

MONITORING SURFACE WATER DYNAMIC USING CLOUD COMPUTING PLATFORM OF GOOGLE EARTH ENGINE

Fatwa Ramdani¹, Putri Setiani²

¹ Geoinformatics Research Group, Brawijaya University, Indonesia, fatwaramdani@ub.ac.id

² Environmental Engineering, Brawijaya University, Indonesia, psetiani@ub.ac.id

ABSTRACT

Water is important resources and the pattern of water dynamics is needed to be monitored. Cloud computing platform named Google Earth Engine (GEE) has benefited the scientists with a limited computing system to monitor large scale water reservoir in multi-period with large size to monitor any reservoir whole over the world. This study introduced the novel and reproducible series of steps to monitor the surface water dynamics using GEE platform study case Selorejo reservoir located in East Java, Indonesia. This study found that during 2017 and 2018 the surface water condition of Selorejo reservoir is relatively in good condition while in 2019 the surface water experienced dramatic decreased due to long dry seasons. The novel procedure proposed in this study is efficient to be applied in any other large scale reservoir.

Key words: big data, reservoir, water dynamic.

1. INTRODUCTION

Water level is an important indicator in a major water body such as large reservoirs and rivers. Changes in water level condition determine the functionality of the water body, both regarding its service for the natural ecosystem and other services that are related to human activities. Selorejo reservoir, the area of interest in this study, is situated in Malang Regency, East Java, Indonesia. Located about 600 meters above sea level, this reservoir is used for electricity generation with a capacity average of 4.5 MW.

Water levels in reservoirs are mainly influenced by two factors, (1) seasonal variation, and (2) by the operator of a hydropower plant, who discharges water through the turbines or stores water in the reservoir, in a fashion that maximizes profit (Hirsch *et al.*, 2014). Dynamics of water level in a hydropower plant may significantly impact the capacity of electricity generation. A previous study in using Google Earth Engine (GEE) for water environment has been done by Hird *et al.* (2017), where a workflow was developed to predict the probability of wetland occurrence within northeastern Alberta, Canada. The study found that the GEE is effective and efficient to support the Alberta Merged Wetland Inventory.

This study aims to propose novel and reproducible series of steps to monitor the surface water dynamics of reservoir using cloud computing of GEE platform.

2. STUDY AREA

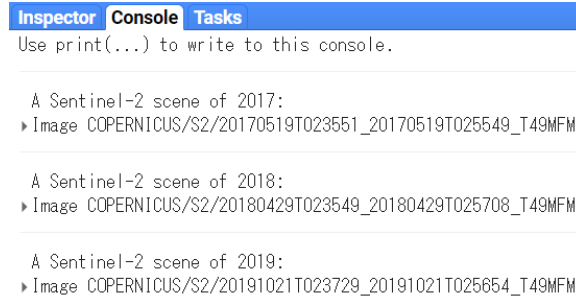
The study area is Selorejo reservoir located in Malang Regency, East Java, Indonesia. Situated between Kelud Mountain, Anjasmoro Mountain, and Kawi Mountain, and in relatively high elevation, approximately 600 meters above sea level, make the cool climate around the reservoir. The Selorejo Hydroelectric Power Plant (PLTA) is located at Pandansari Village, Ngantang District. It was built in 1970 and started operating since July 24, 1973 with a capacity of 4.5 Mega Watt (MW) (ESDM, 2015).

The Selorejo reservoir is used as the source of electric power generation. Electricity generated from the Selorejo hydropower plant sent through a 70 kV transmission network is used to meet the electricity needs of the Malang area (ESDM, 2015). Therefore monitoring the surface water level dynamics is very important for a sustainable energy source.

