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Empang Parit as Silvofishery Model to Support Conserving Mangrove and Increasing Economic Benefit of Social Community

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ABSTRACT

Mangrove, estuary and lagoon ecosystem can be used as the aquatic organism habitat. These ecosystems also have good suitability to support activity of silvofishery system. *Empang parit* as a model of silvofishery using the integrating between the conservation activity of mangrove and aquatic ecosystem with increasing of benefit income for fisherman. This research aimed to analyze the model and pattern of empang parit, environment factor of empang parit and benefit cost analysis of empang parit. The research used vegetation analysis, water quality analysis, cash flow analysis, satellite image analysis, and geographical information analysis. The research explained that empang parit required water temperatur between 29 – 32.6^{o}C, water brightnes between 30 – 60 cm, water salinity between 15 -32 ppt, pH between 7 – 81 and dissolve oxygen between 3.9 – 8.3 mg/L.The empang parit also need *Bruguiera gymnorrhiza*, *Heritiera littoralis* and *Excoecaria agallocha*, *Rhizophora mucronata* and *Rhizophora apiculate* to cover empang parit system. And empang parit gave postive economic value based on value of NPV between 2.754.703–3.871.542 IDR, IRR between 21–48 and R/C between 2.26–2.32.

Keywords: Empang parit; silvofishery system; economic valuation; water quality; mangrove coverage***.***

ABSTRAK

Ekosistem mangrove, muara dan laguna merupakan habitat bagi organisme perairan. Ekosistem tersebut memiliki kesesuaian yang baik untuk mendukung aktivitas sistem silvofisheri. Empang parit merupakan suatu model silvofisheri yang terintegrasi antara aktivitas konservasi mangrove dan ekosistem perairan dengan peningkatan pendapatan nelayan atau petambak. Penelitian ini bertujuan untuk menganalisis model dan pola empang parit, factor yang mempengaruhi empang parit, dan nilai manfaat dan biaya dari empang parit. Penelitian ini menggunakan analisis vegetasi, analisis kualitas air, analisis cash flow, analisis citra satelit dan sistem informasi geografis. Penelitian ini menunjukan bahwa empang parit membutuhkan temperatur air between 29 – 32.6^{o}C, kecerahan air 30 – 60 cm, salinitas air 15 -32 ppt, pH antara 7 – 81 dan oksigen terlarut antara 3.9 – 8.3 mg/L.Empang parit membutuhkan *Bruguiera gymnorrhiza*, *Heritiera littoralis* and *Excoecaria agallocha*, *Rhizophora mucronata* and *Rhizophora apiculata* sebagai pohon pelindung Dan empang parit telah memberikan dampak posistif dari sisi valuasi ekonomi seperti NPV antara Rp 2.754.703–3.871.542, IRR antara 21–48 dan R/C sekitar 2.26–2.32

Kata kunci: Empang parit; sistem silvofisheri; valuasi ekonomi; kualitas air; penutupan mangrove

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1. Introduction

East Segara Anakan Lagoon (E-SAL) as part of Segara Anakan Lagoon is arranged by integrated among a terestrial ecosystem and an aquatic ecosystem like as the mangrove, estuary, lagoon (Ardli & Wolff, 2008; Hilmi, Pareng, et al., 2017; Sari, 2016), tidal swamp ecosystems and tidal mud land (Irwansyah, 2010). As an ecosystem, E-SAL is used as habitats of many organisms (Bengen & Dutton, 2004; Hilmi, Pareng, et al., 2017; Syakti, Ahmed, et al., 2013; Winarno & Setyawan, 2003) such as fish, shrimps, crabs and shells (Bosire et al., 2008; Hilmi et al., 2015; Kanwilyanti et al., 2013; Masagca, 2011). E-SAL also is used as an income and benefit source to support activity of community livelihood. But, the degradation of many ecosystem in E-SAL because conversions (to settlements and others need), exploitations, illegal loggings, water pollution and sedimentations (Adame et al., 2010; Hidayati et al., 2011; Hilmi et al., 2017) give negative impact for productivity and benefit income of silvofishery activity.

