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Foreword

Water, along with air, has always been the basic part of human's life. Among the water bodies, lakes are of severe impacted ecosystems despite its importance to the surroundings. Lakes confer numerous functional roles that may include defense over flood, recharge and storage of groundwater, biodiversity hot spot and the social economic services. Unfortunately, the alarming signals of lakes being under stress are underway. Contamination and pollution, sedimentation, wetland habitat degradation, alien species invasion, and other anthropogenic activities may have been the major stressors often associated with lake's deterioration. Since the issues on lake's deterioration have been globally emerged, a collected commitment should be engaged to supporting lake sustainability.

The World Lake Conference comes forward as an international forum serving to bridge communication among multi-sectoral parties towards sustainable management in lakes and basins. The 16th World Lake Conference, held from Nov 7th to 11th 2016 in Bali, Indonesia, invited distinguished keynote speakers around the globe; Prof. Takehiko Fukushima from University of Tsukuba, Prof. David Hamilton from GLEON, Prof. Walter Rast from ILEC Japan, Prof. Soontak Lee from IHP UNESCO, Dr. Fauzan Ali (Director of Research Center for Limnology, Indonesian Institute of Sciences) and Mr. Alue Dohong from Peatland Restoration Agency (Indonesia). It was also delightful that we had Governor Mikazuki from Shiga Prefectural Government (Japan) and Governor Hashimoto from Ibaraki Prefectural Government (Japan) to deliver their speeches.

The conference had also been completed nicely by the release of Bali Declaration. Another significant output of the conference is the publication of proceedings. The total papers reviewed and compiled in these proceedings are 83 which were broken up into several thematic sections. The sections comprise (1) climate change and water crisis (2) lake environment under stress and their restoration challenges (3) lake and lake basin management and policies (4) multiple water use purposes (5) water education, ecotourism, culture (6) database and knowledgebase systems, informatics and monitoring technologies (7) biodiversity and conservation (8) ecotechnology and ecohydrology (9) manmade lakes (10) limnology and limnological science fundamentals. Lastly, we acknowledge the creditable efforts and dedications that editors, reviewers and the proceeding team have been put forward.

July 2017

Prof. Gadis Sri Haryani
Chairperson of Scientific Advisory Board

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Topic 2. Lake environment under stress and their restoration challenges

THE INCREASE OF FLOATING NET CAGES, AQUACULTURE AREA AND WATER QUALITY IN MANINJAU LAKE, WEST SUMATERA-INDONESIA

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ABSTRACT

This study was carried out to evaluate the increase of floating net cages, aquaculture area and water quality parameter in Maninjau lake. The results showed that the total floating net cages in the years of 2011 (15,000 units), 2012 (15,860 units), 2013 (16,120 units), 2014 (16,580 units) and 2015 (20,608 units) respectively. The location of floating net cages in Maninjau lake still dominant in littoral area, with distance 25 to 100 meter from the edge of the lake. The aquaculture areas which are used for 20,608 units of floating net cages are 113.7 hectares. Meanwhile, based on the size of fish, stocking density and oxygen used for aquaculture, the needed ideal area is 1416,04 hectares. The water quality around floating net cages showed there was no significant differences ($p > 0.05$) between sampling sites. The results obtained the levels of water transparancy was 1.91-1.99 meter, ammonia 0.35-0.65 mg/L, nitrite 0.210-0.254 mg/L and the total phosphorus 00.32-0.80 mg/L, respectively. We conclude that increasing of floating net cages around Maninjau lake is not suitable with aquaculture area which have negative effect to sanity of fish and water quality parameter.

Keywords: Maninjau Lake, floating net cages, aquaculture area, water quality.

INTRODUCTION

Maninjau lake is one of the fifteen lakes in Indonesia which becomes very important priority lake to be saved (Ministry of Environment of the Republic of Indonesia, 2012) because its plays an important role as hydroelectric plants with power 64 MW and the economic value was IDR 71.8 billion/year, tourism IDR 2.15 billion/year, fishing-capture IDR 1.12 billion/year (LIPI, 2009) and aquaculture activity of tilapia dan carp species by using floating net cages is 4,316 units with an investment of IDR 112 billion/year (Syandri, 2003). The total floating net cages in Maninjau lake for tilapia and carp farming always increase in every year. In the year 2001, the total floating net cages was 3,500 units, while in the year 2013 was increase to 16,120 units (Syandri et al., 2014a; Junaidi et al., 2014).

