Silvoaquaculture: Between Fish Production And Mangrove Conservation

Muarif, Yudi Wahyudin, Dewi Merdekawati, Mulyana, Fia Sri Mumpuni

Abstract: Silvoaquaculture is brackish water fishponds combined by mangrove cultivation and it's the best approach for mangrove conservation. Purpose of this study, to determine production performance, economic value, and ecology of mangroves in silvoaquaculture ponds and how to develop it. The study areas are located in Indramayu district, Indonesia. Mangrove ecological data were obtained using a quadratic survey method, and data of fish production and economic value collected by questionnaires. Data analysis uses a statistical test and descriptive (qualitative) approach. There are three type of silvoaquaculture pond i.e Empang Parit, Komplangan, and Kao-kao. Fishery production in silvoaquaculture ponds includes milkfish and shrimp production. Mangroves in silvoaquaculture ponds will provide good support for fish and daily shrimp production in ponds. Total production of milkfish reached 1688.89 (kg/Ha/year) and daily shrimp 505 (kg/Ha/year) with economic value of 44,938,571 (IDR/Ha/year). Good ecological mangrove seen in Empang parit and Komplangan Pond. Kao-kao pond produce high milkfish and daily shrimp, but bad for status ecological mangrove. Mangrove support for fish business and production in silvoaquaculture ponds includes safe pond from the wind, tide, wave, and treatment of water quality from pollutants, additional feed from plankton, and supply nutrients to pond. Each type of silvoaquaculture pond has different advantages and disadvantages and it's considered to development of silvoaquaculture pond.

Index Terms: - coastal, ecology, economic, mangroves, milkfish, nutrient, pond.

1 INTRODUCTION

BRACKISH water aquaculture has become a productive economic activity and an important livelihood of coastal people in Indonesia [1]. The people (fish farmers) in the coastal area have developed traditional brackish water ponds (such as ponds for milkfish cultivation) for a long time and the existence of these ponds has covered most of Indonesia's coastal areas. KKP (2018) reported that milkfish as dominant production from brackish water pond in Indonesia [2]. FAO's data (2018) states that Indonesia was a major producer of finfish (dominant milkfish) with production about 864,100 tons [3]. Brackish water ponds have provided high economic benefits for coastal people so this activity must be sustainable. During its development, construction of brackish water ponds has negative impact to the coastal environment [4], especially degradation of mangrove ecosystems. Fish culture such as milkfish culture in coastal area has converted mangroves into ponds [5][6], and then it resulted degradation of mangrove habitat. About 40% of mangrove habitat in Indonesia was estimated to have be damaged [7]. Mangrove damage must be prevented, because mangroves have many important ecological functions, such as spawning ground, nursery ground, feeding ground for aquatic and terrestrial biota, and that cannot be taken over with even modern technology. Mangrove ecosystems also have others important functions such as protecting beaches, preventing erosion, and maintaining climate change, marine resources [5] and productive and sustainable fisheries [8]. Loss of mangroves would have a wide-spread impact, including this would affect the productivity of offshore waters [9]. Degraded mangrove forest is strongly suspected as a cause of the decline of pond productivity in Indonesia[10]. So, development of brackish water ponds has reduced mangrove habitat and it must be evaluated to find the best solution for its use in the future. Mangrove rehabilitation is not simple, it is expensive, and it requires a long maintenance time, so the best approach is rehabilitation that involves people and provides economic value to coastal people. Silvoaquaculture is an approach integrated cultivation mangrove in fish pond, and this is the form of integration conservation and aquaculture. One of the real forms of silvoaquaculture is the development of milkfish cultivation combined with planting mangroves in brackish water ponds. The integration between mangrove conservation and ponds in the form of silvoaquaculture [11] is a mutually beneficial solution between mangrove conservation and fish farming [12]. Most fish farmers consider silvoaquaculture to be less profitable for fish production than conventional ponds, so It was abandoned. Existence of silvoaquaculture that has survived to this day needs to be investigated to determine the extent to which silvoaquaculture is able to provide economic and ecological benefits. Purpose of this study was to determine production performance, economic value, and ecology of mangroves in silvoaquaculture ponds to describe the strength of conservation and economic aspects that it has played.

