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MONITORING THE SURFACE AREA OF THE JATIGEDE RESERVOIR USING SATELLITE IMAGE SERIES DATA

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ABSTRACT

Jatigede reservoir's main functions are power plants and sources of irrigation for agriculture. The reservoir has been operating since 2016 with ± 4900 ha as the total area. Monitoring the surface area of the Jatigede reservoir using satellite imagery provides spatial and temporal information on the reservoir waters in the period 2017 – 2020. Using Sentinel 2 satellite imagery, the Normalized Difference Water Index (NDWI) method is capable to detect the changes in the water surface of the Jatigede. The Jatigede reservoir area from 2017 to 2020 average is 2989.11 ha, the lowest was 1901.88 ha in November 2019 and the highest was 4064.69 ha in April 2020. The low tide period of the Jatigede reservoir occurred from August 2018 to January 2019, and August 2019 – January 2020 raise the drawdowns area around the waters of the Jatigede reservoir, in addition, the utilization of waters area for floating net cage needs to be well-thought-out and customized with the function of the Jatigede reservoir.

INTRODUCTION

Reservoirs are inundated waters on land that are created by humans by damming rivers [1]. Reservoirs were built for various purposes, including hydroelectric power generation, agricultural irrigation [2;3], moreover, the reservoir is also used for aquaculture in floating net cages [4], tourism, and sports [5;6], and floating solar panels [7;8].

Various activities in the reservoir will result in competition in the use of reservoirs, especially the use of reservoir water surfaces. Competition in the use of space is a foundation of problems, leading to declining water quality and social problems between parties who use the water territory [9;10]. One of the efforts to prevent conflicts over water area utilization is a necessity to periodic monitoring of activities on waters area on reservoirs and surroundings the reservoirs [11].

This study aims to monitor the surface area of the Jatigede reservoir, the new reservoir operating in 2016, with low activities in the reservoir waters area. Monitoring is performed by measuring the water surface on the reservoir using satellite imagery [12], and a free access Sentinel-2 L2A is selected for this study. This monitoring will provide information on the water surface area of the Jatigede reservoir spatially and temporally from 2017 – 2020.

MATERIAL AND METHODS

Study Site

Jatigede Reservoir is located in the southeast part of Sumedang Regency, West Java Province (Figure 1). Jatigede Reservoir with an area of ± 4900 ha, was built by damming the Cimanuk River. The inundation area was submerged the agricultural land in 28 villages in Darmaraja District, Wado District, and Jatigede District. The reservoir development displaces more than 30,000 inhabitants from 10,000 families. Jatigede was built to contribute 110 Megawatt (MW) Hydroelectric Power Plant (PLTA) and functioned as irrigation for 90,000 hectares of productive agricultural land in Cirebon Regency, Indramayu Regency, and Majalengka Regency.