Basically, E-SAL takes freshwater supply from Sapuregel River and Donan River and seawater supply from the Indian Ocean (Hilmi et al., 2020; Hilmi, Sari, Cahyo, et al., 2019; Koswara et al., 2017; Syakti, Hidayati, et al., 2013). The fresh and seawater supply are a main factor which be used to support activity of silvofishery, including *empang parit* system. *Empang parit* is a model of integrated silvofishery require mangrove conservation as main factor to support the aquaculture activity in the silvofishery system. *Empang parit* system also require triggering factors to support integrated system among fishery activity, mangrove conservation and benefit income (Glass et al., 2015; Huang et al., 2003; Sari, 2016). The some researches note that empang parit also has many advantages to support aquaculture (Budihastuti et al., 2012; Duncan et al., 2016; Rose et al., 2015), mangrove preservation, give benefits income and increasing fish production.

Empang parit in E-SAL is initiated by Perhutani West Banyumas as effort to combine mangrove conservation activity and improving economy. Empang parit was daily habit of social community in E-SAL to support improving income. This paper aimed to analyze the model and pattern of empang parit, environment factor of empang parit and benefit cost analysis of empang parit using vegetation analysis, water quality analysis, cash flow analysis, satellite image analysis, and geographical information system.

2. Materials and Methods

2.1. Research Site

This research was conducted in East Segara Anakan Lagoon with coordinates $7^{O}35'$- $7^{O}50'$ South Latitude and $108^{O}45'$- $109^{O}03'$ East Longitude (**Figure 1**). The research objects were mangrove ecosystem (6 stations to analysis mangrove and