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2 METHOD

2.1 Study Area

The study areas included three areas, the first is called Karangsong Village, the second area is Brondong Village, and the third area is called Pabean Ilir Village. Three villages are located in Indramayu district, Indonesia.

2.1 Data Collecting

Mangrove ecological data were obtained using a quadratic survey method. In transect area (10x10 m^2), mangrove species and number of mangrove trees are recorded. Mangrove observed in 10 stations (3 stations in Karangsong, 3 stations in Brondong, and 4 stations in Pabean Ilir). Data of fish production and economic value collected from respondent by questionnaires. Determination of the respondents was done

by purposive sampling for fish farmers in silvoaquaculture ponds (Empang Parit, Komplangan, and Kao-kao).

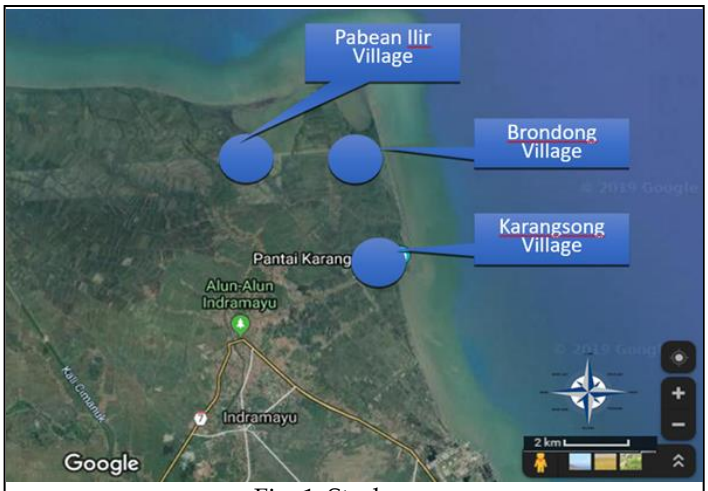

Fig. 1. Study area.

2.2 Data Processes

Production of silvoaquaculture ponds (in three type of ponds: empang parit, kao-kao, komplangan) per year is determined using the average production data from all ponds (kg / Ha / year). This production includes the production of farmed milkfish and the daily production of wild shrimp trapped in pond (called daily shrimp). The economic value of silvoaquaculture ponds (trench ponds, kao-kao, komplangan) per year is determined using average data on profit of milkfish farming from all ponds (IDR/Ha /year) plus daily shrimp income. Mangrove ecology is determined based on mangrove species, mangrove tree density (ind/Ha), and index of importance. Importance value index is used to determine dominant mangrove tree species.

2.3 Data Analysis

Data analysis uses a statistical test approach for analysis milk fish production data. Statistical analysis included data normality test, transformation of data (archi), analysis of variance (ANOVA), and DMRT test. Descriptive (qualitative) approach was used to analyze daily shrimp production data and economic value of silvoaquaculture. Descriptive analytical instrument used literature study. Ecological analysis of mangroves is based on standard criteria for mangrove ecological status established by Indonesian Ministry of Environment. If density of mangrove trees is more than 1500 idv / Ha it is categorized as GOOD (high density), and tree density below 1000 idv / Ha is categorized as BAD (low density).

3 Result and Discussion

3.1 Type of Silvoaquaculture Ponds

Indramayu District is one of the locations in Indonesia where milkfish cultivation on silvoaquaculture ponds [13]. Silvoaquaculture ponds have three type ponds, there are Empang Parit, Komplangan, and Kao-kao (Figure 1). Empang parit found in Karangsong Village, Komplangan located in Brondong and Pabean Ilir Villages, and Kao-kao spread in Karangsong, Brondong, and Pabean Ilir Villages.

Empang parit is silvoaquaculture pond where mangrove tree in the middle of pond (Figure 1a). Komplangan ponds have

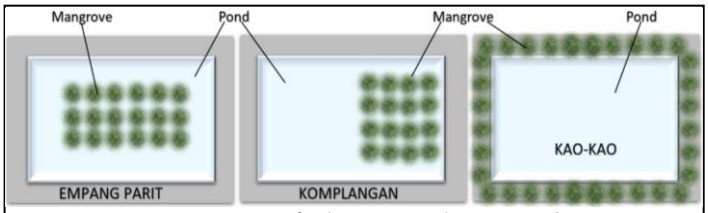

Fig. 2. Types of silvoaquaculture ponds.

mangroves tree on one side of the pond (Figure 1b). Finally, mangrove trees in the kao-kao pond have spread outside the pond (Figure 1c). Empang parit ponds and komplangan ponds have mangrove areas higher than kao-kao ponds.