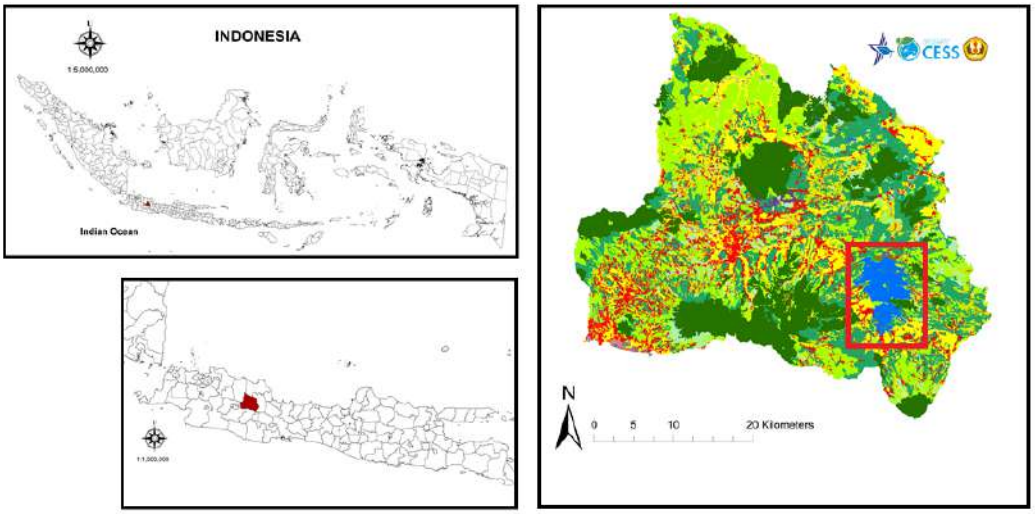

Figure 1. Jatigede Reservoir (red box) Sumedang Regency, West Java

Data Analysis

1. Collecting Remote Sensing Data

Sentinel 2 is a medium-resolution satellite image, can be accessed easily and free. Sentinel 2 image data can be downloaded directly on the https://services.sentinel-hub.com/ page, selected specifically the research location or drawing the area of interest. Satellite images are available in various visual displays according to research needs, as well as a choice of bands (wavelength) according to analysis needs. Measurement of the surface area of the reservoir surfaces water is carried out using NDWI (Normalized Difference Water Index) which is used to determine the area based on the water index on the earth's surface [13].

Temporal data selection was conducted by selecting monthly data. Sentinel-2's temporal resolution is 10 days, however, image selection must be done carefully due to cloud cover in certain areas. Time efficiency in data selection can be done by setting the presentation of cloud cover at that location, in this study the satellite imagery with less than 10% cloud cover of the study area is used.

The satellite images used are images from January 2017 to December 2020, 40 satellite images are used from a potential of 48 satellite images or 1 image per month of the study period.

2. Identification and Measuring Water Surface

Identification and measurement of reservoir surface area conducted in the following steps:

a. NDWI (Normalized Difference Water Index)

Sentinel satellite images used for the NDWI equation are Band-03 and Band-08 using the equation:

$$NDWI = (B03 - B08) \div (B03 + B08)$$

B03 = Green (Central Wavelenghth 560 nm, 10 m spatial resolution)
B08 = Visible and Near Infrared/VNIR (Central Wavelenghth 842 nm, 10 m spatial resolution) [13;14]
.

b. Classification and Surface Measurements

Classification using Unsupervised Isocluster [14;15] in ArcGIS software, categorized into 4 classes and reclassified into 2 classes, Water and Non-Water, and later on, the water surface area is measured.

The satellite imagery data analysis using ArcGIS at the Center for Environment and Sustainability Science (CESS) Universitas Padjadjaran.

RESULT AND DISCUSSION

Spatial Analysis of Jatigede Reservoir Water Surface

The identification of spatially and temporally the water surface of the Jatigede reservoir was achieved using Sentinel 2 satellite imagery. Analyze the temporal data from January 2017 to December 2020, the visualization of the water surface of the Jatigede reservoir can be seen well, however, there are several periods where cloud cover covers more than 10 % of reservoir waters surfaces in January and November 2017, January, February, July and November 2018, December 2019, and February and December 2020 (Figures 2, 3, 4 and 5).

Visually, the water surface in 2017 was relatively constant, while in 2018 there was a decrease in surface area in the period August, September, October, and December, until January 2019, then was continued in the period August, September, October, and November 2019 and January 2020 (Fig. 2, 3, 4 and 5).

