Potential area for floating net fishery in Lake Toba

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Abstract. Lake Toba in North Sumatera, Indonesia, is now designated to be a world-class tourism destination. Aside from its infrastructure development, this largest lake in the Southeast Asia needs to be restored, especially its water quality. While an oligotrophic status is required for tourism purposes, several studies showed that Toba is mesotrophic at its best and hyper-eutrophic at its worst. Numerous studies and reports blame floating net fishery (FNF) for water quality decline in Lake Toba and propose limitation for its production. While the central government allowed FNF to be positioned in certain areas according to its depth and distance from the lakeshore, increasing number of FNF means adding more nutrients to the lake and thus may inhibit the lake’s restoration process. Hence, it is important to identify which areas are potential for FNF location to assist the authorities to regulate FNF. This study used SPOT-6, SPOT-7, and Pleiades satellite imagery to locate the position of existing FNF and to analyse the result to identify a potential location for FNF.

1. Introduction

Lake Toba, south-east Asia's largest lake which maximum area and depth extend to 1,124 km² and 508 m respectively [1], has been relatively famous as a tourism destination in North Sumatera, Indonesia. According to the Government Regulation no. 50/2011 on National Tourism Development Master Plan, Lake Toba is one of 88 national tourism strategic areas across Indonesia. Unfortunately, there was a 30.94% decline in total international tourist arrival in Toba from 2012 to 2013 (Presentation from Deputy for Tourism Destination and Industry Development). Despite the situation, Lake Toba was designated to be a world-class tourism destination and was one of ‘10 New Bali’ in late 2015. To achieve such goal, water quality restoration is one of the main strategies. Restoring Lake Toba water quality means changing the lake’s current hypertrophic and eutrophic state [2,3] back to its oligotrophic state [4].

Floating net fisheries (FNF), a means of aquaculture using layers of net submerged in water body supported on the surface by floating barrels and anchored to the lake bed, is often alleged as the main cause of water quality deterioration. FNF was first practiced in Lake Toba in 1986 as a government program to alleviate poverty. According to Fishery and Marine Services data in 2015, the local society own 11,249 units of FNF around Lake Toba, while large corporate such as Aquafarm Nusantara, Ltd. and Suri Tani Pamuka, Ltd. own 457 and 75 units of FNF respectively.

Since the government targeted Lake Toba to be a world-class tourism destination, discourses regarding FNF emerged; whether FNF must be eliminated or sufficiently restricted. According to Presidential Decree No. 81/2014 on a spatial plan for Lake Toba and surrounding area, FNF is prohibited in areas whose depth is shallower than 30 m, and are subject to restriction in several areas whose depth is 30-100 m. Since increasing number of FNF means adding more nutrients to the lake and thus may inhibit the lakes restoration process, the development of FNF must be avoided at all cost.
It is important to identify which areas are potential for FNF location. This paper identifies such areas to assist the authorities in regulating FNF in Lake Toba.

2. Methods
Spatial distribution of FNF potency was acquired by delineating the lake bed morphometry map using ArcGIS 10.1 based on the lake bed morphometry specification in the society's FNF. The Lake Toba bed morphometry was acquired from spatial analysis using ArcMap 10.1 which combined previous bathymetry map with digital elevation model data of Lake Toba from SRTM 30m. The spatial analysis produced 30 m x 30 m sized DEM grid. The DEM map was to be overlaid with FNF distribution map which was resulted from digit on the screen on SPOT-6, SPOT-7, and Pleiades satellite imagery.

FNF distribution map and lake bed morphometry specification map in FNF zone was verified during field observation in March and October 2016. In addition, an interview was also conducted to the FNF farmers regarding the anchor depth of FNF.

3. Results and Discussion
According to interviews with local FNF farmer, the average depth of anchor for private owned FNF was 62 m with deviation standard 37 m. Exactly 11,417 units of FNF were established in Lake Toba in 2016 (Figure 1) and most of them were established in the littoral zone. These FNF can be distinguished into 33 zones which were distributed in 6 districts: 14 zones in Simalungun district (I.1-I.14), 6 zones in Toba Samosir district (II.1-II.6), 1 zone in Humbang Hasundutan (IV.1), 8 zones in Samosir district (V.1-V.8), 2 zones in Dairi district (VI.1 and VI.2), and 2 zones in Karo district (VII.1 and VII.2).

Most FNF (68.22%) are established in Simalungun district (Figure 2, left), especially in zone I.4 or Haranggaol Horizon subdistrict (53.2%, Figure 2, right). According to the field observation and data from Aquafarm Nusantara Ltd. (2014), FNF in zone I.12 (2.9%), II.13 (0.04%), I.14 (9.10%), II.2 (0.66%), II.3 (1.46%), V.5 (0.71%), V.6 (0.71%) dan V.7 (0.06%) belongs to Aquafarm Nusantara,
Lltd. FNF in zone I.10 (1.36%) belongs to Suri Tani Pamuka, Ltd. The local society owns 84.35% of FNF in Lake Toba.

