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Mapping of Land Use in Cijengkol Village, Subang Regency Using Sentinel-2 MSI (MultiSpectral Instrument)

Pemetaan Penggunaan Lahan di Desa Cijengkol, Kabupaten Subang Menggunakan Citra Sentinel-2 MSI (*MultiSpectral Instrument*)

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ABSTRAK

Setiap tahun penggunaan lahan di Indonesia mengalami peningkatan baik untuk pemukiman, pertanian ataupun penggunaan yang digunakan untuk memenuhi kebutuhan hidup manusia dengan tujuan tertentu. Desa Cijengkol merupakan salah satu desa pengembangan pertanian di Kabupaten Subang dan terpengaruhi oleh topografi, sehingga menghasilkan jenis penggunaan lahan yang berbeda. Tujuan pemetaan ini untuk memberikan informasi terkait klasifikasi penggunaan lahan pemukiman, pertanian, perkebunan, lapangan, dan lainnya di Desa Cijengkol. Pemetaan penggunaan lahan dilakukan pada desa ini untuk mengungkap pembagian penggunaan lahan sehingga dapat menjadi bahan pertimbangan maupun arahan penentuan tata ruang oleh pemerintah setempat. Oleh karena itu, pemetaan ini dilakukan dengan melibatkan sumber data citra Sentinel-2 Multi Spectral Instrument (MSI) dan diproses menggunakan platform Google Earth Engine (GEE) berbasis cloud computing. Enam algoritma indeks penilaian spektral yaitu Enhanced Vegetation Index (EVI), Soil Adjusted Vegetation Index (SAVI), Specific Leaf Area Vegetation Index (SLAVI), Index-Based Built-up Index (IBI), Normalized Difference Built-up Index (NDBI), dan Normalized Difference Water Index (NDWI). Hasil klasifikasi menghasilkan enam jenis penggunaan lahan dengan persentase yaitu kebun campuran (39,69%), pertanian (34,08%), kebun homogen (13,57%), pemukiman (10,58%), lahan terbuka (2,09%), dan badan air (0,001%). Klasifikasi citra pada pemetaan ini juga menghasilkan tingkat akurasi sebesar 82,43% (Overall Accuracy) dan 0,78 (Kappa Statistics). Hasil penelitian dengan tingkat akurasi yang baik, sehingga diharapkan penelitian ini menjadi basis data bagi pemerintah desa setempat serta menjadi referensi untuk penelitian selanjutnya.

Kata kunci: indeks algoritma, pemetaan, penggunaan lahan

ABSTRACT

Every year, land use in Indonesia has increased, both for settlements, agriculture, and other uses that are used to meet the needs of human life for certain purposes. Cijengkol Village is one of the agricultural development villages in Subang Regency and is affected by topography, resulting in different types of land use. This mapping aimed to provide information related to the classification of land use for settlements, agriculture, plantations, fields, and others in Cijengkol Village. Land use mapping was carried out in this village to reveal the distribution of land use so that it could be taken into consideration, as well as directions for determining spatial planning by the local government. Therefore, this mapping was carried out by involving the Sentinel-2 MultiSpectral Instrument (MSI) image data source and processed using a cloud computing-based Google Earth Engine (GEE) platform. Six spectral scoring index algorithms exist the Enhanced Vegetation Index (EVI), Soil Adjusted Vegetation Index (SAVI), Specific Leaf Area Vegetation Index (SLAVI), Index-Based Built-Up Index (IBI), Normalized Difference Built-up Index (NDBI), and the Normalized Difference Water Index (NDWI). The results of the random forest (RF) classification algorithm resulted in six types of land use with percentages, namely mixed gardens (39.69%), agriculture (34.08%), homogeneous gardens (13.57%), residential (10.58%), open land (2.09%), and water bodies (0.001%). Image classification in this mapping also produces an accuracy rate of 82.43% (Overall Accuracy) and 0.78 (Kappa Statistics). The results of this research are of a good level of accuracy, so it is hoped that this research will become a database for the local village government and become a reference for further research.