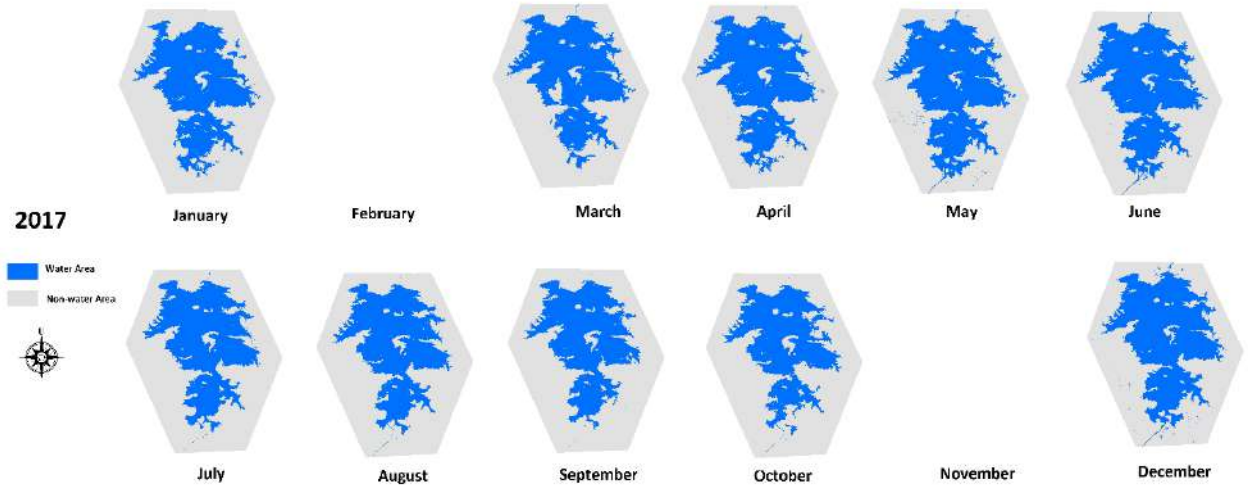

Fig. 2. Visualization Jatigede Reservoir Water Surface January - December 2017

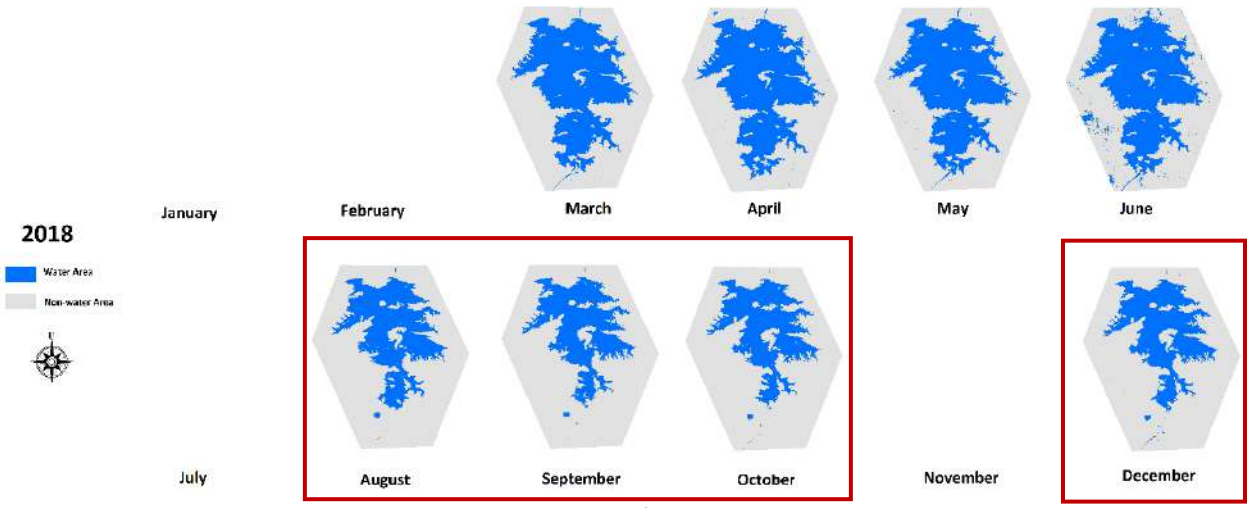

Fig. 3. Visualization Jatigede Reservoir Water Surface January - December 2018

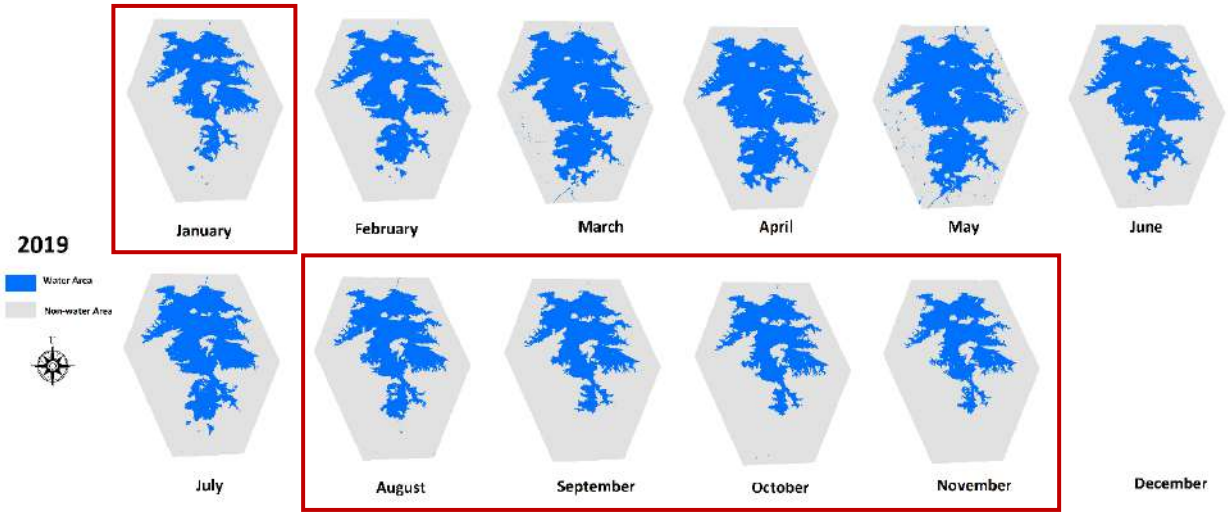

Fig. 4. Visualization Jatigede Reservoir Water Surface January - December 2019

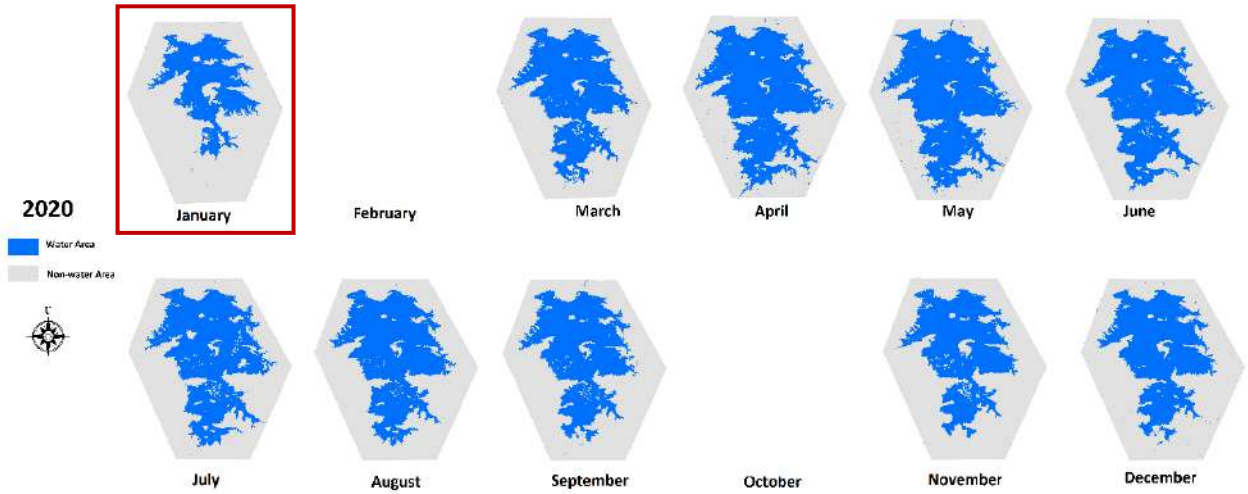

Figure 5. Visualization Jatigede Reservoir Water Surface January - December 2020

The decrease in the surface area of the Jatigede Reservoir at a certain period is found in the southern

(bottom) waters of the reservoir, towards the northeast (bottom right) and southwest (bottom left), and emerged the drawdown area. Administratively, the emerge of drawdown area is located in Karangpakuan Village, Sukaratu Village, Jatibungur Village, Sukamenak Village, and Cisaat Village, Ciranggem Village District (southwest of the reservoir), and Mekarasih in Jatigede District (northeast of the reservoir).