3. DATA AND METHOD

To access the GEE, the user could enter the URL address, <https://code.earthengine.google.com/>. When using GEE platform user have to import the dataset that will be used in the analysis. In this study, we import the Sentinel-2 MSI Level-1c. Then we define the boundary of the study area. The Selorejo boundary is in shapefile format derived from <http://tanahair.indonesia.go.id/>. To import the shapefile we used “importing Table data” module within the GEE platform. Next step is filtering the dataset, we only use data with the cloud-free condition. The result then

will be printed in the console window as shown in Fig. 1, while Fig.2 summarized the procedures proposed in this study.



```

Inspector Console Tasks
Use print(...) to write to this console.

A Sentinel-2 scene of 2017:
► Image COPERNICUS/S2/20170519T023551_20170519T025549_T49MFM

A Sentinel-2 scene of 2018:
► Image COPERNICUS/S2/20180429T023549_20180429T025708_T49MFM

A Sentinel-2 scene of 2019:
► Image COPERNICUS/S2/20191021T023729_20191021T025654_T49MFM

```

Fig. 1. The console window of GEE platform that shows the printed name of cloud-free datasets

The user then could copy and paste the name in the code as input data for Normalized Difference Water Indices (NDWI) analysis. The Normalized Difference Water Index (NDWI) was first proposed by Gao (1996) to detect vegetation water liquid over Jasper Ridge, California and High Plains in northern Colorado, using AVIRIS dataset (NIR and MIR bands). While McFeeters (1996) proposed the same index name but using Green and NIR band. McFeeters (2013) used NDWI to detect the swimming pools for mosquito abatement in County of Fresno, California.

We also set the true-colour image parameter for better visualization. Next, we define the equation for NDWI calculation and add the result in the main window of GEE. To produce the image of surface water dynamics areas, we employed modified NDWI using equation (1) from Xu (2006) for each period of datasets

$$NDWI = \frac{GREEN - NIR}{GREEN + NIR}, \quad (1)$$

NIR is for Near-infrared band, while GREEN is for the green band of Sentinel-2 optical data. NIR band is represented by Band 8, while the green band is represented by Band 3 of Sentinel-2 optical data. Then we stack together all NDWI of each period into a single visualization of surface water dynamics of Selorejo reservoir. The customized code compiled by the authors that used to create these surface water dynamics visualizations is available in the URL <https://tinyurl.com/y7w3qdv4>. The main window will produce seven different layers as shown in Fig. 3.

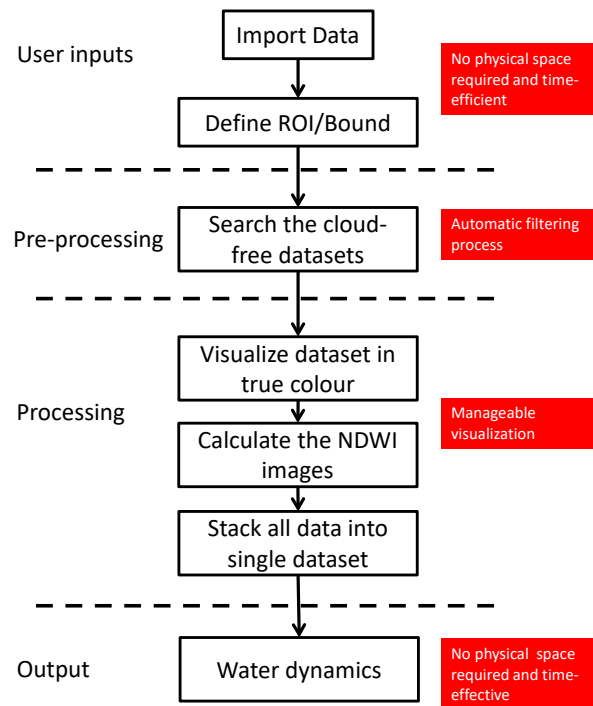


Fig. 2. Flowchart of GEE processing, where the advantages of GEE platform represented in red box

4. RESULT

Fig. 3 shows the result of surface water dynamics based on three different periods of NDWI images. The colorful images represented the changes over the period of analysis. It is clearly seen that the Selorejo reservoir experienced changed amount of water. While Fig. 4 to Fig. 6 showed the NDWI images of each period of analysis.