Keywords: index algorithm, land use, mapping

INTRODUCTION

Every year the use of land in Indonesia has increased for settlement, agriculture, or to meet the needs of human life with a specific purpose. It was also coupled with population growth that continues to increase in an area so that every human activity involving land use results in the land becoming an increasingly scarce resource (Letourneau & Goldstein, 2001). Land use development must be done with proper planning so that land use could be controlled properly.

Data was needed to obtain land use information with accurate and effective methods such as object-based classification methods and pixel-based classification in images (Maksum et al., 2016). Land classification technique with the image was using Remote Sensing which was divided into three parts, namely pixel-based classification technique, sub-pixel-based classification, and object-based classification (Li et al., 2014). Pixel-based classification was a classification used in remote sensing by conducting training areas on images which were then categorized according to pixels and divided into several land covers (Maksum et al., 2016). While Object-based classification was by classifying parts of objects such as polygons resulting from the division of segments in the form of a collection of pixels that have similarities with one another based on spectral characteristics.

An image was a combination of points, lines, fields, and colors in the form of an imitation of an object obtained. The image obtained from remote sensing was called remote sensing, which monitoring the Earth's surface from a distance to space using reflected electromagnetic waves (Purba, 2017). Theremote sensing of human activities in the form of observation of an area could be done easily and quickly within a certain area without having to go to the location directly. After the image data was obtained through remote sensing data processing will be done using a computer with a digital format (Rivanthio, 2016). The processing of spatial data in the digital form obtained from remote sensing was called GIS or geographic information system. Image data processing in digital format usually uses software on a computer that will analyze data such as *Er mapper* or *ArcGis* (A'in et al., 2010).

Indonesia was a vast country that has land with different topographic heights with various types of land cover. These conditions make it difficult to capture data and objects directly so remote sensing technology was needed or remote sensing that could take an image or imitation of an object easily (Maksum et al., 2016). An example of the use of remote sensing was mapping on land use for settlements in an area so that the mapping gets information data that could be used to identify the authors of studies related to good residential spatial planning so that the environment could be maintained properly (Sejati et al., 2020). It could also be applied to land use in Cijengkol Village, Serangpanjang District, Subang Regency, West Java province by making mapping related to land use. The data obtained from the mapping was expected to be additional information, especially the government or readers related to the benefits of mapping. The purpose of this mapping was to provide information related to the classification of residential land use, agriculture, plantations, fields, and others in Cijengkol Village.

MATERIALS AND METHODS

Location and Time of Research

The study location was in Cijengkol Village, Serangpanjang District, Subang Regency, West Java province (Figure 1). Based on the assessment on June 20-July 30, 2022 carried out in Cijengkol Village was a location located right at the foot of Mount Tangkuban Perahu which was located in the Southern position of Subang Regency. Cijengkol village was an area located in a Highland position where land use in the village was very diverse so we chose Cijengkol village as a place for mapping.

Source

This study uses an open-source image Sentinel-2 MSI (MultiSpectral Instrument). Sentinel - 2 imagery was a satellite image with a wide swath and medium spatial resolution, revisit at the same location every 5 days, and could be used for land cover monitoring studies, including vegetation, soil, and water, as well as water networks and coastal areas. Sentinel-2 MSI has the main objective to conduct land monitoring with global coverage of the Earth's surface every 10 days with 1 satellite and 5 days with 2 satellites consisting of sentinel-2A and Sentinel-2B satellites (Julianto et al., 2020). Sentinel 2A was launched on June 23, 2015, and the first images were available for download starting in December 2015. Sentinel 2A was launched from the Kourou Space Base (French Guiana) using an Arianespace Vega rocket. The satellite was equipped with state-of-the-art MSI instruments, which offer high-resolution optical images with 13 different bands of which 4 bands have a resolution of 10 meters, 6 bands have a resolution of 20 meters, and 3 bands have a resolution of 60 meters.

