Land conversion and availability of agricultural land in 2035 in Puncak Area Bogor Regency

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Abstract. Land conversion is the result of a complex interaction between physical, social, and economic activities in land use as human activities in natural resource management. Currently, the land conversion phenomenon is a common sight that we often encounter at any time. As happened in the Puncak area of Bogor Regency, land conversion, the increasing demand for land, has led to increasing land conversion. This study aims to (1) identify land conversion in Bogor Regency in 2005-2015, (2) predict agricultural land conversion in 2035 based on land use trends in Puncak District, Bogor Regency. The analytical methods used are remote sensing techniques, spatial analysis, and making land-use scenarios with GIS and ANN analysis. The results showed that land conversion in Puncak Subdistrict, Bogor Regency during 2005-2019 caused the area of agricultural land to decrease by an average of 82.59 hectares every year due to conversion to developed land and open land. From the prediction of changes in agricultural land area in 2035, it shows a decrease in rice fields and fields on average 60.90 hectares every year. However, the plantation area has increased by an average of 24.35 hectares every year due to the conversion from forest and shrubs.

1. Introduction
The economy in Indonesia is highly dependent on land-based sectors such as settlements, plantations, agriculture, and forestry. This sector holds the third-largest share in the national gross domestic product (GDP) following the manufacturing industry and trade sector. In daily life, land-use activities are a physical form of community socio-economic activities as natural resource management activities in an area [1, 2, 3]. These land-use activities encourage agricultural land conversion in several regions in Indonesia. According to the Statistics (BPS), there was a decrease to 8.00 million hectares between 2013 and 2018 and the agricultural land area to 929.09 thousand hectares.

One of the factors that drive the conversion of agricultural land in West Java is the phenomenon of settlement growth influenced by the influence of urban Jakarta which has spread to the surrounding urban areas so that new satellite cities appear in the surrounding area (suburban) [4]. Another phenomenon that occurs in the Jabodetabek area is the uncontrolled expansion of land areas that are triggered by the road network and Jabodetabek is very dynamic following the increasing need for
residential land so that there are many agricultural lands [5][6]. As in the Puncak Area Bogor Regency, there have been many changes in land use that have narrowed agricultural land due to increased economic activity and population growth which is in line with the increasing need for built-up land that grows in this area which often changes its function, namely agricultural and plantation land [7][8].

The dynamics of land-use change that occur must be in line with the Regional Spatial Plan (RTRW) because (RTRW) is a policy that regulates the allocation of space use and land use as well as the development of an area so that land use does not exceed its carrying capacity. One thing that needs to be considered in the RTRW policy is the availability of agricultural land both now and in the future. This is important because agricultural land in the Puncak area of Bogor Regency is a land that has been converted a lot due to the increasing demand for developed land.

Identification of land cover changes can be done using basic data with a remote sensing approach using aerial photography interpretation and Geographical Information System (GIS) analysis, land change analysis, and land cover prediction in 2035 using predictive analysis models with Artificial Neural Networks (ANN) with factors the influence of arterial roads, distance from collector roads, distance from toll roads, distance from the center of the area, distance from the education center, distance from tourist location soil type, slope, and population density.

This study aims to (1) identify land conversion in Bogor Regency in 2005-2015, (2) predict agricultural land conversion in 2035 based on land use trends in Puncak District, Bogor Regency.

2. Method

Puncak area is located between 106 ° 49'49.63 "E - 107 ° 0'24.78" east longitude and 6 ° 37'29.96 "-6 ° 46'9.04" south latitude. Is Administrative it is in Bogor Regency, West Java, and consists of three districts, including Ciawi District, Cisarua District, and Megamendung District. The total area of the study is ± 18,371.14 hectares.

Primary data collection was carried out by field observations regarding general conditions and land use in the Puncak area carried out in Ciawi District, Cisarua District, and Megamendung District, Bogor Regency. Observations in the field were carried out by tracing the primary arterial road from Ciawi to Cisarua Peak to complete the data and information obtained in the literature study and the results of the analysis of the interpretation of aerial photographs to serve as ground checks for land cover.

Secondary data collection is done by downloading data from data provider sites on the internet. The data downloaded from the internet is in the form of basic data which will then be analyzed to obtain information. Data obtained from the internet is Landsat image data from Landsat TM5 2005 satellite imagery, Landsat 7 ETM + 2019, Landsat 8 OLI 2019, DEMNAS data, RBI data, and well as high-resolution aerial photo data from the Peak Area in 2005 and 2019 from Google Earth.