In this decade, the pressure of the environment condition in Maninjau lake not only caused by the increase of floating net cages (Syandri et al., 2014a; Syandri et al., 2016) but also intensive land used in the catchment area (Machbub, 2010) and used that area for settlement and conversion of paddy fields into fish ponds (Government Agam Regency, 2012; Syandri et al., 2014a). That activity caused directly increase of the organic loading in Maninjau lake and also have effect to the decrease of water quality (Henny, 2009; Yusuf et al., 2011; Junaidi et al., 2014; Syandri et al., 2015a) and the diversity of fish species (Dina et al., 2011; Syandri et al., 2014b).

In this work, we examined the used of Maninjau lake for the aquaculture of tilapia (*Oreochromis niloticus*) and carp (*Cyprinus carpio*) in the floating net cages in Agam Regency of West Sumatera Province, Indonesia. We analyze the increase of floating net cages, aquaculture area and some physico-chemical parameters.

METHODS

Study area

The Maninjau lake with a surface area 9,996 hectare is located in Tanjung Raya district of Agam Regency, West Sumatera Province - Indonesia, the geographical position E:00°12'26.63"-S:0°25'02.80" and E:100°07'43.74"-S:100°16'22.48", located at altitude 461.50 meter above sea level. The regional climate is classified as Schmidth-Ferguson Climate. This lake has characteristics of climate types A and annually receives an average rainfall 3,490 mm, with two distinct seasonal periods of precipitation: a

dry season that normally extends between April and September, and rainy season from October to March. During this study, the monthly precipitations of the rainy season varied between 120 and 200 mm, and in the dry season between 10 and 50 mm.

Data floating net cages and the aquaculture area

The data of floating net cages was collected from the year 2011 to 2014 from Department of Marine and Fisheries science of Agam Regency, whereas the data in the year 2015 was calculated directly from the field. The calculation of aquaculture area in each village were analyzed based on the stocking density of fish, water temperature (26°C), oxygen used/kg fish/hour (0,7 g O_2/kg fish/ hour), elevation of lake (461 meter above sea level), and the ratio of the oxygen used with the available oxygen in the water body. The amount of oxygen used which generated in one day under normal circumstances with water temperature is 26°C = 16.67g O_2 / m^2 which consists of photosynthesis 14.33g and 2.34g of air diffusion, to fish oxygen only provided 22% (3.67 g O_2 / m^2).

ARCGIS 10.1 programme was used for making aquaculture area maps of floating net cages in Maninjau lake. The data used in this study is a multi-temporal satellite image Landsat TM / ETM + and SPOT image of the 4 during the period from the year 2014 to 2015, DEM SRTM resolution of 17 meter.

The water samples were collected every three months in the year of 2015 in four sites from the lake at 1.0 meter depth: A – *Sungai Batang*; B – *Sungai Tampang*; C – *Bayur*; D – *Koto Kaciek* (Figure 1). The water samples in 2-litre per bottles were maintained at 4°C for up to 24 hours. The following physico-chemical parameters of water was analyzed; temperature, pH, amount of ammonia, nitrite, total phosphorus and dissolved oxygen according to the methods described by APHA (APHA, 1998).

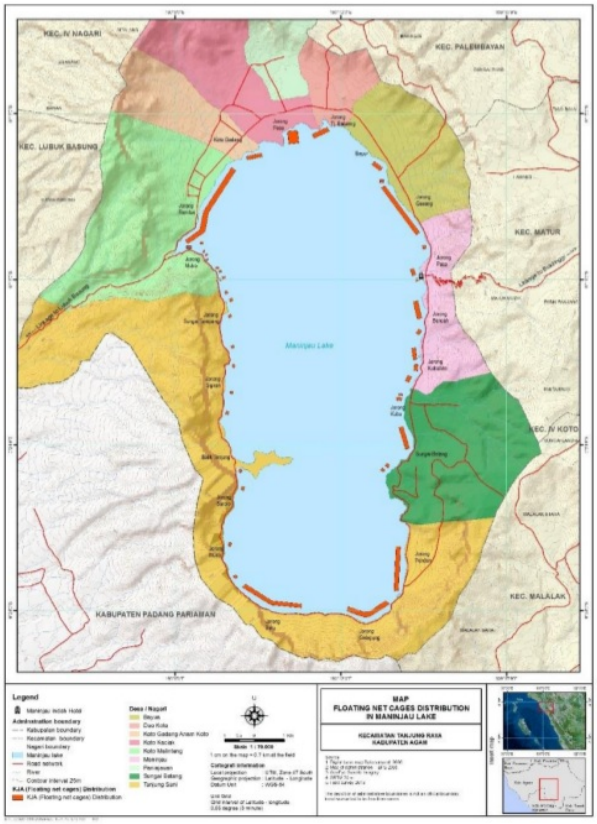

Figure 1. Map of study area in Maninjau lake of Agam Regency-Indonesia

RESULTS AND DISCUSSIONS

The total of floating net cages

The total of floating net cages from the year 2011 to 2015 at Maninjau lake in the district of Tanjung Raya, Agam Regency (**Table 1**).