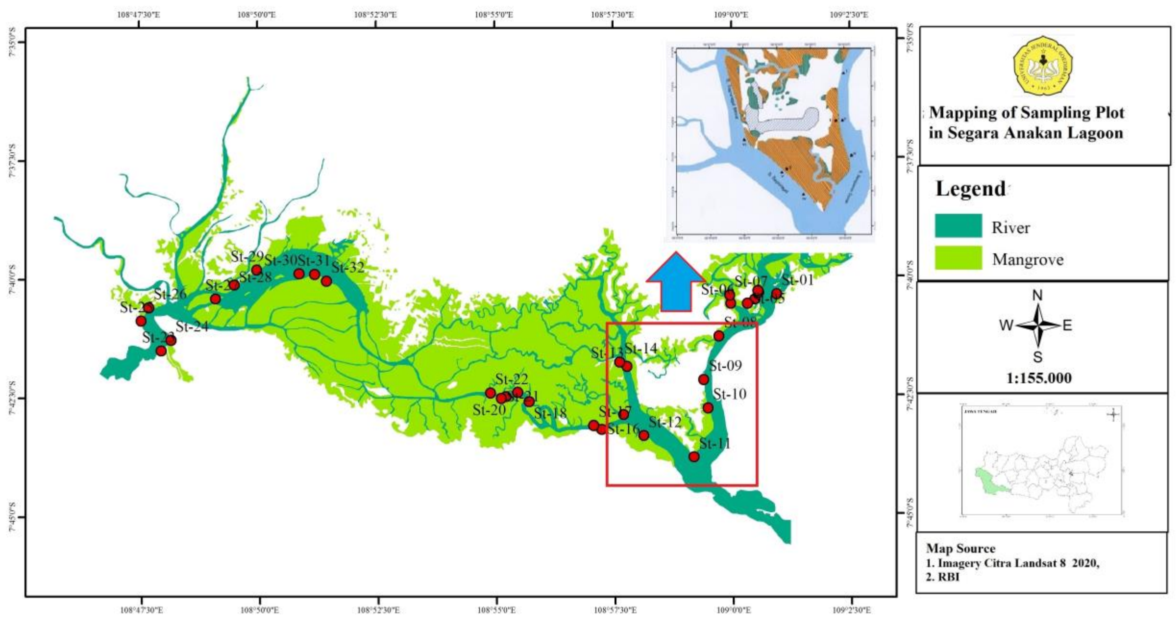


Figure 1. Research Site

Table 1. Water Quality Analysis

No	Variables	Unit	Method
1.	pH	-	APHA,20th.1998 450-H^+/pH meter
2.	Salinity	Ppt	APHA,20th.1998 2520-B /handrefractometer
3.	Brightness	Cm	a secchi disk method
4.	Dissolve oxygen	mg/L	a *dissolved oxygen meter digital device* (Hanna Instrument brand)

water quality) and silvofishery area (2 stations to analysis mangrove, water quality and benefit income). To analysis this research used some variables of that were mangrove covering, mangrove density, water quality and economic value.

2.2. Vegetation Analysis

The vegetation analysis used *line plot transect method* with a size of 10m x10m (trees), 5m x 5m (sapling) and 2m x 2m (seedling) (Kusmana, 1997). The vegetation analysis was done to analysis mangrove density, covering and domination.

2.3. Water Quality Analysis

Water quality analysis used APHA,20th, a secchi disk method and a *dissolved oxygen meter digital device* (**Table 1**). The water analysis were done to analysis potetial of pH, salinity, brightness and dissolve oxygen to support the activity of silvofishery system.

2.4. Satelite Imagery Analysis

Satelite image analysis used geographical analyisis with ArcGIS software, Arc map software and Err Maper programs. This analysis was developed to analysis mangrove covering and potential of shilvofihery area.

2.5. Benefit Cost Analysis

The benefit cost analysis was developed to analysis potential of benefit income from silvofsihery activity. This method used cash flow analysis, revenue and cost analysis (R/C), break event point analysis (BEP), net present value (NPV) and internal rate of return (IRR) (Dijk et al., 2016; M. Brander et al., 2012).

2.6. Social Analysis

Social analysis was developed to get public opinion about potential, productivity, economic and sustainability of silvofishery activity. This anaysis using Focus group discussion with 60 responden in E-SAL

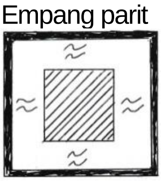
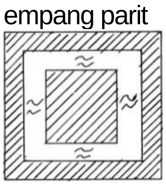
3. Results and Discussion

3.1. The Integrated Silvofishery of Empang Parit

3.1.1. The Empang Parit System

The empang parit system as integrated silvofishery system in E-SAL (**Table 2)** using mangrove vegetation as a main component of silvofihery system to support process of nutrient matter supply, protected area, stability of water

Table 2. Matrix of Empang Parit as A Silvofishery System Models

System silvofishery	Mangrove position	Mangrove density	economic valuation	Physical condition of waters
Traditional Empang parit 	Mangrove ecosystem located only in center of fish pont	Medium-high	Potency income reached Rp 3.337.700/989 m^2	Require temperature between 29 – 32.6^{o}C, water brightnes between 30 – 60 cm, water salinity between 15 -32 ppt, pH between 7 – 81 and Dissolve oxygen between 3.9 – 8.3 mg/L
Integrating of empang parit 	Mangrove plants are on the edge and center of the fish pond	High	Potency income reached Rp 4.875.810/655 m^2	

quality and increasing fish productivity (Budihastuti et al., 2012; Brander et al., 2012). Based on data showed that empang parit system in E-SAL had two models, that are (1) mangrove as centre ecosystem in silvofsihery as known as traditional empang parit and (2) mangrove located in centre and edge of sivofsihery system as known as integrating of empang parit. In the traditional empang parit require medium-high of mangrove density and integrated of empang parit required high mangrove density. The mangrove mangrove density in traditional empang parit and integrating of empang parit had function as nutrient supply, reducing salinity stress and oxygen support (Nelson et al., 2009; Yan & Guizhu, 2007)