Total areas of each type of silvoaquaculture ponds in research location has different. Kao-kao ponds (average 2,36 Ha) have higher area than other type pond of silvoaquaculture (empang parit pond (average 1,38 Ha) and komplangan pond (average 1,47 Ha)). Pond area is a variable that determines pond production [14], but highest of total area has some problem of silvoaquaculture management, especially for feeding treatment.

3.2 Production of Silvoaquaculture Ponds

Milkfish production in silvoaculture ponds ranged from 1309.72-1688.89 kg/Ha/year (Table 1). The highest production belongs to Kao-kao ponds and the lowest production belongs to Komplangan ponds. Analysis of Variance (ANOVA) shows significant differences in production between types of ponds. The DMRT test shows that the highest production of Kao-kao ponds is significantly different from Komplangan ponds but is not statistically significant from the production of Empang Parit ponds. Biotechnical factors during milkfish rearing period influenced milkfish production in silvoaquaculture ponds. Biotechnical aspects observed during the study included water sources, seeds, fertilizers, feed, pond area, and cultivation technology. Important biotechnical factors that influence aquaculture production are seeds [15], feed [15][16], fertilizers [17], and pond area [16] [17]. Fish seeds that are stocked in all silvoaquaculture ponds come from same source, namely all fish seeds from Bali region and are managed by local hatchery. Fish seed size ranges from 2-5 mg/fish. Quality of fish seeds is relatively same so that it is considered to have same effect on fish productionFeed with complete diets (protein, carbohydrates, fats, vitamins, and minerals) necessary for the optimal growth and health of the fish[18]. Feed used in all silvoaquaculture ponds had same nutritional quality (17% protein). Feeding is done in the morning and evening with an average feeding rate 3% (is lower than the feeding rate used by Malik's research (2010) [19] which is 3-5%). In feeding factor, there is a difference in Feed Conversion Ratio (FCR) where Komplangan ponds have a higher FCR than other types of ponds. The higher FCR is caused by uneven distribution of feed due to obstruction of mangroves that are clustered on one side of the pond. Inefficient feed in Komplangan ponds affects low production in these ponds.

TABLE 1
PRODUCTION OF MILKFISH AND SHRIMP IN SILVOAQUACULTURE PONDS

Type of Pond	Production (kg/Ha/year)	
	Milkfish	Daily shrimp
Empang Parit	1612,53[ab]	120
Kao-kao	1688,89[b]	480
Komplangan	1309,72[a]	505

Note: Different superscripts show different types of farms.

Water area of each pond is different, because mangrove area for each type of pond is different. Kao-kao pond has fewer mangroves so that it has a wider waters area of pond than Empang Parit and Komplangan ponds. High area of water bodies in the Kao-kao pond supported the high production of milkfish in these ponds.

Fig. 3. Fishing port activity in Karangsong

Daily shrimp production is strongly influenced by mangrove conditions as shrimp nursery ground. Komplangan ponds that have extensive mangroves provide high support (505 kg/year) for daily shrimp production in these ponds (Table 1). Strange conditions are found in Empang Parit ponds which have extensive mangroves (Figure 1) but daily shrimp production is low (120 kg / year). Location of Empang Parit pond is in Karangsong village, where this location is close to settlements, fishing ports, and oil mining (Fig. 3). Several health stressors (sewage, domestic, industrial and agricultural effluents carrying organic matter with highly toxic substances) are significantly depleting biodiversity of aquatic [20], and in this case decreased of shrimp population. High variety and high intensity of activities around the Empang Parit Pond (Karangsong Coast) impact on stress of aquatic environment, including pollution in shrimp habitat, so that daily shrimp production in this location is low.