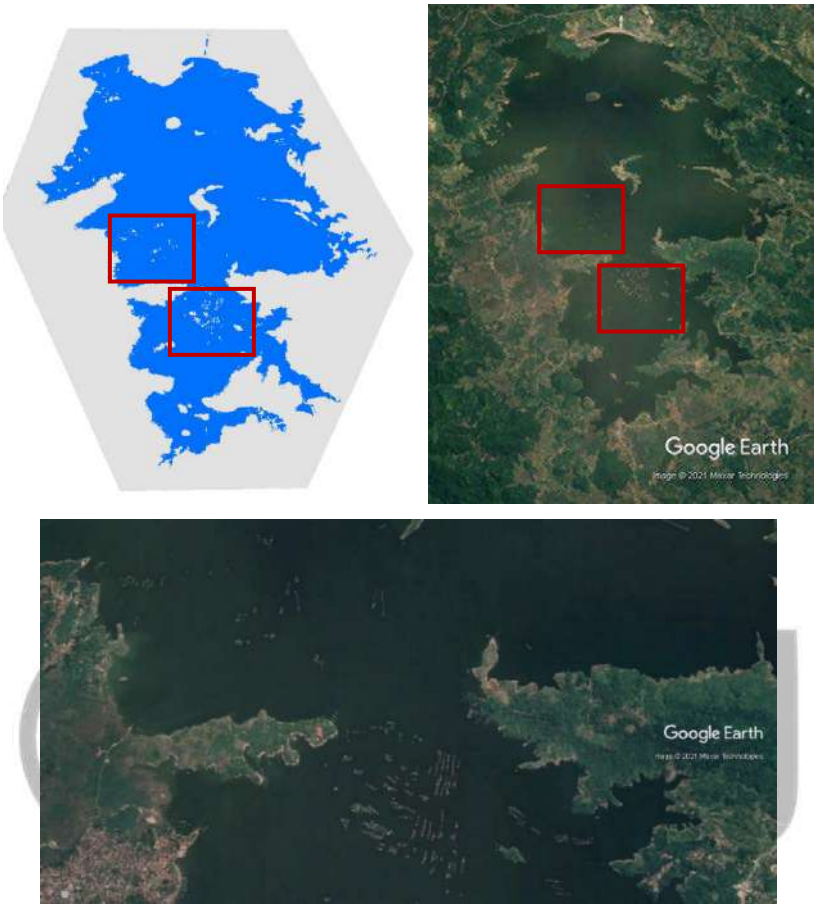

Fig. 6. Floating Net Cages on Jatigede Reservoir

Moreover, the identification of water surface area on the Jatigede reservoir also reveals the utilization of water surfaces for aquaculture in floating net cages indicated in the red box (Fig. 6). Visualization of floating net cage activity confirmed on Google Earth images (Fig. 6).

Temporal Analysis of Jatigede Reservoir Water Surface

Since the first inundation of the Jatigede reservoir area in 2016, the Jatigede reservoir water surface area has fluctuated in the 2017 – 2020 period. The Jatigede reservoir area from 2017 to 2020 has an average of 2989.11 ha, the lowest was 1901.88 ha in November 2019 and the highest was 4064.69 ha in April 2020 (Fig. 7). The water surface annual periods of the Jatigede reservoir area dynamically (Figure 7) as follows, in the 2017 period the average was 3145.39 ha, the lowest was 2700.11 ha (October) and the highest was 3682.45 ha (June); the 2018 period averaged 2875.42ha, the lowest was 2112.97 ha (October) and the highest was 3682.45 ha (June); the 2019 period averaged 2722.93 ha, the lowest was 1901.88 ha (November) and the highest was 3751.26 ha (May); in the 2020 period the average was 3087.89 ha, the lowest was 2111.48 (January) and the highest was 4064.69 ha (April).

