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ESTIMATION OF ABOVE GROUND CARBON STOCKS AT LAND-USE SYSTEM IN KUNINGAN REGENCY

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A B S T R A C T

Role vegetation in binding carbon happens on during photosynthesis process. Land-use change from vegetate land to non-vegetate will increase GHGs through carbon release to atmosphere. Kuningan Regency is upstream region for some region in below. This research aims for knowing land cover and land-use and above ground carbon stocks in the Kuningan Regency. Geographical Information System (GIS) and remote sensing were used to determine the changes based on date series of Landsat satellite imagery. Estimating total carbon stocks determined basis of the land cover and land-use spatial data. Typically aboveground carbon stock density (ton C ha-1) obtained from Directorate of Forest Resource Inventory and Monitoring (IPSDH) in 2015. The result showed that there was largest potential of above ground carbon stocks in Kuningan derived from mix garden and forest that contribute reached 4.81 million ton C or 91.67% of total carbon stock potential. Carbon stock from mix gardens reached 2.27 million ton C or 43.37 % and 2.53 million ton C form forest or 48.29% of the total potential carbon stock, covering primary forests 1.52 million tons C (28.98%), pine and teak plantations 813,058.76 ton C (15.49%) and 200,790.92 ton C (3.82%) respectively.

Keywords **:** GIS, carbon stocks, land-use system

1. Introduction

About 20% of world Greenhouse Gases (GHG) emissions caused by deforestation, even in countries that have high biodiversity such as Indonesia and Brazil. Emission from land-use, land-use change and forestry in Indonesian at 2000 is estimated 2,563 Mt CO_2 or same with 20% of total emissions from land and forest change in the world, big partly contributor emission is deforestation and forest degradation (WWF, 2008; Helms, 1998).

As effort to reduce GHG, Indonesian government committed for emission decrease by 26% with own business and 41% with international donate on year 2020 (President Rule No. 61 of 2011 on National Action Plan-Decrease of Greenhouse Gases Emissions (RAN-GRK) and President Rule No. 71 year 2011 about Inventory of GHG) .

Role vegetation in binding carbon happens on during photosynthesis process. Land-use change from vegetate land to non-vegetate will increase GHGs through carbon release to atmosphere. Expected that between 1990-1999, land-use change give donations about 1.7 Gt $year^{-1}$ of total CO_2 emissions (Watson *et. al*., 2000, in Lusiana *et. al*., 2005)

Nasihin *et. al*. (2016) within 20 years (1994-2015) in Kuningan Regency there has been a change of land cover and land-use as vegetated land be use other, Forest nature 7.5%, 1.1% for forest plantations and mix gardens of 31.78%.

Kuningan Regency is upstream region for some region in below, i.e. Cirebon Regency in West Java Province and Brebes Regency in Central Java Province. Kuningan Regency plays a role as supplier's natural resource for area surrounding, especially water resources. Research aim for knowing land cover and land-use and above ground carbon stocks in the Kuningan Regency.

2. Methods

2.1. Study Sites

This study carried out in Kuningan Regency is located at the eastern-part West Java province, that geographically located at 108º 23'–108º 47' longitude and 6º 47'–7º 12' latitude with area reached 119,571 hectares. Bordering with Cirebon Regency in northern, Majalengka Regency in western, Ciamis Regency in the southern, and Brebes Regency, Central Java province in eastern. Kuningan Regency covering 32 subdistricts and 381 villages (Figure 1).

2.2. Landsat and Geospatial Data

Landsat 8 OLI (operational land imager) imagery Level 1T path 121 row 65 band 1-7 acquisition 2016 were used to produce land cover and land-use maps of Kuningan Regency, obtained from the United State Geological Survey (USGS) Global Visualization View (GloVis) via website http://glovis.usgs.gov/. Spatial resolution of Landsat 8 OLI images is 30 m with 7 spectral channels, ranging from 0.45-0.69 m in the visible spectrum and 0.76-2.35 m in the infrared spectrum. Each band represents different characteristics of wavelengths used to capture features on the earth surface.

Auxiliary geospatial data was required to support the analyses conducted in Kuningan Regency. Two main types of information needed are topography, administrative. Topography and administrative map to show the spatial distribution of land cover, land-use and carbon stocks above ground level in study area. Image data processing was performed using ENVI version 4.5 and Arc.Gis version 10.3 for vector-based data processing

2.3. Reference Data

Reference data were developed for each land cover and land-use type and then randomly divided for classifier training samples and accuracy assessment. Training samples for each

land cover and land-use types were used to classification of land cover and land-use types and accuracy assessment of the classification results. Reference data for training samples and accuracy assessment were obtained during field verification and based on interpreter knowledge of the appearance of data in representing the earth surface information in the image data. Global Positioning System (GPS) was used to record the position of training samples. A total of 10 land cover classes were identified during field data collection and 10,239 pixels (921.51 ha) were used for training samples and accuracy assessment.

2.4. Analysis

Land cover and land-use classification were conducted using supervised classification methods. Generally, supervised classification gives more good results than unsupervised classification (Helms, 1998).

Supervised classification is a classification method that provides guidance to computer in classification process. Supervised classification requires training samples that is representative of the classes specified. Training area that has been obtained then can be used as input in the process of classification for the overall image of the same. For classifier training samples was used with maximum likelihood classification.

Estimating total carbon stocks determined basis of the land cover and land-use spatial data. For specify total carbon stocks is accumulation from carbon stocks each land cover and land-use types per unit area (ton C ha^{-1}) multiplied with area in each class. Typically aboveground carbon stock density (ton C ha-1) obtained from Directorate of Forest Resource Inventory and Monitoring (IPSDH) in 2015 such as shown in table 1.