3.3 Economic Value of Silvoaquaculture Ponds

Distribution of economic value from silvoaquaculture ponds ranges from 29,842,778-44,938,571 (IDR/Ha/Year). The highest economic income is obtained by Kao-kao pond farmers (44,938,571 IDR/Ha/Year). Komplangan pond farmers get an economic value of 39,590,983 (IDR/Ha/Year), while Empang Parit farmers get the lowest economic value of 29,842,778 (IDR/Ha/Year). Factors affecting income of milkfish farming include pond area and fish production[21]. Fish farming which has a large pond is able to maintain many fish and will produce a lot of fish. Furthermore, high fish production will provide a high fish sale value. Economic value of each pond is influenced by amount of production (Table 1) obtained per year. Kao-kao pond which the largest production of milkfish and daily shrimp has the greatest economic value. Even though Empang Parit pond has a higher milkfish production than Komplangan pond, but it has a very low daily shrimp production, so that the total economic value of Empang Parit pond is lower than that of the Komplangan pond. Conclusion, Empang Parit ponds are the lowest economic value of Silvoaquaculture ponds.

TABLE 2
ECONOMIC VALUE OF MILKFISH AND SHRIMP
IN SILVOAQUACULTURE PONDS

Type of Pond	Economic Value (IDR/Ha/Year)		
	Milkfish	Daily shrimp	Total
Empang Parit	26.686.111	3.156.667	29.842.778
Kao-kao	32.311.905	12.626.667	44.938.571
Komplangan	26.306.678	13.284.306	39.590.983

3.4 Mangrove Ecology in Silvoaquaculture Pond

Mangroves in silvoaquaculture ponds are mangroves that intentionally planted as an effort to preserve them (Fig 4). Mangrove conservation is important to stop continuous degradation of mangrove ecosystem. Important function of mangroves as a provider of ecological and environmental services must be maintained and even enhanced. Without conservation, mangroves will disappear from coastal areas and have a negative impact on all sectors of life for coastal people including aquaculture activities. Mangrove species found in silvoaquaculture ponds include Avicennia marina, Rhizophora mucronata, Rhizophora stylosa, and Rhizophora apiculata. Mangrove species most commonly found is Rhizophora mucronata, indicating the species most widely planted by farmers and the most adaptive to the pond environment (Fig 4). Rhizophora mucronata is more tolerant of harder substrate and sand[22]. Mangrove density ranged from 733-2333 (idv/Ha) (Table 3). The highest density was found in the Empang Parit and Komplangan ponds, while the lowest mangrove density was found in the Kao-kao pond. The density level is related to the ecological status, so that Empang Parit and Komplangan ponds have a good mangrove ecology while Kao-kao ponds have a bad mangrove ecology.

Fig. 4*. Mangrove in silvoaquaculture ponds.*

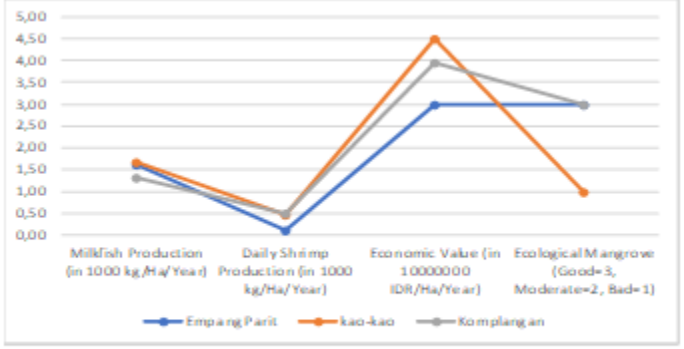

Fig. 5. Relationship of Production, Economic Value, and Mangrove Ecology in Silvoaquaculture Ponds.

Mangroves supported major fishery resources of significant economic importance until offshore water[23]. The ecological quality of mangroves has a positive effect on fishery production, including production of silvoaquaculture ponds. This research illustrates high production of milkfish and daily shrimp as a positive contribution from mangroves. Mangroves that live in silvoaquaculture ponds not only have a positive impact on silvoaquaculture ponds, but also have a positive impact on other ponds around silvoaquaculture ponds. This role causes the production of the Kao-kao pond, which has a large water body, to be higher in production, because it is actually supported by good mangroves in Empang Parit and komplangan ponds which are nearby.