3.1.2. Potential Economic of Empang Parit

Based on economic valuation analysis showed that empang parit gave the net income per plot reached 8.874.286- 10.140.000 IDR kg^{-1}, BCR (benefit cost ratio) between 2.26 – 2.36, Break even point between 1.305.025 - 1.394.696 IDR, Net present Value between 2.754.703 - 3.871.542 IDR, and Internal Rate of Return between 21 – 48 %. (**Table 3).** This data showed that empang parit system in E-SAL had good profitability because has R/C > 1, IRR > interest rate, and NPV > 1. Badola & Hussain (2005), Melaku Canu et al., (2015) and Dijk et al., (2016) notes that economic activity has R/C > 1.5 is considered very profitable.

Empang parit system as a model of silvofihery system has two aventages that are perservation of mangrove ecosystem and give economic benefit. The perservation of mangrove ecosistem as the first avantage is showed by mangrove need approximatelly 655- 1200 m^2 to support emapang parit system. Mangrove has role to supply nutrient from decompotions of mangrove litter (Fernandes et al., 2016; Liu et al., 2014; Sasaki et al., 2016), freshwater supply (Hilmi, Sari, Cahyo, et al., 2019; Hoppe-Speer et al., 2011; Li et al., 2012; Sari, 2016), support spawning ground area, nursery ground and feeding ground (Fairuz-fozi et al., 2018; Masagca, 2011; Micheli, 1993; Nobbs, 2003). On the other hand, mangrove ecosystem also perserves sylvofishery from sedimentation, water and heavy metal pollution and the impact of water inundation (Hilmi, 2018; Hilmi, Kusmana, et al., 2019; Syakti, Hidayati, et al., 2013).

The second aventage is improving fish productivity, benefit and revenue of aquaculture activities. Based on the data showed that Empang parit system has good profitability, because has R/C > 1, IRR > interest rate, and NPV > 1. Empang parit system also had a break event point (BEP) between 1.305.025 - 1.394.696 IDR, Net present Value between 2.754.703 - 3.871.542 IDR, IRR data between 21 – 48 % more than interest rate. Based on the economic data and indicators on Table 3 also showed that the empang parit can be used as a silvofishery model, because has ability to return capital, profitable activity and can increase fisherman income (Abubakar, 2008; Fitzgerald, 1997; Wibowo & Titin, 2006).

3.2. The Factors Supporting Empang Parit System

3.2.1. Water Quality

The temperature, brightness, water salinity, pH and dissolve oxygen as the water quality indicators in Empang Parit System can be seen on **Table 4**. This data showed a comparison between water quality in mangrove ecosystem with Empang Parit System. The data showed that temperature in mangrove ecosystem < empang parit system, brightness in mangrove ecosystem < empang parit system, Salinity and pH in mangrove ecosystem similar with empang parit system, and dissolve oxygen in mangrove ecosystem < empang parit system. However, mangrove ecosystem and empang parit system have good suitability to support living aquatic organism in silvofishery system, because has similarity with standard of aquatic organism life (UU 82 tahun 2001, 2001). The empang parit and mangrove ecosystem in E-SAL have temperature between 29 – 32.6°C, water brightnes between 30 – 60 cm, water salinity between 15 -32 ppt, pH between 7 – 81 and Dissolve oxygen between 3.9 – 8.3 mg/L.

Silvofishery system including empang parit in Segara Anakan Cilacap require good condition of water quality and mangrove ecosystem to support aquaculture activity (Bao et al., 2013). Water quality is the ***first factor*** supporting of empang parit system. Based on water quality, mangrove ecosystem in E-SAL has high suitability to support empang parit system. The indicator of water quality in mangrove ecosystem to support empang parit system are temperature as *the first indicator* has score between 29 ^{O}C - 30 ^{O}C, with the average temperature of 29.58 ^{O}C. Andarani et al., (2016), Yan & Guizhu (2007) and (Wang et al., 2019) note that mangrove need temperature between 28–32 ^{O}C to support photosynthesis and growth process. *The second indicator* is water brightness which has ranges between 35-50 cm. Suhendra et al., (2018), Hilmi, Sari, & Setijanto, (2019), Santoso et al., (2010), Holtermann et al., (2009) write that mangrove density give influence water brightness. *The third indicator* is water salinity. Water salinity in mangrove ecosystem in E-SAL has ranges between 20-26 ppt. According Hilmi et al., (2019) and Andarani et al., (2016) note that the optimum of water

