Utilization of Sentinel 1-A for Identification Land Use changes in Citarum Watershed

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Abstract. Citarum Watershed is one of critical watershed that must be restored which included in five priority watersheds. Land use change is one of the problems that occurred in Citarum Watershed for several years. Information about land use change is required as consideration in order to plan policies regarding revitalization of Citarum Watershed. Remote Sensing is widely well-known of its use for environmental monitoring, especially for land use change detection. Remote Sensing application is commonly use optical image to derive information about land use change in Citarum Watershed beside its limitation related to cloud cover. Sentinel 1A produces SAR data which obtain free cloud information in Citarum Watershed, and it can be used to cover optical satellite weakness. This research utilizing training samples from image in 2016 and 2018 then using random forest to classify land use in 2016 and 2018. Both classification results can be used to generate new image to see the land use change. Purpose of this research is to understand the potential of Sentinel-1A data to detect land use change. Result of this research shown that Sentinel-1A could generate land use change even the confidence level is still below 70 percent and still need many improvements.

1. Introduction

Citarum watershed is one of fifteen critical Watershed which included in Indonesia’s medium term development plan in 2015-2019[1]. Citarum watershed become one of fifteen critical Watershed because it has many damaged areas. Citarum watershed has many settlement areas around it. There was a big flood which produce a big loss for adjacent housing area in 2016. One of the main causes that makes this problem appear is land use change[2]. Land use change can be described by complex interaction of behavior and structural factors associated with the demand, technological capacity, social relations affecting demand and capacity [3]. Land use changes could be occurred naturally or purposely changed by human [2]

Citarum watershed Located in West Java, Indonesia Citarum watershed upstream located in mount Wayang and disembogue in Java Sea[4]. Citarum watershed occurred critical land caused by land use change in Watershed Citarum. Land use change closely linked with the issue of the sustainability of socio-economic development and other activities of humans.[5] Remote sensing is the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation [6]. Remote Sensing as one of the most popular sciences could see changes in land use in Citarum watershed. Changes in land use could be known through Remote Sensing data.

Remote Sensing instrument are primary two type active and passive. Active sensor means that provide their own source of energy to observe object and passive sensor detect natural energy (radiation) that is emitted or reflected by the object or scene being observed. Reflected sunlight is the most common
source of radiation measured by passive sensors. Previous research had been carried out on Citarum upstream watershed with Landsat to obtain information about land use change with Maximum likelihood classification to derive information about land use with multi temporal data [7]. Another Research has already using Sentinel 1 for preliminary study to mapping paddy fields[8].

Landsat has an advantage with temporal resolution in sixteen days but it has a problem to see monitoring land use change especially tropical area with many areas covered by clouds therefore need another data to obtain information about land use besides using optical data. Sentinel 1 as SAR data could gain information land use change because it is use band C which is could penetrate cloud cover. One of previous research has used Sentinel 1 to get land cover using sentinel 1 data with SVM this research proved that using dual polarimetry increased the accuracy of image classification [9]. The purpose of this research is to find out whether sentinel 1 can be used to obtain land use changes to get information about land use changes especially in Indonesia a country which one mostly area covered by clouds and obtain accuracy of Sentinel 1 to obtain land use change.

2. Data and Methodology

The location of this study is located in Citarum Watershed which is located in West Java precisely located in Bandung Barat regency, Sumedang Regency, Bandung City and Ciamis Regency. This research using sentinel 1 data in 2016 and 2018 from ESA (European Space Agency). The accuracy test of land cover classification in this study using two datasets from 2016 and 2018 using SNAP software. This study started by correction phases of the downloaded data. First phase is radiometric calibration which applied to the datasets. Radiometric calibration is needed in order to compare the intensity from two datasets. Second phase is speckle filtering. Speckles existence reduce land cover separation based on radiometry and texture. That is the reason why we need speckle filtering, to reduce the noises and amplify the possibility of land cover separation with least information loss. Third phase is geometric correction, and this study use range-doppler terrain correction. In operational aspect, utilization of SAR data has a lot of obstacles when compared to optical data, especially in geometry [10]. This problem occurs because of the acquisition process. SAR sensor take the data sideways, and the results are layover, foreshortening, and shadow error. To conclude those problems, octorectification process using range-doppler terrain correction is needed. This correction needs the satellite orbit data, acquisition time, slope from the surface, and DEM reference to obtain the coordinate of element backscatter that already match to satellite’s orbit reference system [10].

Forth phase is classification process using random forest algorithm. Random forest is a classification which is randomly and iteratively samples data to obtain large group of classification [11].non-parametric algorithm which has good and efficient performance to process data that has many complex features [12]. Random forest is a Random Forest algorithm will have optimal performance if depend on the sample quantity and maximum number of the features that being used to divide the class [13]The classification process divides the data to five main classes. The classification process using threshold is 0.3 it means if the sample under 0.3 is not classified as a previously defined class.
Figure 1 Workflow Land use Change

After doing classification process in image in 2016 and 2018 we should overlay two images in 2016 and 2018 to make a new image. New Image contains information about land use change from 2016 and 2018.