TABLE 3

MANGROVE ECOLOGICAL STATUS IN SILVOAQUACULTURE PONDS

Station	Mangrove Species	Density (idv/Ha)	Dominant Species	Ecological status	Type of Pond
Station 1	Avicennia marina, Rhizophora mucronata	2067	Rhizophora mucronata	Good	Empang Parit
Station 2	Avicennia marina, Rhizophora mucronata, Rhizophora stylosa	2333	Avicennia marina	Good	Empang Parit
Station 3	Rhizophora mucronata	1500	Rhizophora mucronata	Good	Empang Parit
Station 4	Rhizophora mucronata	767	Rhizophora mucronata	Bad	Kao-kao
Station 5	Rhizophora mucronata	1867	Rhizophora mucronata	Good	Komplangan
Station 6	Rhizophora mucronata	1567	Rhizophora mucronata	Good	Komplangan
Station 7	Avicennia marina, Rhizophora mucronata	967	Rhizophora mucronata	Bad	Kao-kao

Fish farmer reported that mangrove presence in the silvoaquaculture pond has some advantages such as safe pond from the wind, tide, wave (mangroves protect the beach from erosion [24]), and so treatment of water quality from pollutants (mangrove plants are able to become water pollution biofilters [25]). Another advantage of mangroves is that the additional feed is obtained from plankton [26] and, nutrient-rich mangroves supply nutrients in pond [27]. However, farmers also reported the negative effect of mangroves on the fish cultivation process, such as poison from the tree and substrate mangrove [11], many fish predators live in mangrove [28], difficult to feed treatment, difficult for harvest fish, etc.

3.5 Relationship of Production, Economic Value, and Mangrove Ecology in Silvoaquaculture Ponds

Mangroves are important coastal ecosystems that provide positive support for fisheries resources. Increasing mangrove tree planting increasing fish populations [29] and existence of mangroves supports the life of various types of fish[30]. Mangroves in silvoaquaculture ponds will provide good support for fish and shrimp production in ponds. Figure 5 illustrates the relationship between production, economic value, and ecological status of mangroves in each type of silvoaquaculture pond. Empang Parit ponds have the advantages of high milkfish production and good mangrove ecology, but low daily shrimp production as a result of high activity from settlements, tourism, fishing ports, etc. Komplangan pond has advantage of high daily shrimp production and good mangrove ecology, but milkfish production is low due to low feed efficiency. Kao-kao pond has the advantage of high daily production of milkfish and shrimp, but mangrove ecology is relatively bad. Each type of silvoaquaculture pond has different advantages and disadvantages, for this reason its development policy must be able to correct existing weaknesses. Table 4 describes considerations and improvements for application of each type of silvoaquaculture pond. Empang Parit and Komplangan ponds which have a high mangrove density (good mangrove) can be applied in locations near coast and preferably far from center of activities that can be a source of pollution. Feed efficiency improvements are carried out in Komplangan ponds. Kao-kao ponds should be located some distance from coast (because mangroves are thin), and the mangrove density needs to be increased.

TABLE 4
CONSIDERATION AND IMPROVEMENT FOR SILVOAQUACULTURE PONDS

Type of Pond	Catagory		Existing conditions	Considerat & Improveme
	Advantage	Disadvantage		
Empang Parit	• Good mangrove • high milkfish production	• Low daily shrimp production as impact from environmental pollution	• Location is between conventional and komplangan ponds, and far from settlements	• Applie to ponds close to tl coast, • Locati far from sources c pollution
Kao-kao	• High milkfish and daily shrimp production	• Bad mangrove	• Location is near the beach and far from settlements	• Applie to ponds located fa from coas • Locati far from sources c pollution, • Increa mangrove density
Komplangan	• Good mangrove • High daily shrimp production	• Low milkfish production becouse Low feed efficiency	• Location is close to the beach and close to sources of pollution (settlements, industrial, fishing ports, oil mining, tourism, etc.)	• Applie ponds clo to coast, • Locati away fron pollution sources, • Improv feed efficiency

4 CONCLUSIONS

Silvoaquaculture is able to properly integrate milkfish production and mangrove conservation. Fishery production in silvoaquaculture ponds includes milkfish and shrimp production. Total production of milkfish reached 1688.89 (kg/Ha/year) and daily shrimp 505 (kg/Ha/year) with economic value of 44,938,571 (IDR/Ha/year). Mangrove support for fish business and production in silvoaquaculture ponds includes safe pond from the wind, tide, wave, and treatment of water quality from pollutants, additional feed from plankton, and supply nutrients to pond. Good ecological mangrove seen in Empang parit and Komplangan Pond. Kao-kao pond produce high milkfish and daily shrimp, but bad for status ecological mangrove. Development of silvoaquaculture pond consider advantages and disadvantages of silvoaquaculture pond. Empang Parit and Komplangan ponds can be applied in locations near coast and preferably far from center of activities that can be a source of pollution. Feed efficiency improvements are carried out in Komplangan ponds. Kao-kao ponds should be located some distance from coast, and the mangrove density needs to be increased.