Table 3. Analysis of Cash Flow Analysis as Feasibility Indicator of an Empang Parit

No	Description	Unit	Station 1 (traditional empang parit)	Station 2 (integrating of empang parit)
	Area of pond	m^2	989	655
	Total Production	Kg yr^{-1}	99,76	154
	Selling price			
	- Grouper	IDR kg^{-1}	60.000	-
	- Crab	IDR kg^{-1}	-	55.000
	Investment costs	IDR kg^{-1}	10.140.000	8.874.286
	Operating costs	IDR kg^{-1}	2.647.800	3.594.190
1	Net income/ plot	IDR kg^{-1}	3.337.700	4.875.810
2	R/C		2,26	2,35
3	BEP	IDR.	1.394.696	1.305.025
4	NPV	IDR	2.754.703	3.871.542
5	IRR	%	21	48

salinity to support mangrove growth between 10-30 ppt (Kusmana et al., 2000). *The fourth indicator* is pH which ranges between 7.2 - 7.8 (Average pH was 7.8). According to Cahyanto & Kuraesin, (2013), Kusmana et al., (2000) and Nelson et al., (2009) note that the potential pH has range between 6.0–9.0 *The last indicator* is dissolved oxygen (DO). Mangrove in E-SAL has DO between 4.2–5.7 mg/L with an average of 4.9 mg/L. According to Sari et al., (2016), The good classified of DO has range of 6,2-7 mg/L which give good impact to support the diffusion and photosynthesis processes of aquatic organisms. The low potential of DO in Segara Anakan is influenced by sedimentation, water pollution, water inundation and turbidity (Adame et al., 2010; Cahyo, 2012; Santoso et al., 2010; Sari et al., 2016; Schaduw, 2018).

Whereas water quality in silvofishery system also shows that *The first indicator* is water temperature which has average temperature between 30.4 ^{O}C - 32.6 ^{O}C. The data of water temperature give good supporting of productivity and metabolic activities of fish growth. Ellison (2008), Huang et al., (2003), Rose et al., (2015) and Kordi and Tancung, (2007) note that normal standard of water temperature to support fish growth, metabolize and fish reproduction are 28–32 ^{O}C. While according to Kuntiyo, (2004) the optimum temperature for maintaining mangrove crabs is 26-32 ^{O}C. And Supratno & Kasnadi, (2003) also note that the optimum temperature to support aquaculture system in fish ponds are 28–32 ^{O}C. *The second indicator* is water salinity as an main factor of influencing survival and fish metabolism activity (Henmi et al., 2017; Ukpong, 1997; Volta et al., 2018). Water salinity in the empang parit system has ranges between 15 ppt – 32 ppt. Supratno & Kasnadi (2003) and Hai & Yakupitiyage, (2005) state the silvofishery system has good productivity on water salinity between 25–35 ppt. *The third indicator* is pH, which shows pH of in Empang Partit E-SAL between 7 – 8.1. Based on the standard pH note that the good fish productivity in silvofishery system with ranges between 7 -8.5. *The fourth indicator* is Dissolve Oxygen (DO). Empang parit system in E-SAL has DO between 3.9 – 8.3 mg/L. Basically, potential DO > 5 mg/l give good