Table 1. The total of floating net cages in Maninjau lake (units)

No	Village	2011	2012	2013	2014	2015
1	Maninjau	1531	1,743	1,795	1,843	1,597
2	Bayua	2324	2,349	2,425	2,856	4,178
3	II Koto	816	907	1,050	866	866
4	Koto Kaciek	1013	1,013	1,060	1,260	1,409
5	Koto Gadang	202	202	190	200	200
6	Koto Malintang	2448	3,768	3,850	3,650	3,612
7	Tanjung Sani	5194	4,140	4,000	4,108	5,461
8	Sungai Batang	1472	1,741	1,750	1,797	3,285
	Total	15,000	15,860	16,120	16,580	20,608

Sources : Data in the year 2011- 2014 was secondary data and the year 2015 is the primary data.

If we compared the total floating net cages in the year 2015 with the year 2011-2014, the unit was increased in every year. The increased of floating net cages has positive impact on fish farmers, fish feed traders, fish sales and other labor. According to (Nasution et al, 2011; Syandri et al., 2015a), business of tilapia and carp cultured on the floating net cages in Maninjau lake have positive impact to increase society income in the district of Tanjung Raya, Agam Regency. Meanwhile, that activity have negative impact on the water quality parameter (Henny, 2009; Syandri et al., 2014a; Syandri et al., 2015a; Syandri et al., 2016).

The aquaculture area around floating net cages in Maninjau lake still dominant in littoral area with distance 25 to 100 meter from the edge of the lake. Floating net cages was placed on water depth between 10 to 50 meter. The aquaculture area of floating net cages in *Sungai Batang*, *Tanjung Sani*, *Bayur*, and *Koto Kaciek* village are presented in **Figure 2,3,4,5**, respectively.

The aquaculture areas which are used for 20,608 units of floating net cages are 113.7 hectares. Meanwhile, based on the size of fish, stocking density and oxygen used for aquaculture, the needed ideal area is 1416,04 hectares (**Table 2**).

Table 2. The total floating net cages, aquaculture area in the field and ideal aquaculture area

Village	Floating net cages (units)	Aquaculture area in the field (hectare)	Ideal aquaculture area (hectare)
Maninjau	1,597	11.98	109.73
Bayur	4,178	31.34	287.08
II Koto	866	6.49	59.50
Koto Kaciek	1,409	10.57	96.82
Koto Gadang VI Koto	200	1.60	13.75
Koto Malintang	3,612	27.09	248.20
Tanjung Sani	5,461	40.95	375.24
Sungai Batang	3,285	24.63	225.72
Total	20,608	113.7	1,416.04

Source: Primary survey data, October 2015.