Data Analysis

The machine random forest algorithm was a simple but widely used algorithm that was used without hyperparameter tuning. Usually, this algorithm was used in classification and regression models. This study uses 6 spectral assessment index algorithms, namely Enhanced Vegetation Index (EVI), Soil Adjusted Vegetation Index (SAVI), Specific Leaf Area Vegetation Index (SLAVI), Index-Based Built-up Index (IBI), Normalized Difference Built-up Index (NDBI), and Normalized Difference Water Index (NDWI). The process of research on land use mapping using Sentinel-2 MSI (MultiSpectral Instrument) image was presented in Figure 2. Image acquisition in this study using sentinel-2 satellite imagery. The sentinel-2 satellite was an MSI (MultiSpectral Instrument) image orbited with the aimed of obtaining images or images in monitoring the Earth's surface and to continue the Landsat 5/7, SPOT-5, SPOT-Vegetation and Envisat MERIS missions (Oktaviani & Kusuma 2017). Spatial-based classification and detection process using the formula vegetation index, built-up land index, and water index using Google Earth Engine (GEE) platform based on cloud computing and classification based on 6 index algorithms in Table 1.

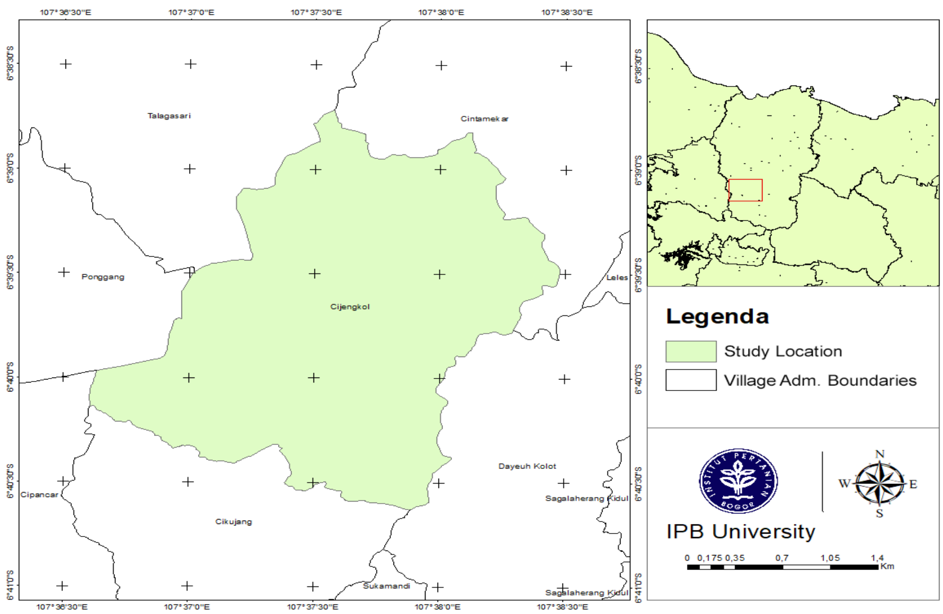

Figure 1. Research location map

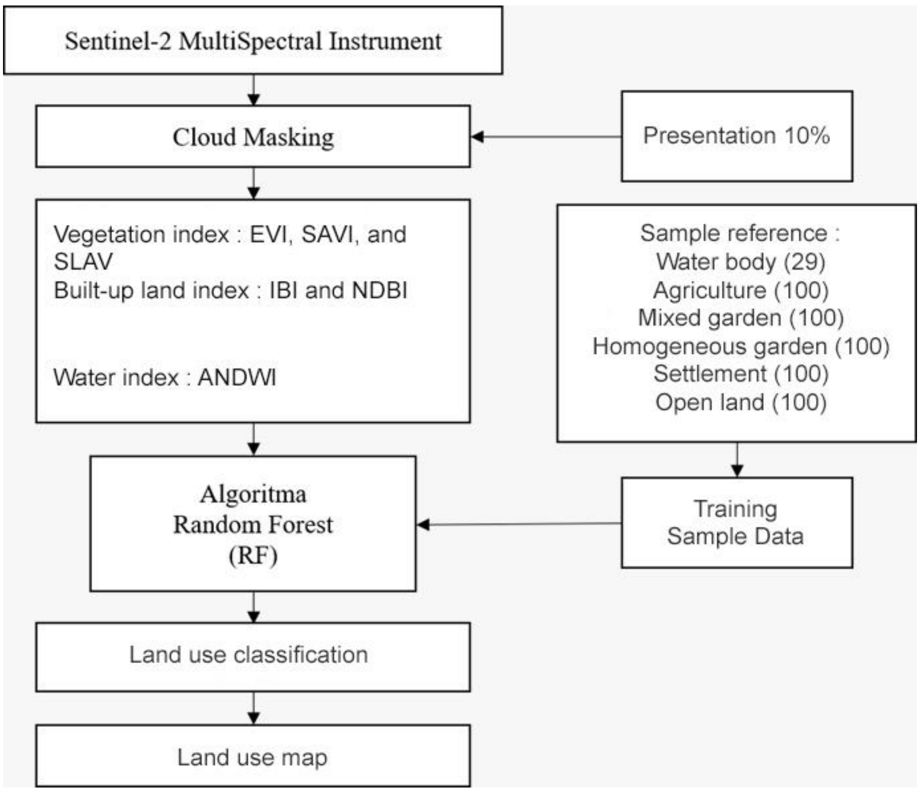

Figure 2. Flow chart

Table 1. Index algorithm used in the classification process

Method	Equation	Source
Enhanced Vegetation Index (EVI)	EVI = G ((NIR - Red) /(NIR + C1 x Red - C2x Blue + L))	Anderson et al., 2011
Soil Adjusted Vegetation Index (SAVI)	SAVI = 1.5 (NIR - Red)/ (NIR + Red + 0.5)	Rouse, 1973
Specific Leaf Area Vegetation Index (SLAVI)	SLAVI = NIR / (Red + SWIR)	Lymburner et al., 2000
Index-Based Built-up Index (IBI)	IBI = ((NIR)/NIR + Red)) + ((Green) / Green + SWIR1))	Xu, 2008
Normalized Difference Built-up Index (NDBI)	NDBI = (SWIR - NIR) / (SWIR + NIR)	Zha et al., 2003
Normalized difference water index (NDWI)	NDWI = (Green - NIR) / (Green + NIR)	McFeeters, 1996

Assessment Accuracy

The quality of mapping data needs to be measured to determine the map's accuracy level. The quality of the map itself could be measured in several ways, such as using the level of positional accuracy of the mapped object or with the level of thematic accuracy (Haryana & Susilo 2015). An accuracy test was conducted to determine the level of quality of information