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REFERENCES

[1] N. Fira, Analisis ekonomi konversi lahan mangrove menjadi lahan tambak Kecamatan Labakkang Kabupaten Pangkep. Makassar: Program Studi Sosial Ekonomi Perikanan, Departemen Perikanan, Fakultas Perikanan dan Ilmu Kelautan, Universitas Hasanuddin, 2017.

[2] KKP, Kelautan dan perikanan dalam angka tahun 2018. Jakarta: Kementerian Kelautan dan Perikanan (KKP), 2018.

[3] FAO, The State of World Fisheries and Aquaculture 2018. Rome: FAO, 2018.

[4] M. . Adewolu, S. L. Akintola, A. Jimoh, F. Owodehinde, O. Whenu, and K. Fakoya, “Environmental threats to the development of aquaculture in Lagos State , Nigeria,” Eur. J. Sci. Res., vol. 34, no. 3, pp. 337–347, 2009.

[5] UNEP, The importance of mangroves to people: a call to action, Van Bochov. Cambridge.: United Nations Environment Programme World Conservation Monitoring Centre, 2014.

[6] Ishak and I. A. Saputra, “Pengaruh aktivitas penduduk terhadap kerusakan hutan mangrove di Desa Lalombi Kecamatan Banawa Selatan,” J. GeoTadulako, vol. 3, no. 6, pp. 52–63, 2015.

[7] D. Murdiyarso et al., “The potential of Indonesian mangrove forests for global climate change mitigation,” Nat. Clim. Chang., vol. 5, no. 2015, pp. 1089–1092, 2015.

[8] Muarif, “Karakteristik Ekosistem Mangrove di Kawasan Pesisir Kepulauan Natuna,” J. Mina Sains, vol. 3, no. 2, pp. 44–49, 2017.

[9] Muarif, A. Damar, S. Hariyadi, M. Boer, and D. Sutrisno, “Tingkat kepekaan mangrove Indonesia terhadap tumpahan minyak,” J. Mns. dan Lingkung., vol. 23, no. 3, pp. 374–380, 2016.

[10] T. Ahmad, M. Tjarongs, and F. Cholik, “The Use of mangrove stands for shrimp pond waste-water treatment,” IFR J., vol. 7, no. 1, pp. 1–15, 2001.

[11] W. J. Fitzgerald, “Silvofisheries : Integrated Mangrove Forest Aquaculture Systems,” in Ecological aquaculture: the evolution of the llue revolution, Oxford: Blackwell Science Ltd, 2002, pp. 161–262.

[12] R. H. Bosma, T. H. Nguyen, A. J. Siahainenia, H. T. P. Tran, and H. N. Tran, “Shrimp-based livelihoods in mangrove silvo-aquaculture farming systems,” Rev. Aquac., vol. 8, no. 2016, pp. 43–60, 2016.

[13] Muarif, Y. Wahyudin, and D. Merdekawati, “Water quality at silvoaquaculture pond in indramayu regency,” IOP Conf. Ser. Earth Environ. Sci., vol. 383, no. 2019, p. 012033, 2019.

[14] E. Noviyanti, D. Rohmat, and Nandi, “Pengaruh usaha budidaya tambak terhadap kondisi sosial ekonomi petani tambak di Kecamatan Cibuaya Kabupaten Karawang,” Antol. Pendidik. Geogr., vol. 4, no. 2, pp. 1–14, 2016.

[15] A. Hidayatullah, “Analisis faktor-faktor yang mempengaruhi produksi usaha keramba ikan mas di Kecamatan Babirik Kabupaten Hulu Sungai Utara,” Al Ulum Sains dan Teknol., vol. 2, no. 1, pp. 14–19, 2016.