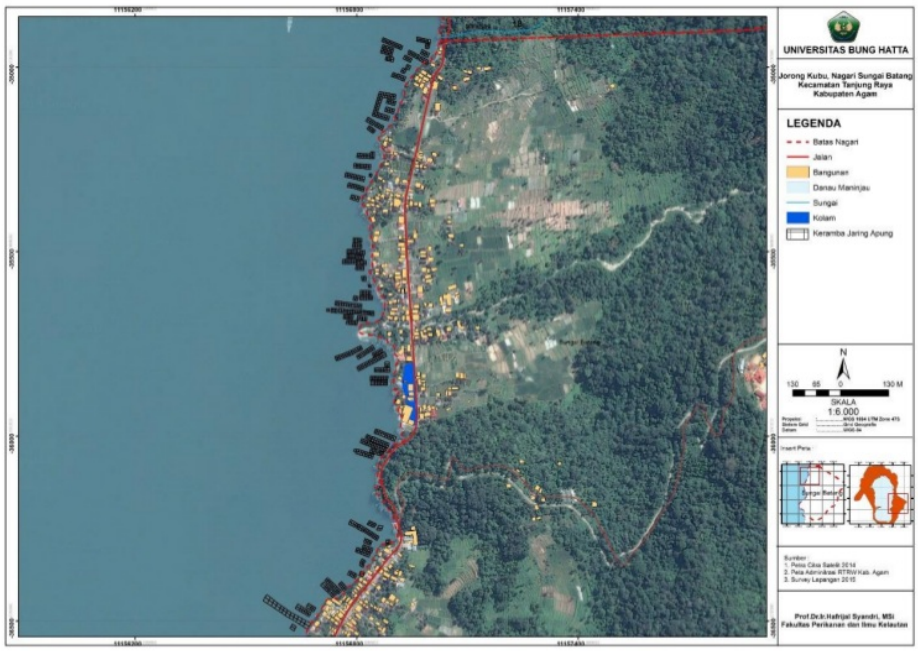

Figure 2. The aquaculture area of floating net cages in *Sungai Batang* village

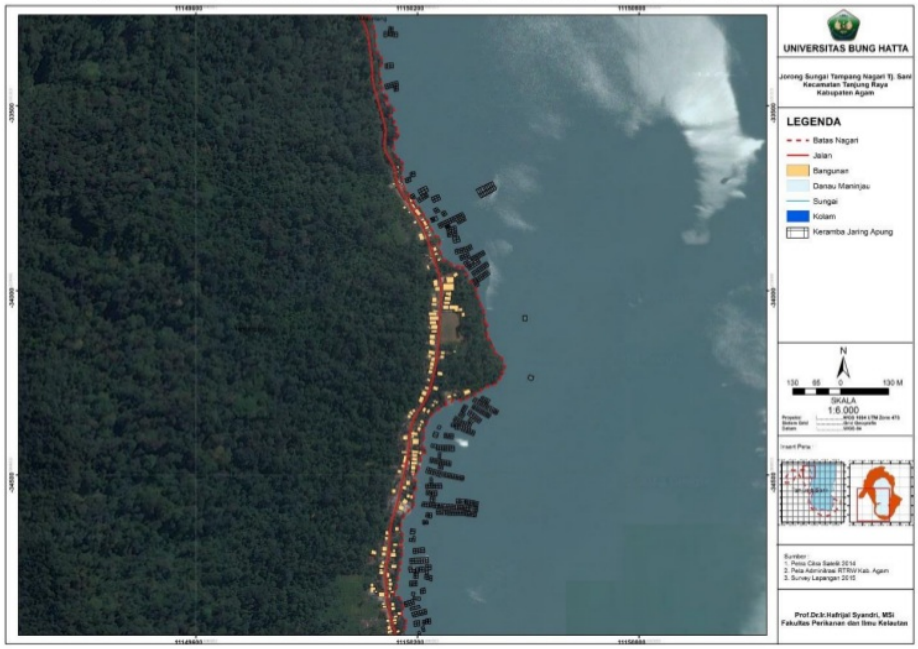

Figure 3. The aquaculture area of floating net cages in *Tanjung Sani* Village

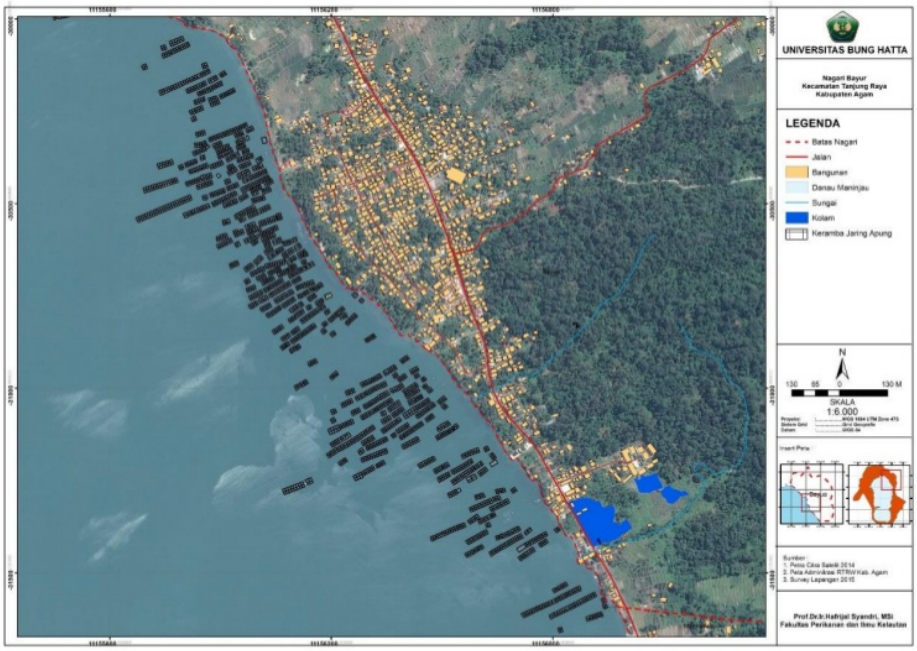

Figure 4. The aquaculture area of floating net cages in *Bayur* Village

Figure 5. The aquaculture area of floating net cages in *Koto Kaciek* Village

Water quality parameters in the floating net cages

The results on the physico-chemical parameters of the water samples from the four sampling sites on the fish farm in Maninjau lake are presented in **Table 3**. The average water transparancy in all sampling site varied between 1.91 m and 1.99 m. The temperature showed that strong fluctuations over the study periode (**Table 3**), especially in the *Bayur* site (26-30°C). Throughout the experiment, the amount of

pH, ammonia, nitrite, total phosphorous and dissloved oxygen in Maninjau lake did not showed significantly different between sampling site ($p > 0.05$). The levels of pH varied from 7.29 to 8.10, with the higher means for the dominant of floating net cages (site C and D) (**Table 3**). The ammonia content varied from 0.35 to 0.65 mg/L, with higher means for the site A. The nitrite content varied from 0.210 to 0.254 mg/L, with similar means for all sites. The total phosphorus content ranged from 0.32 to 0.80 mg/L, and the highest concentrations refer to Sungai Tampang, due to many activities around floting net cages. Dissolved oxygen content was slightly varied between sampling sites, with average values between 6.14 and 6.80 mg/L (**Table 3**). The water quality of floating net cages was directly influences the productivity and sanity of fish (Henny, 2009; Syandri et al., 2015a; Syandri et al., 2016). According to Asir and Pulatsu (2008), intensive aquacultural activity causes release the organic waste and