Table 4. Water quality in Mangrove Ecosystem and Empang Parit in E-SAL

Parameter	Mangrove ecosytem						Empang Parit Sytem						Standard index
							Station 1			Station 2			
	1	2	3	4	5	6	Min	Average	Max	Min	Average	Max	
Temperature ^{O}C	29,5	29,2	30	29,8	30	29	30,4	31,3	32,6	30,1	31,6	32,5	28-32
Brightness cm	40	40	35	50	45	50	30	44,8	60	30	44,5	60	-
Salinity ‰	20	20	20	24	26	20	25	27,32	32	15	18,79	20	s/d 34
pH	7,5	7,5	7,6	7,5	7,8	7,2	7,3	7,5	8	7	7,6	8,1	7-8,5
DO mg/L	4,6	4,2	4,3	5,3	5,7	5,1	5,2	6,1	6,5	3,9	5,7	8,3	>5

suitability to support fish farming. Supratno & Kasnadi, (2003) also notes that DO range between 4.0–8.0 mg/l give high supporting of fish metabolic and productivity, but if potential of DO value < 4 mg/l will inhibit fish growth and organism dying (Hai & Yakupitiyage, 2005; Patty, 2015).

3.2.2. Mangrove Density

The second factors to support empang parit system are mangrove density and species dominance in mangrove ecosystem (**Table 5).** The mangrove density and species domiannce have importat role to support empang parit system. Segara Anakan Lagoon has 11 true mangrove species and 2 associate mangrove species that are *Bruguiera gymnorrhiza, Ceriop decandra, Ceriop tagal, Nypa frutican, Avicennia marina, Rhizophora apiculata, Heritiera littoralis, Excoecaria agallocha, Rhizophora mucronata, Xylocarpus moluccensis* and *Lumnitzera racemosa* as true mangrove species and *Hibiscus tiliaceus* and *Finlaysonia maritime* as asosiate species.

The data in Empang Parit system E-SAL also showed that Station 1 had higher density than station 2. And then, based on species domination showed that in Stations 1 had *Bruguiera gymnorrhiza and Ceriops decandra* as the species dominant and *Heritiera littoralis* as species dominant in Station 2. Hilmi et al., (2015), Su et al., (2014) and Teh et al., (2008) note that silvofsihery system has good productivity if is located on zone 3 and 4 of mangrove ecosystem. The mangrove zone 3 and 4 have charcteristize as mangrove ecosystem are influenced by a normal tide and are dominated by *Bruguiera* and *Xylocarpus granatum*, *Heritiera littoralis, Bruguiera sexangula, Nypa frutican* and *Lumnitzera littorea*.

Different with potential mangrove in Empang Parit system, the lagoon of E-SAL has good potential of mangrove density and species dominance. The data on Table 5 showed that the potential of mangrove density and species dominance covering empang parit system. The data on Table 5 also showed that the station 1 was dominated by *Bruguiera gymnorrhiza* (highest domination), *Avicennia marina* (moderate domination), and C*eriops tagal, Ceriops decandra and Rhizophora apiculata* (low domination) and Station 2 was dominated by *Heritiera littoralis, Excoecaria agallocha* and *Hibiscus tiliaceus* as highest domination species and *Ceriops decandra, Rhizophora mucronata* and *Lumnitzera racemosa* (low domination). The domination index give influencing relative frequencies (coverage area), relative densities (mangrove density and presence) and relative dominance (mangrove diameter) (Bengen & Dutton, 2004; Kantharajan et al., 2018;