Figure 2. Percentage of existing FNF number in each district (left) and each zone (right).

According to the North Sumatera Agency of Environmental Impact Management (BAPEDALDA) survey in 2007, the number of FNF in Lake Toba was 4,922 units. A year later, Fishery and Marine Services of North Sumatera announced that FNF number in Lake Toba had become 5,232 units, which means that FNF number had increased up to 6.3% within one year. Compared to identification result in this paper, the number of FNF owned by the society increased 14.3% annually.

BAPEDALDA survey in 2007 showed that society's FNF was distributed in 51 zones. According to our identification, only 33 zones were occupied by society's FNF, which means that there was a decrease in zone number of society's FNF at around 4.1% annually. The decrease was seemingly due to unions of increasing number of adjacent society's FNF. This means that society's FNF became widely distributed.

Identification result of lake depth and lake bed-slope is shown in Figure 3. According to the result of 30 m x 30 m grid used in this research, Lake Toba's area and volume are 112,905.18 Ha, and 257,818,449,600 m³ on 905 m above mean sea level, respectively. Since the difference between this result and the previous result from [1] is less than 5%, segmentation using 30 m x 30 m in this research is considerably representing Lake Toba's dimension.

Figure 3. Distribution of lake depth in 30 m x 30 m grid (left) and lake bed-slope (right)
Around 25% of the lake's area was less than 100 m deep (Figure 4, left), and those areas were in the littoral zone (Figure 3, left), while those which were deeper than 100 m lie in the central part of the lake (Figure 3, left). Approximately 90% of the lake bed-slope is less than 15° (Figure 4, right) and this area lies in the central part of the lake, while littoral zone is mostly steeper than 15° (Figure 3, right).

Figure 4. Histogram of the area and percent of accumulative per depth (left) and bed slope (right).

Overlaying Figure 1 with Figure 3 gives the information on average FNF density per grid (Figure 5). The average of FNF density was 45 units/grid, while the highest and the lowest values of it were obtained in zone I.4 and zone I.9 which were 119.4 units/grid and 14 units/grid, respectively. FNF density per grid is influencing eutrophication which could lead to massive fish death in FNF in Lake Toba [5]. According to data From Research Institute for Fisheries Enhancement, there was a massive fish death in zone I.4 in May 2016 [6].

Figure 5. Average FNF density in each zone in Lake Toba

Overlaying Figure 1 and 3 also gives information on FNF distribution according to the depth of its location and the lake bed-slope (Figure 6). The result showed that 90% of the total FNF occupies areas that have a depth of fewer than 100 m and lake bed-slope less than 25°. Since the number of society's FNF was 84.53%, according to Figure 6, these FNF were located in areas that have a depth less than 80 m and bed slope less than 20°. The average depth of society's FNF area was 50 m (standard deviation of 45 m). Since this value did not differ significantly with interview result, the result of map identification can be considered correct.
Figure 6. FNF distribution according to depth of area (left) and lake bed-slope (right). Black vertical bars denote the number of FNF; the grey curves denote the FNF number accumulation.

Based on these results, potential areas for society's FNF can be identified (Figure 7). These potential areas located mostly in Samosir district (13,129.28 Ha). Potential areas in Simalungun, Toba Samosir, Tapanuli Utara, Humbang Hasundutan, Dairi, and Karo are 2775.35 Ha, 7248.33 Ha, 1427.96 Ha, 378.34 Ha, 1252.95 Ha, and 277.95 Ha, respectively.

Figure 7. Map of FNF potential area in Lake Toba.

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References

[1] Lukman, Ridwansyah I 2010 Kajian morfometri dan beberapa parameter stratifikasi perairan Danau Toba Limnotek 17(2) 158–70

[2] Purnomo K, Kartamihardja E S, Wijopriono, Fahmi Z, Wahyono M M, Faizah R and Sarnita A S 2005 Riset Pemetaan Kapasitas Sumberdaya Ikan dan Lingkungan di Danau Toba, Sumatera Utara (Pusat Riset Perikanan Tangkap BRKP-DKP) p 31

[3] Nomosatryo S, Lukman 2012 Klasifikasi trofik Danau Toba Limnotek 19(1) 13–21

[4] Lehmusluoto P, Machbub B, Terangna N, Rusniputro S, Achmad F, Boer L, Brahmaana S S, Priadi B, Setiadjii B, Sayuman O and Margana A 1997 Expedition Indodanau Technical Report: National Inventory of the Major Lakes and Reservoir in Indonesia (Helsinki: General Limnology) p 72

[5] Harsono E 2016 Model eutrofikasi 2-dimensi berlapis untuk optimalisasi lokasi zona budidaya ikan karamba jaring apung (KJA) di Waduk Jatiluhur Jurnal Biologi Indonesia 12(1) 277–89

[6] Research Institute for Fisheries Enhancement 2016 (http://bp2ksi.litbang.kkp.go.id/index.php/8-halaman-depan/49-kematian-ikan-secara-massal-di-danau-toba-penyebab-dan-antisipasinya)