The last step is doing accuracy test from new image. Accuracy test needed to know how many samples match the conditions in the field is there land use change or unchanged. The sample is taken class representation from a class that has been created Accuracy test using Google Earth image to see previous object in 2016 and object in 2018.

\[ OA = \frac{\Sigma \text{correct prediction}}{\text{total number of prediction}} \]
3. Result and Discussion

Result of this research is information about area of each class from random forest in 2016 and 2018. The result of area in 2016 and 2018 can see in table below:

| Class Info          | Area in 2016 (ha) | Area in 2018 (ha) | Percentage Area in 2016 (%) | Percentage Area in 2018 (%) | Distinction (%) |
|---------------------|-------------------|-------------------|----------------------------|----------------------------|-----------------|
| Urban Area          | 42692.85          | 82862.91          | 18.45                      | 35.80                      | 17.36           |
| Forest pure and mixed | 41076.81         | 27362.07          | 17.75                      | 11.82                      | -5.93           |
| Water Body          | 3654.39           | 3959.45           | 1.58                       | 1.71                       | 0.13            |
| Dry Land Farming    | 90951.30          | 74630.77          | 39.30                      | 32.24                      | -7.05           |
| Wet Agriculture Land| 53076.62          | 42636.75          | 22.93                      | 18.42                      | -4.51           |
| Total (Ha)          | 231451.97         | 231451.97         | 100                        | 100                        | 0               |

Based on result the biggest distinction is class urban area with 17.36. The distinction has a negative value which is mean has a decrease area from 2016 and 2018. Positive value change occurred in urban area which is within 2 years there is an increase in urban area whether settlement or industries. Land use class that has not changed significantly is water body. And rest of all get decrease of area.

![Image of Land Use in Citarum upstream watershed in 2016 and 2018](image)

**Figure 2** Land Use in Citarum upstream watershed in 2016 and 2018

Another result of this research is created a new image from 2016 and 2018 which is created by overlay class value in two images. Overlay of class value from two images created by confusion matrix table which created in ERmapper with mathematical function. The output result is new image which contain information about pixel value change in each class. The output image could see in image below.
Figure 3 Image of Land Use Change

Total area unchanged based total area in Citarum upstream watershed is 34.03% from all of change in Citarum upstream watershed. It means 65.97% change from one class to another class in 2016 to 2018. Overall accuracy from samples taken in Land use change prove 19 of 30 sample. Overall accuracy is 66.7% which mean sample taken in Land use change image classification same as location in Google Earth. Problem faced in this classification is the number of classes that are not included in the class that has been determined it occurred because sample for classification has similarity in Sentinel 1 data. Same similarity found in urban area and dry farming and also Water body with wet agricultural land. Same similarity in urban area and dry farming occurred because decibel value from Sentinel 1 image same similarity. Same with water body and wet agricultural land occurred because in wet agriculture land enter the fallow phase which contains a lot of water. Overall using Sentinel 1 for land use change could provide information about land use change rapidly.

4. Conclusion
Result of land use change shown in 2016 to 2018 there are change in each class which is has increased area and decreased area in each class of classification. The result shown that Sentinel 1-A for land use classification still need improvement because accuracy test is below 70 percent.

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References

[1] Indonesia Government, “Peraturan Presiden Republik Indonesia Tentang Percepatan Pengendalian Pencemaran dan Kerusakan Daerah Aliran Sungai Citarum,” Sekretariat Negara, vol. 3, no. 1, pp. 1–53, 2018.

[2] M. Agaton, Y. Setiawan, and H. Effendi, “Land Use/Land Cover Change Detection in an Urban Watershed: A Case Study of Upper Citarum Watershed, West Java Province, Indonesia,” Procedia Environ. Sci., vol. 33, pp. 654–660, 2016.

[3] P. H. Verburg, J. R. Ritsema van Eck, T. C. M. de Nijs, M. J. Dijst, and P. Schot, “Determinants of land-use change patterns in the Netherlands,” Environ. Plan. B Plan. Des., vol. 31, no. 1, pp. 125–150, 2004.

[4] N. Kurniasih, “Pengelolaan DAS Citarum berkelanjutan,” J. Teknol. Lingkung., vol. 3, no. 2, pp. 82–91, 2002.

[5] A. A. Keller, E. Fournier, and J. Fox, “Minimizing impacts of land use change on ecosystem services using multi-criteria heuristic analysis,” J. Environ. Manage., vol. 156, pp. 23–30, 2015.

[6] J. W. C. Thomas M. Lillesand, Ralph W. Kiefer, Remote Sensing and Image Interpretation, vol. 53. 1989.

[7] F. Yulianto, T. Maulana, and M. R. Khomarudin, “Analysis of the dynamics of land use change and its prediction based on the integration of remotely sensed data and CA-Markov model, in the upstream Citarum Watershed, West Java, Indonesia,” Int. J. Digit. Earth, vol. 0, no. 0, pp. 1–26, 2018.

[8] M. N. Fathoni and D. Kushardono, “Kajian Awal Pemanfaatan Data Radar Sentinel-1 untuk Pemetaan Lahan Baku Sawah di Kabupaten Indramayu Jawa Barat Preliminary Study of Sentinel-1 Radar Data Application for Paddy Field Mapping in Indramayu - West Java,” Semin. Nas. Penginderaan Jauh ke-4, no. April 2018, pp. 179–186, 2017.

[9] S. Abdikan, F. B. Sanli, M. Ustuner, and F. Calò, “Land cover mapping using sentinel-1 SAR data,” Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci. - ISPRS Arch., vol. 41, no. July, pp. 757–761, 2016.

[10] B. Septiana, A. P. Wijaya, and A. Suprayogi, “Jurnal Geodesi Undip Januari 2017 Metode SAR Simulation Terrain Correction Menggunakan Data SAR SENTINEL – 1,” vol. 6, pp. 148–157, 2017.

[11] L. Breiman, “Random Forest,” pp. 1–33, 2001.

[12] M. Belgiu and L. Drăgu, “Random forest in remote sensing: A review of applications and future directions,” ISPRS J. Photogramm. Remote Sens., vol. 114, pp. 24–31, 2016.

[13] K. Van Tricht, A. Gobin, S. Gilliams, and I. Piccard, “Synergistic use of radar sentinel-1 and optical sentinel-2 imagery for crop mapping: A case study for Belgium,” Remote Sens., vol. 10, no. 10, pp. 1–22, 2018.