Furthermore, the NDWI image for each period shows the contrast surface water condition between 2019, 2018, and 2017. Surface water is represented in bright color while the non-water is represented in black color. The reservoir in the year 2019 experienced dramatic changed as shown in Fig. 6 where the image is dominated by black colour.

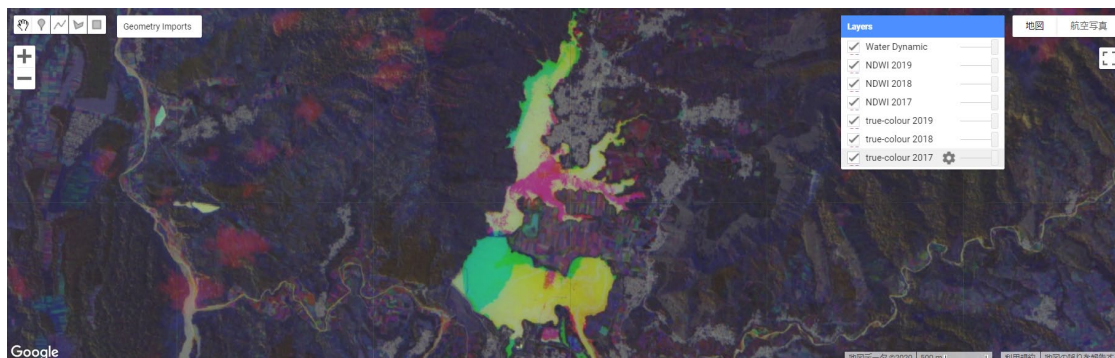


Fig. 3. Surface water dynamic showed in color within the GEE platform (non-water surface in black)

Layer panel in the top right of the main image window is generated with seven different layers to evaluate the result of each period of analysis using the visual method. That is surface water dynamic image, NDWI image of the year 2017, 2018, and 2019, as well as the true-colour image of the year 2017, 2018, and 2019. Transparency scale bar also provided next to layer caption to make visual assessment easier. This series of step that proposed in this study is reproducible and easy to use for any location.

