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Land Cover Mapping in Lake Rawa Pening Using Landsat 9 Imagery and Google Earth Engine

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Abstract

Lake Rawa Pening, in Semarang Regency, is one of the super lakes of revitalization priority. Lake revitalization is an activity to restore the natural function of the lake as a water reservoir through lake dredging, cleaning of invasive alien plants, and land use planning. This makes land use and land cover information in Lake Rawa Pening useful for formulating policy strategies related to revitalization. This study will discuss land cover mapping in Lake Rawa Pening. Mapping using Landsat 9 Imagery and machine learning on Google Earth Engine (GEE). Machine Learning used in this study is CART (Classification and Regression Tree) and RF (Random Forest). The research result shows that the land cover map with the best accuracy is obtained from machine learning RF with an overall accuracy of around 0.78, while CART machine learning is approximately 0.76. The overall accuracy values for CART and RF are not much different because they are both decision tree-based machine learning. This research needs to be developed using cloud masking, comparing image transformations, and comparing its predecessor data, namely Landsat 8. This is useful for providing representative land cover data as the basis for the policy of revitalizing Lake Rawa Pening.

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INTRODUCTION

Lake is a large natural water bodies surrounded by land. Indonesia has 840 large lakes and 735 small lakes (Haryani, 2013). Among these lakes, there are several lakes that have severe environmental damage that need to be revitalized. Lake Rawa Pening, in Semarang Regency is one of the super priority lakes handled by the Kementerian Pekerjaan Umum dan Perumahan Rakyat (Indonesian Ministry of Public Works and Housing) along with 5 other lakes. The revitalization of Lake Rawapening with Lake Toba, Lake Tondano, Lake Limboto, Lake Tempe and Lake Maninjau has been carried out in 2020 and will continue in 2021 (Tri, 2021).

Lake revitalization is an activity to restore the natural function of the lake as a water reservoir through lake dredging, cleaning of invasive alien plants, making embankments and land use planning in watershed areas (Gobel & Koton, 2017; Mahmud et al, 2020; Suawa et al, 2021). Information on land use and land cover in Lake Rawa Pening is useful for formulating policy strategies related to revitalization. This is because land cover change affects the water quality of Lake Rawa Pening such as sedimentation (Apriliyana, 2015; Soewandita, 2017; Sanjoto et al, 2020).

Land cover information can be extracted from satellite imagery by analytical techniques such as visual interpretation or digital interpretation. One platform that provides satellite imagery data and data processing is Google Earth Engine (GEE). GEE is a geo big data application which has access to large data and cloud-based data processing, so that data processing can be carried out without a super computer (Tamiminia et al, 2020, Fariz & Nurhidayati, 2020). GEE also provides machine learning that facilitates data processing such as Random Forest (RF), Classification and Regression Tree (CART) and so on (Arjasakusuma et al, 2020; Fariz et al, 2021). Therefore, this study discusses land cover mapping in Lake Rawa Pening using machine learning in GEE. For satellite imagery, the latest data release is Landsat 9 satellite imagery. The use of Landsat 9 satellite imagery distinguishes it from previous studies such as Hardini et al (2012), Heriza et al (2015) and Bangun et al (2021).

METHOD

This study is more precisely located in the Rawa Pening Catchment Area, where the area is an upstream part of the Rawapening Watershed sub-watershed. Administratively, the Rawapening catchment area is in Semarang Regency, Central Java Province, Indonesia (Figure 1). Geomorphologically, Rawa Pening is surrounded by mountains that function as water catchments area (Sanjoto et al, 2020).

Figure 1. Study location in map

Data collection and analysis uses the GEE platform via the code.earthengine.google.com page. The dataset used is USGS Landsat 9 Level 2, Collection 2, Tier 1 recording March 2022.This dataset contains atmospherically corrected surface reflectance from the data produced by the Landsat 9 OLI/TIRS sensors. The bands used are bands 1 to 7 which have the highest accuracy compared to the combination of all bands in the Landsat image (Yu et al, 2019; Fariz & Nurhidayati, 2020).

The next stage is supervised classification using machine learning. Machine learning that is compared in this study is RF and CART. The land cover mapped in this study only consists of 6 classes, namely water bodies, forest and agroforestry areas, agricultural areas, open fields, built up and cloud cover. To support the supervised classification process using machine learning, several training samples are needed. The training sample used in this study is 300

points. In addition to the classification sample, a test sample was also taken which was used to test the accuracy of the classification results. The number of test sample points in this study is 180 points.