3. Data analysis

3.1 Analysis of changes in land cover in the Puncak Area 2005-2019

The preparation stage includes the preparation of a 2005 land cover map, a 2019 land cover map, and a 2020 land cover map. The first stage is data collection including primary and secondary data collection. The third stage of image analysis is then carried out geometric corrections and uniform coordinates, in this case, using the UTM 48 S zone and then clip the map according to the base map of the study area is carried out. The second stage is the classification of land cover for 2005, 2019, and 2020 at a scale of 1: 50,000. The land use classification observed in this study was divided into eight categories of a forest, garden/plantation, built-up land, paddy fields, moor, shrubs, open areas, and water bodies. The results of this stage are land cover maps for 2005, 2019. This stage produces a land cover map for 2005 and 2019 which is then overlapped to produce a transitional matrix of land cover change from 2005 to 2019. from this matrix, it can be seen that changes in the land cover area occurred in the 2005 to 2019 timeframe which can then be seen arranged in the form of a changing table.
3.2. Prediction of change in Puncak area cover in land cover 2035

The first stage is predicting land cover change in 2035 in the Puncak area using the LCM (Land Change Modeler) application model available in the TerrSet Geospatial Monitoring and Modeling System software. The second stage is to determine a sub-model of the transition from all land uses to developed land than to test and select the drivers. The driving factor used is the driving factor that affects the increase in opportunities for conversion of other land uses to built-up land, the independent variables used include distance from roads, rivers, activity centers, tourist sites for soil types, slopes of slopes, and population density. The third stage is to determine the limiting factors for land cover change. In this study, the limiting factors for the type, slope of the slope, population density, distance from arterial roads and distance from collector roads, distance from highways, distance from urban centers, and distance from educational centers, distance from tourist centers, distance from regional centers. The fourth stage tests the value of Cramer's V. The resulting range of values ranged from 0-1, where getting closer to value 1 indicates that these factors have a very strong relationship and the value 0 indicates a disconnection [10]. The fifth stage is the prediction of locations that have the potential to experience a change in land use (transition potential). After the potential transitions are modeled one by one, a running model is carried out by selecting the approach applied, Multilayer perception MLP and Neural Network for ANN. The sixth stage is model validation with a crosstab of the 2020 land projection map against the 2020 actual land use map. The Kappa value or the value of the suitability between the number of columns and rows is a maximum of 1.00. Kappa values 0.81–1.00 indicate very good suitability. Kappa values 0.61–0.80 are good, 0.41–0.60 are moderate, 0.21–0.40 are less than moderate, and a value <0.21 is said to be bad [11]. The seventh stage is a prediction of land cover change in the peak area in 2035, assuming that the pattern of future land-use changes is the same as the pattern of changes in land use in the past [5].

4. Result and discussion

4.1. Analysis of changes in land cover in the peak area 2005-2019

The results of the analysis of the land cover map resulted in eight categories of land use including forest, Garden / Plantation, built land, rice fields, fields/moor, water bodies, open field, and shrubs. In general, changes in land use in the peak area between 2015 and 2019 moved dynamically, some experienced an increase and some experienced a decline. The number of build land increased by 1730 hectares and open land increased by 29 hectares. The increase in the area of developed build land is the result of land-use change. Where forests have decreased by -1688 hectares, gardens/plantations have decreased by -1470 hectares, fields/moor have decreased by -521 hectares, rice fields have decreased by -906 hectares, and shrubs have decreased by -115 hectares, the water body has not changed. Changes in land use between 2005-2019 are presented in table 1 and figures.

| Table 1. Area of land change from 2005 to 2019 |
|-----------------------------------------------|
| Land Use          | The year 2005 Area (hectare) | The year 2019 Area (hectare) | Area of Change |
| Forest             | 7646                         | 5958                         | -1688          |
| Garden / Plantation| 3685                         | 5155                         | 1470           |
| Field / Moor       | 2306                         | 1785                         | -521           |
| Built land         | 1299                         | 3029                         | 1730           |
| Open field         | 3                            | 32                           | 29             |
| Rice fields        | 3013                         | 2107                         | -906           |
| Shrubs             | 378                          | 263                          | -115           |
| Water              | 42                           | 42                           | 0              |
| Total              | 18371.14                     | 18371.14                     |                |
Based on table 1 and graphic 1 above, it shows that the area from 2005 to 2019 has decreased the area of agricultural land in the peak area of Bogor Regency. The largest decrease in agricultural land area is rice fields. The conversion of agricultural land in the peak area of the Bogor Regency is influenced by the high demand for developed land. This land conversion is spread over most of the central and northern regions in the location of the peak area. Graph illustrating land cover change from 2005 to 2019 in Figure 1 and a map of the land cover change in 2005-2019 in Figure 2.