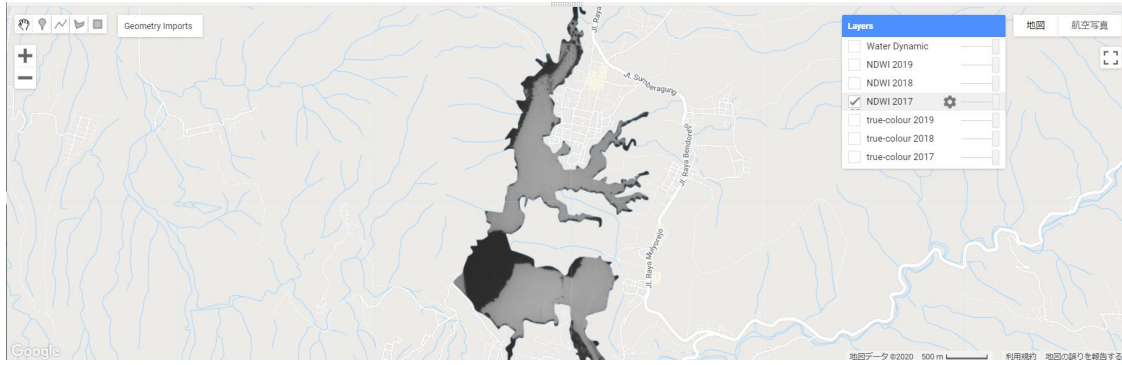


Fig. 4. NDWI image of the year 2017

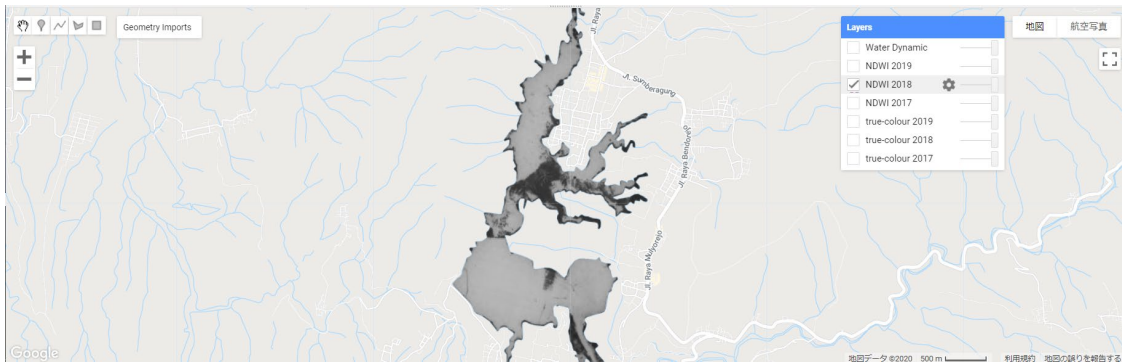


Fig. 5. NDWI image of the year 2018

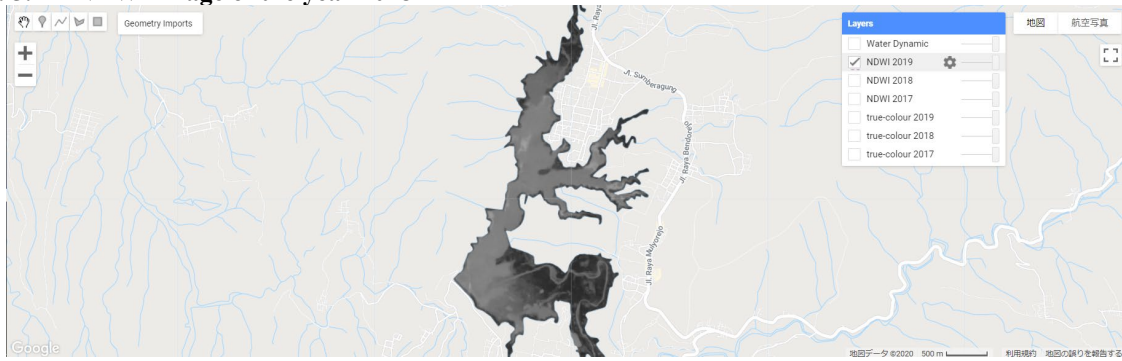


Fig. 6. NDWI image of the year 2019

Histogram of each period also produced and shown in Fig. 7. It is clearly shown that during 2017 and 2018 the surface water condition of Selorjeo reservoir is relatively in good condition while in 2019 the surface water experienced dramatic decreased due to long drought seasons.