RESULT AND DISCUSSION

The land cover mapping process using GEE is very rapid because it does not require data download and cloud-based data processing. Based on the supervised classification results which is then performed an interpretation accuracy test shows that the land cover in the Rawa Pening's water catchment area was classified into 6 (six) land cover classes consisting of water bodies, forest and agroforestry area, agricultural area, open field, built up and cloud cover. Cloud cover is included in the land cover classes because the date of imagery acquisition is during the rainy season with lots of cloud cover. After the land cover classes are determined, the next step is collecting training samples for each land cover class and selecting a machine learning algorithm. The configuration for each machine learning in this study is presented in Table 1.

Tabel 1. Configuration for each machine learning in this study

Machine learning	Expression
CART	ee.Classifier.smileCart(6, 1)
Random forest	ee.Classifier.smileRandomForest(10, null, 1, 0.5, null, 0)

The accuracy test result shows that the land cover map with the best accuracy is obtained from machine learning RF with an overall accuracy of around 0.78, while CART machine learning is approximately 0.76. The overall accuracy values for CART and RF are not much different because they are both decision tree-based machine learning. This decision tree is similar to the way humans determine a decision, where there is a split process in determining information (Patel & Prajapati, 2018).

The decision tree on land cover mapping is made using a splitting class based on the reflectance value of the satellite image (Awaliyan & Sulistioadi, 2018). Therefore, the accuracy of mapping using machine learning can increase if more input data is used (Arjasakusuma et al., 2021). Farda's research in 2017 became an excellent example because it uses many input data. The use of a lot of input data can be a solution from the mapping results in this study, namely by adding image transformations such as NDVI and NDWI (Loukika et al, 2021). The classification results have accuracy above 0.70, but there are still misclassifications, such as forest classified as water bodies (Figure 2).

Future Work: Land Cover Mapping in Rawa Pening

Misclassification of mapping results in this study is probably due to data quality factors. The quality of the data is the presence of clouds and cloud shadows, limiting the use of the obtained images and misclassification (Kalkan & Maktav, 2018). In our opinion, that is the cause of the emergence of misclassification of objects into water bodies or forest objects. The solution to that problem is using cloud masking with multitemporal approaches (Mateo-García et al., 2018).