interpretation results using a confusion matrix. This study uses the accuracy analysis method seen from the value of statistical kappa and the percentage of overall accuracy, with the presentation using the confusion matrix table. Validation points involved in this analysis consisted of water bodies (29 points), agriculture (100 points), mixed Gardens (100 points), homogeneous Gardens (100 points), settlements (100 points), and open land (100 points). Validation data was 30% of the total data used will then be tested and compared with the results of land use classification, so as to obtain information on the level of accuracy.

Kappa Statistic

$$= \frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r} x_{i+}x_{+1}}{N\sum_{i=1}^{r} x_{i+}x_{+1}} \quad \text{.........................(1)}$$

User's Accuracy

$$= \frac{x_{ii}}{x_{+i}} \times 100\% \quad \text{.........................(2)}$$

Producer's

$$\text{Accuracy} = \frac{x_{ii}}{x_{i}} \times 100\% \quad \text{.........................(3)}$$

$$\text{Overall Accuracy} = \frac{\sum_{i=1}^{r} x_{ii}}{N} \quad \text{.........................(4)}$$

RESULTS AND DISCUSSION

Cijengkol village was one of six villages in Serangpanjang District, Subang Regency, West Java province. Cijengkol village was located at an altitude of 600 meters above sea level. Cijengkol village land conditions at the time of the search most of the land used as agricultural land and plantations. The use of community land area in Cijengkol Village, Subang Regency was used for various types of land classification (Figure 3 & 4). Dominant land use was used as a mixed garden, covering an area of 261.52 ha, the percentage of 39.69% of the total land area of Cijengkol Village was used for planting fruit crops such as mangosteen and several trees such as sengon, jabon, and suren or could be called an agroforestry system. In addition, the area of land was also predominantly used in agriculture covering an area of 224.54 ha with a percentage of 34.08% which was used as rice fields. In addition, there were also homogeneous plantations with land use as oil palm crops covering an area of 89.39 ha with a percentage of 13.57%, land use for settlements and buildings covering an area of 69.74 ha with a percentage of 10.58%, open land use covering an area of 13.75 ha with a percentage of 2.09%, and water bodies 0.01 ha with a percentage of 0.01% (Table 3).