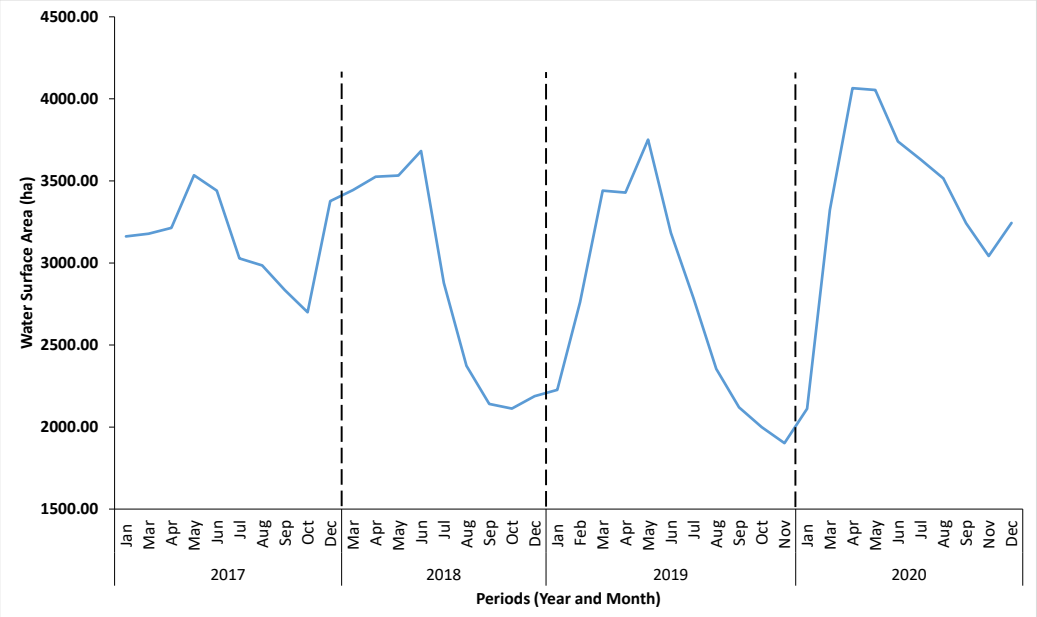

Fig. 7. Jatigede Reservoir Water Surface Temporal Periods 2017 - 2020

In addition to the annual period, it can be seen that the Jatigede Reservoir has a fairly low receding period, starting from August 2018 to January 2019, and August 2019 – January 2020 (Figure 7). This period rises the drawdown area surroundings the waters of the Jatigede Reservoir.

Jatigede Reservoir Utilization

Jatigede reservoir waters in the period 2017 to 2020 are spatially and temporally dynamic. The reservoir area before inundation was an agricultural area, therefore in a certain period (July - December) has the potential to be temporarily reused as an agricultural cultivation business with agricultural commodities that have a short growing period [16;17].

Utilization of the waters of the Jatigede Reservoir for aquaculture with the floating net cage system has been practiced in several locations, however, up today this activity has not obtained a permit as an activity which is allowed in the Jatigede Reservoir (RTRW Sumedang Regency 2018). The management of the Jatigede Reservoir needs to be established with the existence of zoning in the Jatigede Reservoir, this is to ensure various activities for the use of waters and aquatic resources in the Jatigede Reservoir. The management plan and strategies are very important to prevent problems and conflicts, learns from several problems in reservoir management in Indonesia [18;9;10].

CONCLUSION

Monitoring the water surface of the Jatigede Reservoir using Sentinel 2 satellite imagery provides information on water areas dynamic in the 2017 - 2020 period, later on, periodically indicate the potential of rising drawdown area around the reservoir area has the potential to be temporarily reused as agricultural cultivation by the community around the reservoir. The study also reveals the aquaculture activities on floating net cages, which must be considered by the Jatigede reservoir management, in order the utilization of water space does not cause problems in the future.

Research using satellite imagery is still constrained by the availability of images in a certain period, furthermore, this research can be developed with more complete parameters to provide more comprehensive input in manage the Jatigede reservoir area.

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