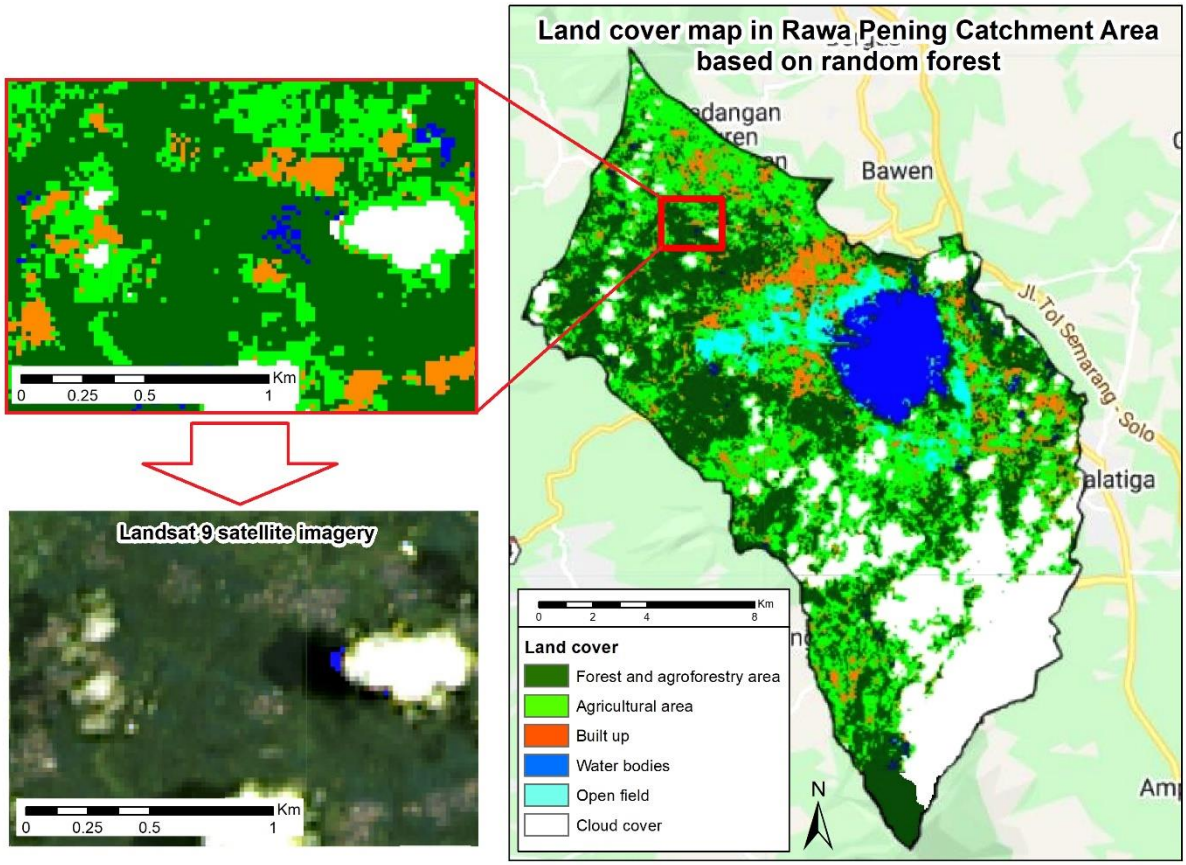

Figure 2. Land cover mapping results based on RF

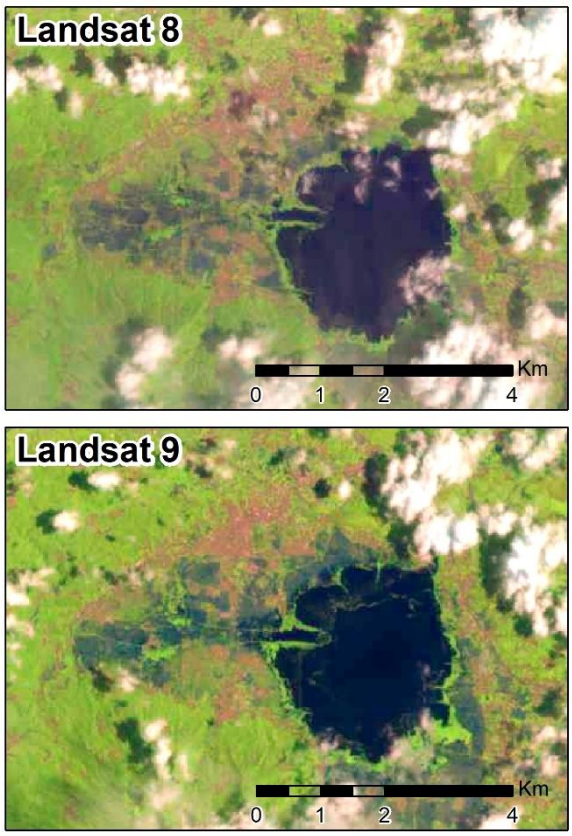

Figure 3. Comparison of Lake Rawa Pening from Landsat 8 and Landsat 9

The use of Landsat 9 in this study was also not fully explored, such as comparing band combinations or image transformations. This study needs to be developed by comparing band combinations or image transformations and corresponding with the previous dataset, namely Landsat 8. Landsat 9 carries the same instruments as the Landsat 8 satellite but with some improvement, namely a slightly better signal-to-noise ratio than Landsat 8 (USGS, 2022). There are differences in appearance between Landsat 8 and Landsat 9, where Landsat 9 imagery looks clearer (Figure 3). This study helps provide representative land cover data as the basis for the policy of revitalizing Lake Rawa Pening.

CONCLUSION

Machine learning in GEE is very helpful in land cover rapid mapping, the highest accuracy for land cover mapping in Lake Rawa Pening is

RF (78% overall accuracy). CART also has an overall accuracy not much different from RF, although the two mapping results still have misclassifications. This research needs to be developed using cloud masking, comparing image transformations and comparing its predecessor data, namely Landsat 8. This is useful for providing representative land cover data as the basis for the policy of revitalizing Lake Rawa Pening.

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