Research conducted by Wang et al. (2018) states that MSI sentinel-2 data has great potential to improve the accuracy of field survey data. The condition of mixed plantation land was based on the calculation of a land use area of 261.52 ha or 39.69% of the total land use area in Cijengkol Village. The condition of mixed plantations in the village was illustrated by the type of trees, fruit crops, and agriculture, or could be said to be an agroforestry system (Figure 5 & 6). Agroforestry was one of the multi-tiered land uses that combines trees with seasonal plants below (Olivia et al., 2015). A mixed plantation system in the form of agroforestry provides more benefits economically and ecologically useful for farmers. The dominant plant in the mixed garden in the village of cijengkol was mangosteen. (*Garcinia mangostana* L.) as fruit plants and trees such as Sengon and Suren. The harvest from mangosteen in Cijengkol Village was sold by the community and even exported abroad, while the trees were harvested to meet the needs of carpentry wood raw materials. The next largest land-use area was used as agricultural land along 224.54 ha or 34.08% of the total land use area in the form of rice fields. The management system carried out by the Cijengkol Village community was carried out 3 times a year because of the availability of sufficient water and irrigated both from direct rivers and from irrigation. Rice was the main commodity recognized by the people of Cijengkol village with the most harvest. Rice in the village of Cijengkol was good enough because farmers have received support from the Agricultural Extension Center (BPP) Serangpanjang district such as control of plant-driving organisms. Field monitoring, and always coordinating with extension workers in case of pest and disease attacks (Effendy et al., 2020).

Classification results provide information in the form of land use mapping. However, the results of the classification sometimes do not correspond to the type of actual use. This was one part of the role of accuracy analysis, where the classification results were compared with the validation data using the table confusion matrix and calculation of accuracy with recombination of indexes (Table 4). Based on the results obtained, overall accuracy (OA) and kappa coefficient showed a value of 82.43% and 0.78, respectively (Table 5). According to the assessment the existing OA value was appropriate and acceptable because it passes the minimum limit of 70% (BIG 2014). Kappa values classified by quality were included in the substantial or strong (Table 2). When viewed from the kappa coefficient, the value obtained close to 1 means that it was well accepted. kappa values range from 0 to 1 (Rwanga & Ndambuki, 2017). The value of the user's accuracy in the class of water bodies was not high, it showed that there was an error when classifying the class of water bodies where at the time of classifying the water body into the class of agriculture or rice fields that were flooded.

Table 2. Interpretation of kappa values

Kappa Values	Description
< 0.00	*Poor*
0.00-0.20	*Slight*
0.21-0.40	*Fair*
0.41-0.60	*Moderate*
0.61-0.80	*Substantial*
0.81-1.00	*Almost perfect*

