O6-14

Long-Term Monitoring of Lake Surface Area Change in Indonesia from Global Surface Water Data

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Keywords: Lake monitoring, Surface Area changes, Landsat, Google Earth Engine

ABSTRACT

Currently, the conditions of lakes in Indonesia have changed in terms of water surface area, especially for the main lake (larger than 10 km^2). A manual method to extract the water surface area for long-term monitoring requires time, is costly and requires a lot of resources. Nowadays, with the development of digital image processing, the manual method is no longer effective and efficient. In this study, Global Surface Water provided by Google Earth Engine combined with simple polygon masking was used to identify lakes larger than 10 km^2. Results from this study show that total water surface area has increased for inland water body in Indonesia from the year 1988 until 2015. Some because of new water body formed from the former mine sites. In the other hand, some lakes decreased their water surface area. Lake Limboto, in the north side of Sulawesi Island, decreased by 12.8 km^2 from 2001 until 2014. The objectives of this study are to obtain long-term monitoring water surface area for all main lakes so that it can be used to update lake information in Indonesia.

1. INTRODUCTION

Indonesia consists of 17,504 islands with 1,905 million km² land area. With this separated land and a wide area, effective and efficient ways to monitor all resources are needed. Accurate maps of surface water are essential for many environmental applications, such as lakes monitoring. The assessment of the role of lakes requires good estimates of the areal extent and shape of water bodies. Upscaling to large regions, except in limited areas where precise maps are available, so far depends on statistical estimates of the number and size of lakes [1].

Precise estimation of surface water using satellite imagery remains a challenging task due to the sensor limitations, complex land cover, topography, and atmospheric conditions [2]. There are many lakes in Indonesia, some are facing drought, water loss, and decreasing water surface area.

Calculation and monitoring temporal change for all lakes in Indonesia is very expensive if done manually. In the other hand, using remote sensing satellite data is time-consuming to identify the main lakes by manual digitation. Especially for a large number of lakes and small size water surface area. Join Research Center of European Commission already provide Global Water Surface [3] through Google Earth Engine data catalog. The problem is that the water body information is mixed for all types such as lake, reservoir, river and coastal object. Therefore the objectives of this study are: separation of all waterbody types (lake, reservoir, river and coastal object) from Global Surface Water data, calculate water surface area and count the number of all lakes larger than 10 km^2. In addition monitoring spatial and temporal change for all lakes in Indonesia.

2. METHOD

The research area of this study is Indonesia inland water surface. Global Water Surface was used as the main input to identify main lakes in Indonesia. This data was extracted and processed using Landsat TM, ETM and OLI from 1982 until 2015. There is much information provided by Global Water Surface, yearly water history which consists of permanent water and seasonal water.

High-resolution satellite data from Google Maps and Google Earth were used for validation of all the lakes identified. River and coastal object masking were built to separate from other water bodies. All processing was done by Python arcpy.

3. RESULTS

The permanent water surface was used as main data input in the processing to identify all lakes larger than 10 km^2. Years 1984 – 1987, 1992 - 1993 and1998 were not included in the processing because the water surface did not cover all inland Indonesia area. River and coastal object were separated from permanent water to reduce the waterbody types. Some river in Kalimantan island and Irian Jaya island have big water surface area. Many pond

and paddy fields are spread along north coast Java island.

Figure 1 shows processing results from water surface area after separating into waterbody types. Water surface with seasonal data is very dynamic, and in this data, it is also included seasonal water body for all types. If we see the differences with permanent water, the pattern is not so different. The differences occur very prominently after the separation of the river and coastal water bodies. Although small, the water surface area seems to increase significantly from 1988 until 2015.

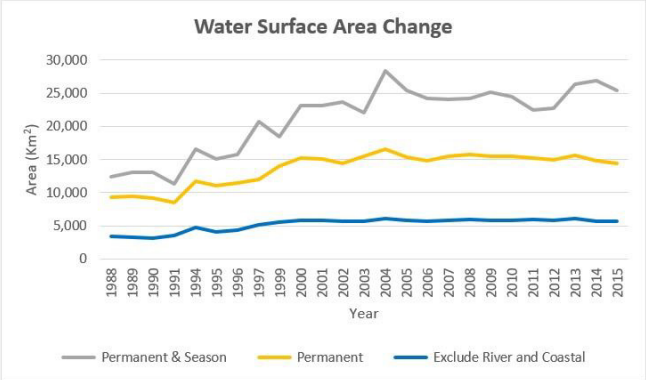

Fig. 1 Total water surface area change over years

48 lakes were found with an area larger than 10 km^2 (Table 1). Most of the lakes are on the Irian Jaya island. Compared to the number of lakes from [4] in [5], there is a difference in the number of lakes on the Sumatera, Kalimantan, Nusa Tenggara, and Mollucas Islands.

Table 1 Number of main lakes

Location/Island	Lake >10 km^2
Sumatera	9
Java and Bali	1
Kalimantan	8
Sulawesi	9
Nusa Tenggara (West and East)	2
Irian Jaya	16
Mollucas	3
Total	48

4. DISCUSSION

Even though the total water surface area is increasing, some lakes are decreasing their water surface area. One of the cases is happening in Lake Limboto, reduce by 12.8 km^2 from 2001 to 2014 (Table 2). This value was calculated from permanent water only. As shown in figure 2, seasonal water surface area changes dynamically, but still in the range between 20 – 45 km^2. Water surface area of Lake Limboto changes every two to four years decreasing and increasing. But with a small area, significantly reduce for each year. With this temporal change of surface area, we can monitor all changes happening for all main lake in Indonesia.

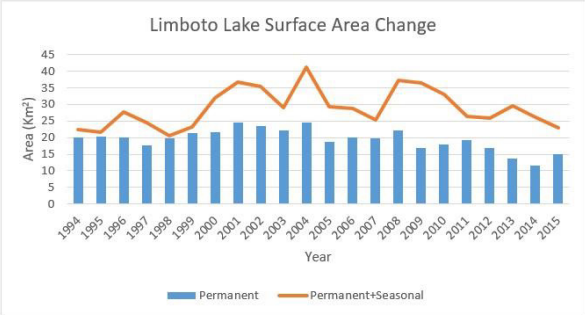

Fig. 2 Water surface area change of Limboto Lake

Table 2 Limboto Lake water surface area decrease

Year	Area (km^2)	Change (km^2)
2001	24.44	-2.25
2003	22.19	-2.12
2006	20.07	-0.15
2007	19.92	-1.9
2010	18.02	-1.12
2012	16.9	-3.31
2013	13.59	-1.94
2014	11.65	-12.8

5. CONCLUSION

Over the year 1988 until 2015, permanent water increased significantly even though in a small value. In the last year of this study, 2015, it was found 48 main lakes spread over Indonesian Islands. In the opposite side, some lakes face water loss and decreasing water surface area (e.g: Lake Limboto). Lake Limboto from 2001 until 2014 already lost 12.8 km^2 of its water surface area. New water surface formed from the former mine sites. These results are expected to be additional information to save all lakes decreasing its water surface area in Indonesia.

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