Figure 1. Graph of land changes for 2005-2019 in Puncak area

Figure 2. Map land change in the Puncak area for 2005-2019
4.2. Prediction of conversion of agricultural land in the Puncak Area in 2035

After overlaying land cover from 2005 to 2019 and fulfilling the Kappa requirements, then predicting land cover in 2035. by using the driving factor for land cover change and testing the Cramer’s V value in ANN for each tested variable has a value that meets the requirements for inclusion into land change models, the test results were obtained with an accuracy of 82.38 percent with a skilled size of 0.73. Furthermore, the land cover from the test results is predicted to be actual in 2019 using the ANN method.

The prediction results of land use in 2035 are based on land use trends that can lead to changes in which built-up land has increased significantly, namely 1,939 hectares, followed by plantation areas of 390 hectares and shrubs of 62 hectares. Meanwhile, the forest area with the widest area decreased by -1,416 ha, followed by rice fields -803 ha and paddy fields -171 ha. While the area of air bodies has not changed, this is because the air bodies have not experienced a significant change from the previous trend. This change in land cover indicates that there is a high demand for land that will affect land conversion in the peak area in the future. The desire to convert the land into plantation areas and built-up land tend to increase in the Puncak Area. This can be seen from the increase in the area of plantation and built-up land in 2035. This is in line with the results of Dani’s research (2016) which states that the peak area is still considered capable of serving the needs of the surrounding community compared to other areas, this causes the attractiveness of this area to be quite high. Predictions of land cover change in 2035 can be seen in table 2.

| Land Use            | The year 2019 | The year 2035 | Area of Change |
|---------------------|---------------|---------------|----------------|
|                     | Area (hectare)| Area (hectare)|                |
| Forest              | 5,958         | 4,542         | -1,416         |
| Garden / Plantation| 5,155         | 5,544         | 390            |
| Field / Moor        | 1,785         | 1,614         | -171           |
| Built land          | 3,029         | 4,968         | 1,939          |
| Open field          | 32            | 32            | 0              |
| Rice fields         | 2,107         | 1,304         | -803           |
| Shrubs              | 263           | 324           | 62             |
| Water               | 42            | 42            | -              |
| Total               | 5,958         | 4,542         | -1,416         |

Based on table 2 above, it can be seen that from 2019 to 2035 there has been a decrease in the area of agricultural land in the peak area of Bogor Regency. The largest decrease was in rice fields and fields. Although there was an increase in the area of plantation land that was converted from forest land, a lot of plantation land was also converted into developed land and open land. The high demand for land for built-up areas greatly affects another land cover, with the demand for developed land, it will be marked by the development of supporting facilities and infrastructure so that it attracts community interest to invest causing an increase in land demand, this causes land conversion The conversion of agricultural land in the Puncak area will be a problem of decreasing the area of paddy fields which will affect the food security of the community. Also, the conversion of agricultural land into built-up land will affect the environmental ecology in the Peak area in particular which will have a major impact on the surrounding area at large... Also, the area of agricultural land in an area can be reduced due to land conversion which can cause a decrease in the carrying capacity of rice fields which will threaten the food security of the community. A graph of projected land cover change from 2019 to 2035 can be seen in Figure 3 and a map of the land cover change in 2019-2035 can be seen in Figure 4.
The area of decline in agricultural land in 2019-2035

| Area of Change | Forest | Garden / Plantation | Field / Moor | Built land | Open field | Rice fields | Shrubs | Water |
|----------------|--------|---------------------|--------------|------------|------------|-------------|--------|-------|
| -1,416         | 390    | -171                | 1,939        | -0         | -803       | 62          | -      | -     |

Figure 3. Graph of land changes for 2019-2035 in Puncak area

Figure 4. Prediction Map of Land Change in 2019-2035
5. Conclusions
The conversion of land functions in the top area of the regency tends to decrease agricultural land area. The area of agricultural land with the most decline in 2035 is rice fields. As for land, there was also a decline. In 2035 the land that tends to increase is a settlement. The results of this study indicate that land-use policy measures are needed to maintain agricultural land in the peak area. This research can also be used as input for the revision of the Regency Spatial Plan in the context of spatial use so that the area of agricultural land can be maintained.

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