[16] N. Laksmidevi and J. Purwohandoyo, “Faktor-Faktor yang Mempengaruhi Produksi dan Produktivitas Kolam Budidaya Ikan di Kawasan Minapolitan Kecamatan Polanharjo, Kabupaten Klaten (Kasus di Desa Nganjat dan Desa Janti),” J. Bumi Indones., vol. 7, no. 2, pp. 1–12, 2018.

[17] A. S. Oktober et al., “Analisis Efisiensi Faktor Produksi Usaha Budidaya Ikan Bandeng (Chanos chanos) (Studi Kasus pada Alumni Peserta Pelatihan Budidaya Ikan di

BPPP Banyuwangi),” J. Aquac. Sci., vol. 2, no. 1, pp. 43–60, 2017.
[18] S. Craig, V. College, V. Medicine, and V. Tech, “Understanding fish nutrition , feeds, and feeding,” Virginia Coop. Ext., pp. 420–256, 2017.
[19] A. Malik, “Pengaruh pemberian suplemen dan probiotik terhadap hasil panen bandeng (Chanos chanos) di wilayah Desa Kentong Kecamatan Glagah Kabupaten Lamongan,” GROUPER J. Ilm. Perikan., vol. 1, no. 1, pp. 57–65, 2010.
[20] V. Lake, S. W. E, and N. T. P. V. S, “A First Report On The Plankton Status Of,” Int. J. Sci. Technol. Res., vol. 9, no. 03, pp. 260–264, 2020.
[21] M. Saipal, M. Surullah, and S. W. Mustafa, “Faktorfaktor yang mempengaruhi pendapatan petani tambak Ikan Bandeng di Desa Salekoe Kecamatan Malangke Kabupaten Luwu Utara,” J. Ekon. Pembang., vol. 5, no. 1, pp. 31–41, 2019.
[22] R. Fitriadi and J. Masyitha, “Species Composition Of The Mangrove In Lambur Luar Village , East Sabak , Kabupaten Tanjung Jabung Timur , Indonesia,” Int. J. Sci. Technol. Res., vol. 7, no. 11, pp. 52–57, 2018.
[23] L. N. Simon and D. Raffaelli, “A Trophic Model Of The Cameroon Estuary Mangrove With Simulations Of Mangrove Impacts,” Int. J. Sci. Technol. Res., vol. 5, no. 8, pp. 137–155, 2016.
[24] I. Sualia, B. Eko, and I. Suryadiputra, Panduan pengelolaan budidaya tambak ramah lingkungan di daerah mangrove. Bogor: Wetlands International – Indonesia Programme, 2010.
[25] N. Kariada and A. Irsadi, “Peranan mangrove sebagai biofilter pencemaran air wilayah tambak bandeng Tapak , Semarang,” J. Mns. dan Lingkung., vol. 21, no. 2, pp. 188–194, 2014.
[26] A. M. Samosir, E. F. Prahastianto, and S. Hariyadi, “Keberadaan Mangrove dan Produksi Ikan di Desa Grinting, Kecamatan Bulakamba, Kabupaten Brebes.,” J. Ilmu-ilmu Perair. dan Perikan. Indones., vol. 17, no. 1, pp. 261–270, 2011.
[27] M. D. Indrayanti, A. Fahrudin, and I. Setiobudiandi, “Penilaian Jasa Ekosistem Mangrove di Teluk Blanakan Kabupaten Subang,” J. Ilmu Pertan. Indones., vol. 20, no. 2, pp. 91–96, 2015.
[28] M. A. Dzakiy, A. Buchori, F. Nurdyansyah, R. Istiyaningsih, and V. Nindita, “Pembuatan desain kolam ikan bandeng berbasis konsep biosecurity bagi masyarakat petani tambak di pesisir Kabupaten Demak,” J. Dedicators Community, vol. 1, no. 2, pp. 103–113, 2017.
[29] E. K. Lestari, S. Komariyah, and S. Nurafiah, “The Analysis of economic structure based on shift share approach In East Java Province (Study in Minapolitan Area),” Int. J. Sci. Technol. Res., vol. 8, no. 12, pp. 1447–1452, 2019.
[30] N. Umi and S. Mulyani, “Bioeconomy of Ponyfish (Leiognathus Sp) in Tegal Regency Waters,” Int. J. Sci. Technol. Res., vol. 9, no. 02, pp. 1876–1878, 2020.