is higher than A (2.35) as described in Table 7.

Table 7. Cost and Receipt through the Application of Phronima Suppa

		Receipt (IDR million)		
Application	Cost (IDR million)	Shrimp	Milk Fish	Amount
Without Phronima Suppa (A)				
Average	2.78	4.92	3.07	7.99
With Phronima Suppa (B)				
Average	3.12	22.60	-	22.60

The pond applying the phronima (B) is better at survival level, production, and size of shrimp. These three aspects absolutely influence farmers' income and profit. Shrimp price varies according to size. The phronima application results in relatively bigger black tiger shrimp (39.67±0.71/kg) in relatively shorter time (47.00±2.12 days). The application has big potential to empower farmers of marginal ponds along Pare-Pare gulf coast. The R/C-ratio value of the application, which is 8.48, is considered high and means that each unit of spending will result in eight units of income so the application has big potential to increase farmers' income and welfare. The result of research by Burhan (2014) indicates that the average R/C-ratio value of ponds in Lowita, Pinrang [40], is 1.83± 0.33, lower than that of ponds without phronima suppa (2.35). The difference in value indicates a gap between farmers guidance and cultivation management in the coast of Pare-Pare gulf.

Contribution of phronima suppa to farmers' income and welfare improvement goes with ponds managing success, resulting in additional value for black tiger shrimp cultivation, particularly in marginal ponds in the coast of Pare-Pare gulf. What happens in these ponds needs to be handled in integrated way in order to normalize environmental support capacity. Continuous application of phronima suppa determines farmers' success in the cultivation in the coastal area impacted by the climate anomaly. Ridwan, one of the farmers using phronima suppa, now has a 3-ha pond and hires 12 workers. Previously, this man was just a tenant of a 1-ha pond.

Good knowledge of climate anomaly and adaptation process has managed to increase black tiger shrimp production to 217.89 kg/ha with a receipt of IDR 22.60 million/ha. The community's production and income increase significantly through the improvement of environmental management and the application of phronima suppa.

4. Conclusions

The climate anomaly has been occurring in the coast of Pare-Pare gulf for three years, impacting water quality, plankton availability, and pathogen explosion.The field school learning has resulted in changes in managerial decision and efforts to adapt to the climate anomaly through the adjustment of black tiger shrimp stocking time to October until November and the optimizing of phronima suppa application. The extreme climate anticipation has succeeded in increasing the black tiger shrimp production to 217.89 kg/ha for 47 days growing season with a receipt of IDR 22.60 million/ha in the coast of Pare-Pare gulf. The climate anomaly learning and managerial decision quality improvement need to be developed to be a part of community's adaptation to the coastal climate anomaly.

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