Land Use Classification

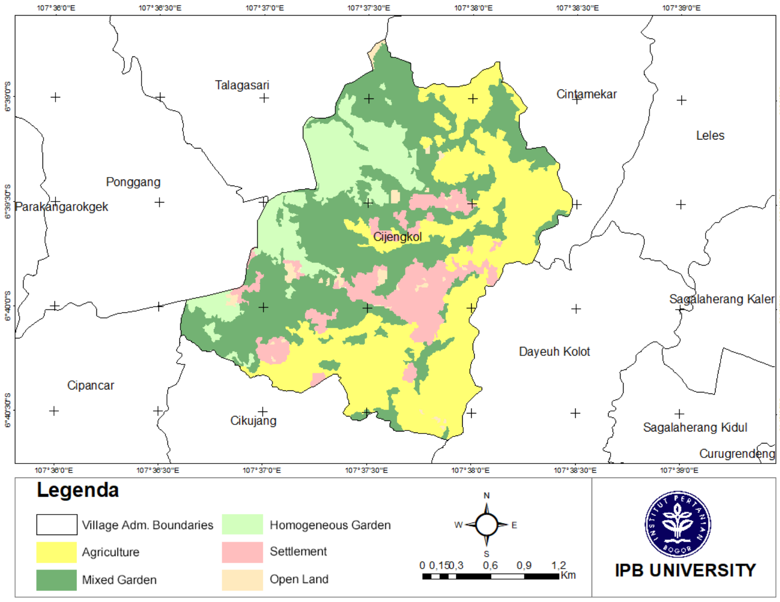

Figure 3. Land use classification results

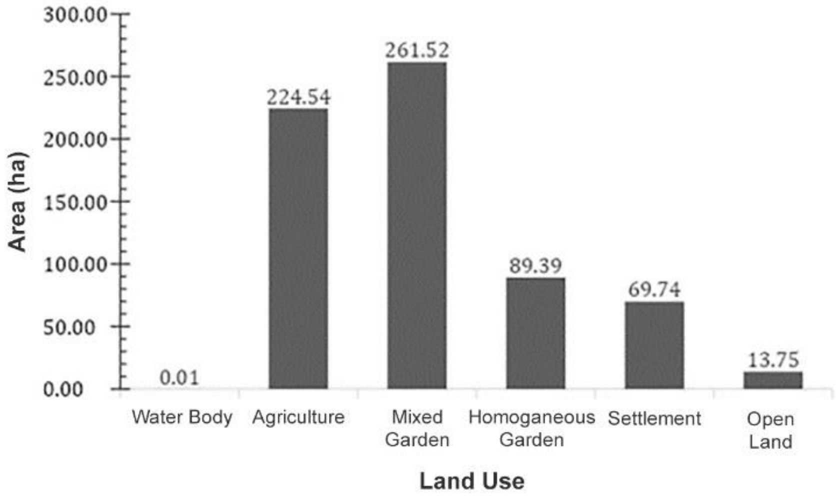

Figure 4. Land use graph

Table 3. Percentage of land use

Land Use	Extents	
	Extents (ha)	Percentage (%)
Water Body (0.001%)	0.01	0.001
Agriculture (34.08%)	224.54	34.08
Mixed Garden (39.69%)	261.52	39.69
Homogeneous Garden (13.57%)	89.39	13.57
Settlement (10.58%)	69.74	10.58
Open Land (2.09%)	13.75	2.09

Accuracy Rate

Table 4. Confusion matrix and calculation of accuracy with recombination of indexes

Land use	Data validation						
	Water Body	Agriculture	Mixed Graden	Homogeneous Garden	Settlement	Open Land	Total (*User*)
Water Body	0	0	0	0	0	0	0
Agriculture	9	37	0	0	0	0	46
Mixed Graden	0	5	32	5	0	1	43
Homogeneous Garden	0	0	10	37	0	0	47
Settlement	3	0	0	0	40	4	47
Open Land	0	0	0	0	2	37	39
Total (*Producer*)	12	42	42	42	42	42	222

Table 5. *Kappa statistic* and *persentase overall accuracy* value

	User's accuracy	*Producer's accuracy*
Water Body	0%	0%
Agriculture	80%	88%
Mixed Graden	74%	76%
Homogeneous Garden	79%	88%
Settlement	85%	95%
Open Land	95%	88%
Overall Accuracy (OA, %)	82.43%	
Kappa coefisien (KA)	0.78	

Landscape Location Research

Figure 5. Landscape condition of mixed plantation Cijengkol Village

Figure 6. Agricultural landscape condition of Cijengkol Village

CONCLUSION

Based on the results of the classification of six spectral assessment indexes from sentinel-2 MSI image data through the Google Earth Engine (GEE) platform process, land area was obtained from six land use classes that have been classified, namely water bodies, mixed gardens, homogeneous gardens, settlements, and open land. The largest amount of land use data is used for mixed gardening and agriculture. Accuracy calculation gets overall accuracy (OA) and kappa coefficient of 82.43% and 0.78 including the value received and the value of kappa including substantial or strong so this study is expected to be a database for the local village government and a reference for further research.

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