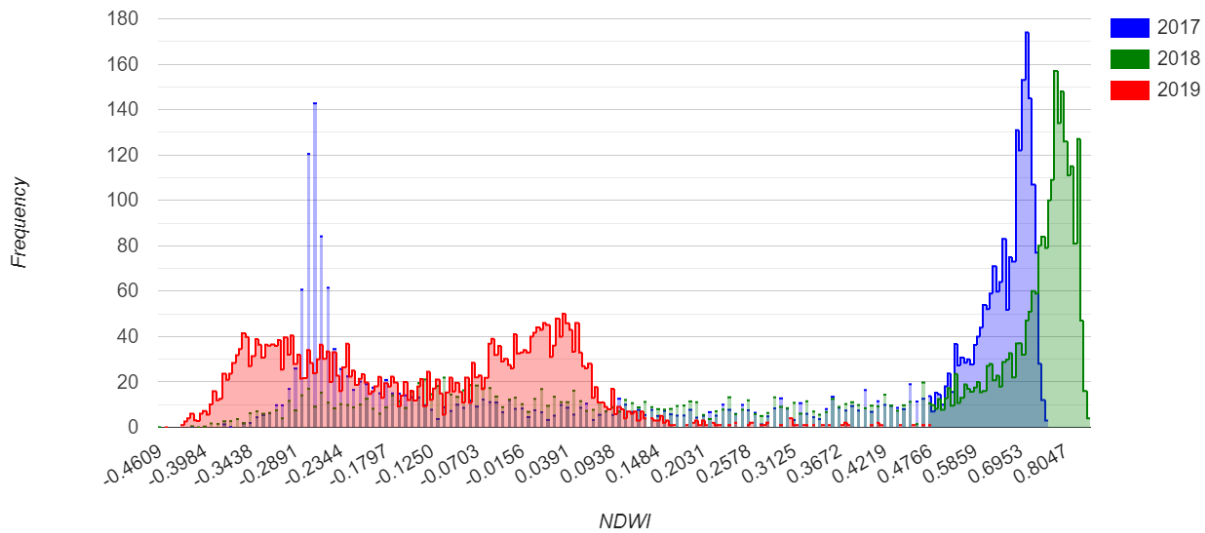


Fig. 7. Histogram of surface water dynamics

To proof the proposed method is efficient and effective to monitor the surface water dynamic, we then applied the proposed method on the largest reservoir in Java Island, Jatiluhur reservoir. Located in Purwakarta, West Java Province, Jatiluhur reservoir covers more than 83 square kilometers of surface water. Figure 8 shows the histogram of Jatiluhur reservoir for three different periods, 2017 to 2019. While Figure 9 shows the surface water dynamic of Jatiluhur reservoir. It is clearly shown that Jatiluhur reservoir also experienced decrease in water capacity in the year 2019, it is consistent with the Selorejo reservoir, since the year 2019 is the lowest year of rainfall and the longest dry season in Java Island. While the year 2017 and 2018 the surface water is relatively stable. The URL to access the Jatiluhur reservoir is available here: <https://tinyurl.com/u3x2qv2>