soluble inorganic nutrients, such as nitrogen and phosphorus content, which can cause or accelerate eutrophication in natural aquatic systems. Nutrient release (especially nitrogen and phosphorus) consists of dissolved and particulate fraction. The differences water quality parameters is not only between species, but also within species, depend on feeds employed, feeding regimes, culture systems, productivity, sanity of the fish, and environmental parameters of the local area (Gorlach-Lira, 2013; Junaidi et al., 2014; Syandri et al., 2015a; Syandri et al., 2016).

Table 3. Water quality parameters in floating net cages

	Site A	Site B	Site C	Site D
		Water transparancy (m)		
Mean	1.96	1.98	1.99	1.91
Standart deviation	0.14	0.07	0.10	0.10
Median	1.85	1.98	2.01	1.94
Min-Max	1.80-2.10	1.90-2.08	1.85-2.10	1.90-2.00
		Temperature (^{0}C)		
Mean	27.75	28.5	28.25	28.5.
Standart deviation	1.25	1.29	1.70	1.29
Median	28.5	28.5	28.5	28.5
Min-Max	26.0-29.0	27-30	26-30	27-30
		pH		
Mean	7.72	7.67	7.95	7.86
Standart deviation	0.35	0.33	0.23	0.16
Median	7.59	7.70	7.95	7.92
Min-Max	7.29-8.10	7.30-8.0	7.70-8.20	7.70-8.10
		Ammonia (mg/L)		
Mean	0.59	0.41	0.37	0.46
Standart deviation	0.06	0.03	0.02	0.05
Median	0.60	0.41	0.375	0.465
Min-Max	0.50-0.65	0.38-0.45	0.35-0.41	0.40-0.51
		Nitrite (mg/L)		
Mean	0.167	0.144	0.232	0.165
Standart deviation	0.017	0.044	0.018	0.047
Median	0.165	0.126	0.233	0.175
Min-Max	0.148-0.190	0.144-0.210	0.210-0.254	0.100-0.210
		Total phosphorus (mg/L)		
Mean	0.565	0.716	0.485	0.392
Standart deviation	0.031	0.111	0.050	0.056
Median	0.540	0.705	0.475	0.400
Min-Max	0.53-0.60	0.59-0.80	0.44-0.55	0.32-0.45
		Dissolved Oxygen (mg/L)		
Mean	6.307	6.375	6.140	6.805
Standart deviation	0.617	0.302	0.384	0.308
Median	6.41	6.355	5.985	6.66
Min-Max	5.49-6.92	6.07-6.72	5.50-6.45	6.37-7.08

A = Sungai Batang; B = Sungai Tampang; C = Bayur; D = Koto Kaciek

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