Table 5. Density And Sepcies Domination Index of Mangrove Ecosystem in E-SAL

Species	Mangrove density (trees/ha)				Domi nation index	Species	species covera ge	Covering Mangrove
	Tree	sapling	seedling	Association				
Empang Parit Station 1								
Bruguiera gymnorrhiza	900	24200	167500		116,71	*Rhizophora mucronata*	56%	
Ceriop decandra	50	16200	126250		37,18	*Rhizophora apiculata*	20%	57%
Ceriop tagal	100	3800	20000		48,18	*Bruguiera gymnorrhiza*	24%	
Nypafrutican	0	1000	13750		Td			
Avicennia marina	50	200	0		60,98			
Rhizophora apiculata	150	4400	11250		36,95			
Finlaysonia maritime				shrub				
Total	1250							
Empang Parit Station 2								
Heritiera littoralis	500	800	0		59,52	*Rhizophora mucronata*	34%	
Excoecaria agallocha	100	0	0		53,54	*Rhizophora apiculata*	37%	
Ceriops decandra	50	0	0		23,79	*Bruguiera gymnorrhiza*	14%	
Ceriop tagal	0	200	1250		td	*Ceriop decandra*	6%	46%
Rhizophora mucronata	100	0	0		23,42	*Sonneratia alba*	3%	
Xylocarpus moluccensis	0	400	1250		td	*Avicennia marina*	6%	
Hibiscustiliaceus	300	400	0		54,3			
Lumnitzera racemosa	150	0	0		37,36			
Nypa frutican	0	200	2500		td			
Finlaysonia maritime	0	0	0	shurb	td			
Total	1200							

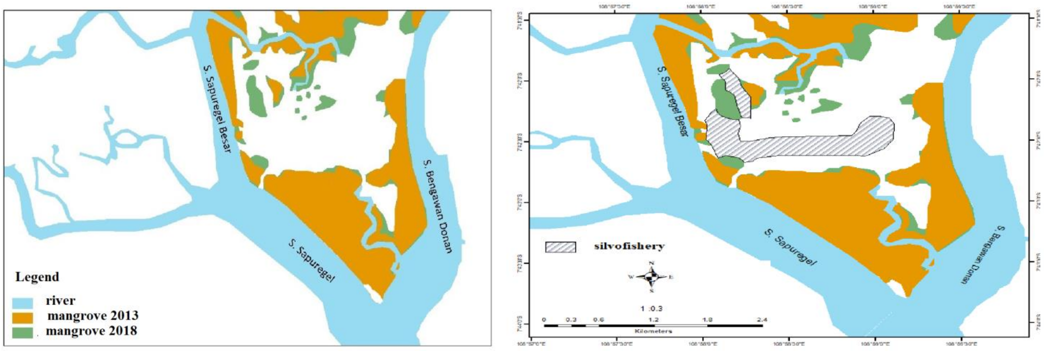


Figure 2. Integrated silvofishery area and mangrove ecosystem

Kusmana, 1997). This data had difference with (Ratini, 2016) research which notes that the mangrove ecosystem in Ujungalang Kampunglaut is dominated by *Acanthus ebracteatus* (shrubs), *Aegiceras corniculatum* and *Rhizophora apiculate* (seedling), *Sonneratia alba* (sapling), *Sonneratia caseolaris* and *Avicennia alba* (Trees).

3.2.3 Mangrove covering

The last factor to support empang parit system is mangrove covering which show the increasing trend from 603,00 ha (2013) to 617.80 ha (2018) (**Figure 2**). This condition is caused by increasing of community's participation and awerness to preserve the mangrove ecosystem, because many peoples in E-SAL aware that mangrove ecosystem has many benefits to increase nutrient, freshwater and oxygen supply.

Based on **Figure 2** showed that mangrove coverage in Empang Parit System in E-SAL has good suitable to support fish productivity in aquaculture system, because mangrove in E-SAL has covering > 60 %. KEPMENLH no 201 (2004) note that mangrove covarage in empang parit system has three classes of mangrove coverage, that are are low coverage (mangrove coerage < 40 %), medium coverage (magrove coverage 40 – 60 %) and high coverage (mangrove coverage > 60 %). The similar with. Zuna, (1998) notes that the optimal of mangrove coverage to support silvofishery system is between 37-65%.

4. Conclusions

The integration of silvofishery system has two systems that are (1) silvofishery using mangrove ecosystem as the center of fish ponds, and (2) silvofshery using mangrove ecosystem in the center and edge of fish ponds. The integration of silvofishery system is well profitable to support the increase in economic value of aquaculture activity, because has NPV > 0, BCR > 1 and IRR > interest rate.

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