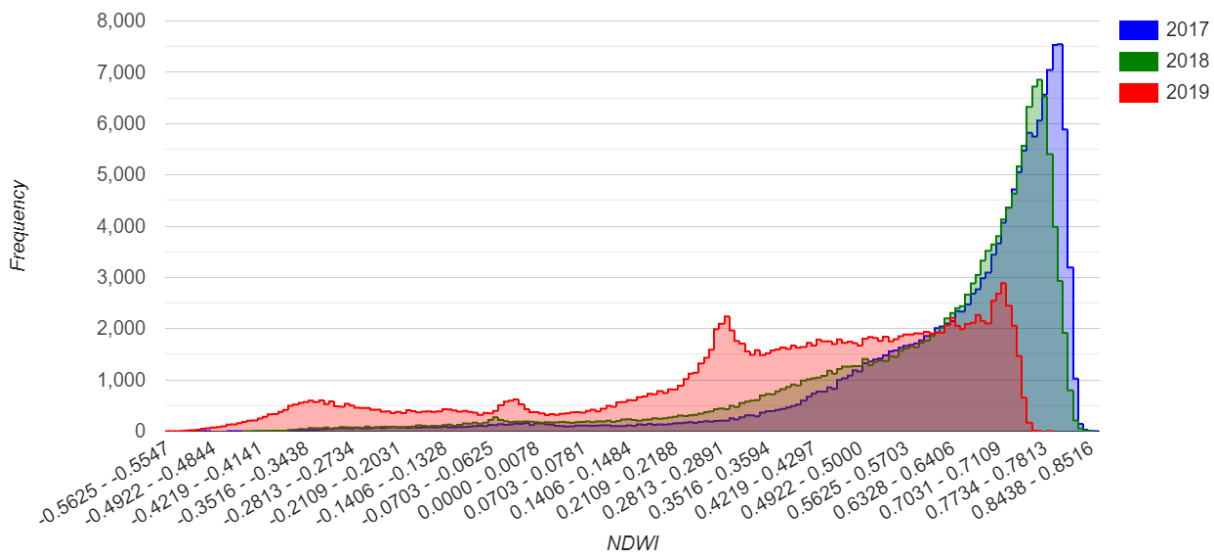


Fig. 8. Histogram of surface water dynamics of Jatiluhur reservoir

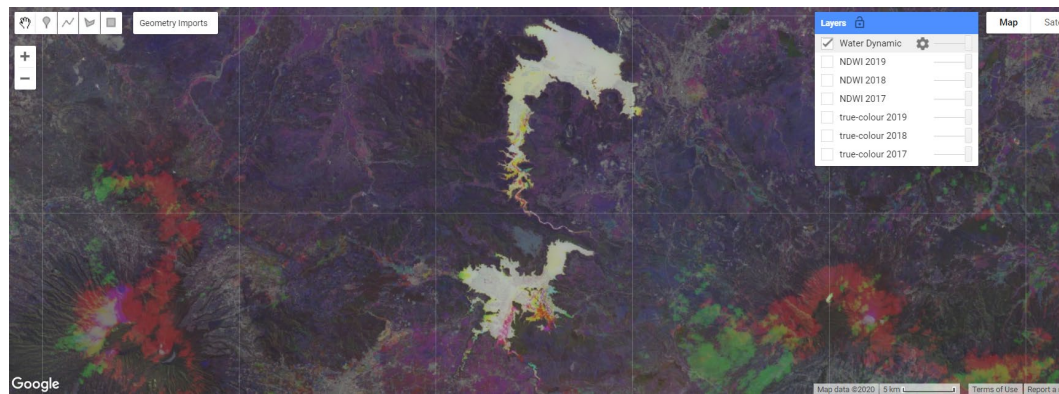


Fig. 9. Surface water dynamic showed in color within the GEE platform (non-water surface in black)

5. CONCLUSIONS

This study concludes that performing geospatial analysis in the GEE platform is the best possible manner with the least waste of time and effort. However, the user needs to have basic knowledge in scripting and map algebra to work with a web-based application such as GEE.

Large-scale series satellite data sets could be analyzed within seconds, this is a huge milestone for web-based geospatial analysis. Especially for monitoring the sustainable energy source like water in a reservoir. Where approximately 100 lines of codes could generate seven different layers for water dynamic monitoring of three different periods.

The series of steps proposed in this study is easy to reproduce and applied in other different for surface water dynamic monitoring. We proof it through applied the proposed method on the largest reservoir in Java Island, and found consistent result.

REFERENCES

- ESDM. (2015). Mengintip PLTA Selorejo. Available at: <http://ebtke.esdm.go.id/post/2015/03/30/819/mengintip.plta.selorejo> (accessed on 29 April 2020)
- Gao, B.C. (1996). NDWI—A Normalized Difference Water Index for Remote Sensing of Vegetation Liquid Water from Space. *Remote Sensing of Environment*, 58, 257–266. [https://doi.org/10.1016/S0034-4257\(96\)00067-3](https://doi.org/10.1016/S0034-4257(96)00067-3)
- Google Earth Engine (GEE). (2019). Histogram. Available at https://developers.google.com/earth-engine/charts_image_histogram
- Hird, J.N., DeLancey, E.R., McDermid, G.J., and Kariyeva, J. (2017). Google earth engine, open-access satellite data, and machine learning in support of large-area probabilistic wetland mapping. *Remote Sensing*, 9(12), 1–27. <https://doi.org/10.3390/rs9121315>
- Hirsch, P.E., Schillinger, S., Weigt, H., and Burkhardt-Holm, P. (2014). A hydro-economic model for water level fluctuations: Combining limnology with economics for sustainable development of hydropower. *PLoS ONE*, 9(12), 1–26. <https://doi.org/10.1371/journal.pone.0114889>
- McFeeters, S.K. (1996). The use of the Normalized Difference Water Index (NDWI) in the delineation of open water features. *International Journal of Remote Sensing*, 17(7), 1425–1432. <https://doi.org/10.1080/01431169608948714>
- McFeeters, S.K. (2013). Using the normalized difference water index (ndwi) within a geographic information system to detect swimming pools for mosquito abatement: A practical approach. *Remote Sensing*, 5(7), 3544–3561. <https://doi.org/10.3390/rs5073544>
- Xu, H. (2006). Modification of normalised difference water index (NDWI) to enhance open water features in remotely sensed imagery. *International Journal of Remote Sensing*, 27(14), 3025–3033. <https://doi.org/10.1080/01431160600589179>