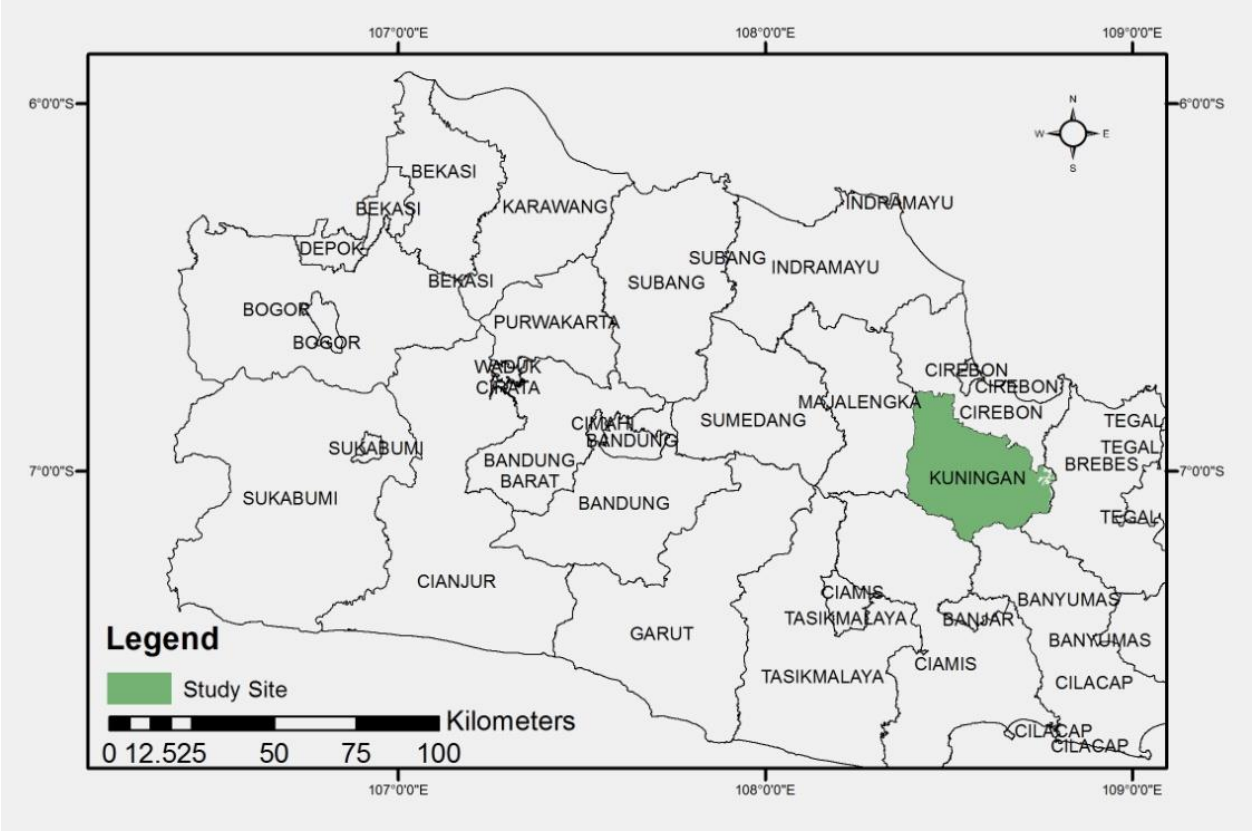

Figure 1. Study Sites

Table 1. National Scale Carbon Stocks of Land-use and Land Cover Types

No	Land Cover and Land-Use	Carbon Stock (C ton ha^{-1})
1	Primary Forest	132.99
2	Secondary Forest	98.84
3	Forest Plantation	98.38
4	Grass and Shrubs	30.00
5	Plantation / Mix Garden	63.00
6	Settlement	4.00
7	Bare land	2.50
8	Water Body	0.00
9	Cropland	10.00
10	Paddy fields	2.00

Source: Directorate of IPSDH, 2015

3. Results

3.1. Image Classification

Classification process to produce land cover and land-use classes based only on spectral characters derived from training samples. Spectral separability analysis is used for selecting classes and training data for classification. Spectral separability was calculated using Jeffries-Matusita (J-M) Distance that measures the divergence between spectral means. The J-M distances values range from 0 to 2, where values greater than 1.9 are highly separable, and value less than 1.0 require class clumping or new training data for traditional mean-based classification methods.

In this study training samples distributed for each land cover and land-use types with value of J-M distance1.984 in average. This value the showing each land covers and land-use are highly separable. In supervised classification, training areas are used to define spectral patterns/signature for a specific land cover feature. The signature will then be used by a set of classifiers to identify similar patterns of characteristics over all the area of interest. The result will be an image categorized into a number of land cover types. Maximum likelihood algorithm used as supervised classification using 1-7 band combinations.

Accuracy assessment of classification used error matrices (confusion matrix) as cross-tabulations of the mapped class versus the reference class were used to assess classification accuracy (Congalton & Green, 1999). Overall accuracyand the Kappa statistic were then derived from the error matrices. Accuracy assessment showed overall accuracy 93.17 %, with kappa statistic of 92%, indicating that the classification can be trusted because the Kappa value belonging to the high category is more than 0.8 (Landis and Koch 1977 in Congalton and Green 1999). For Kappa's statistical values, Monserud and Leemans (1992) in Gutierrez *et. al.* (2012) suggests that values higher than 0.85 represent excellent suitability between classification results and references, and has met the truth and accuracy of classification (Jensen 1986).

Image classification result of Landsat OLI 2016 show land cover and land-use in Kuningan Regency classified to 10 class, ie primary forest, pine and teak forest/plantation, mix garden, settlements, cropland, paddy fields, grass and shrubs, bare land, and water body.

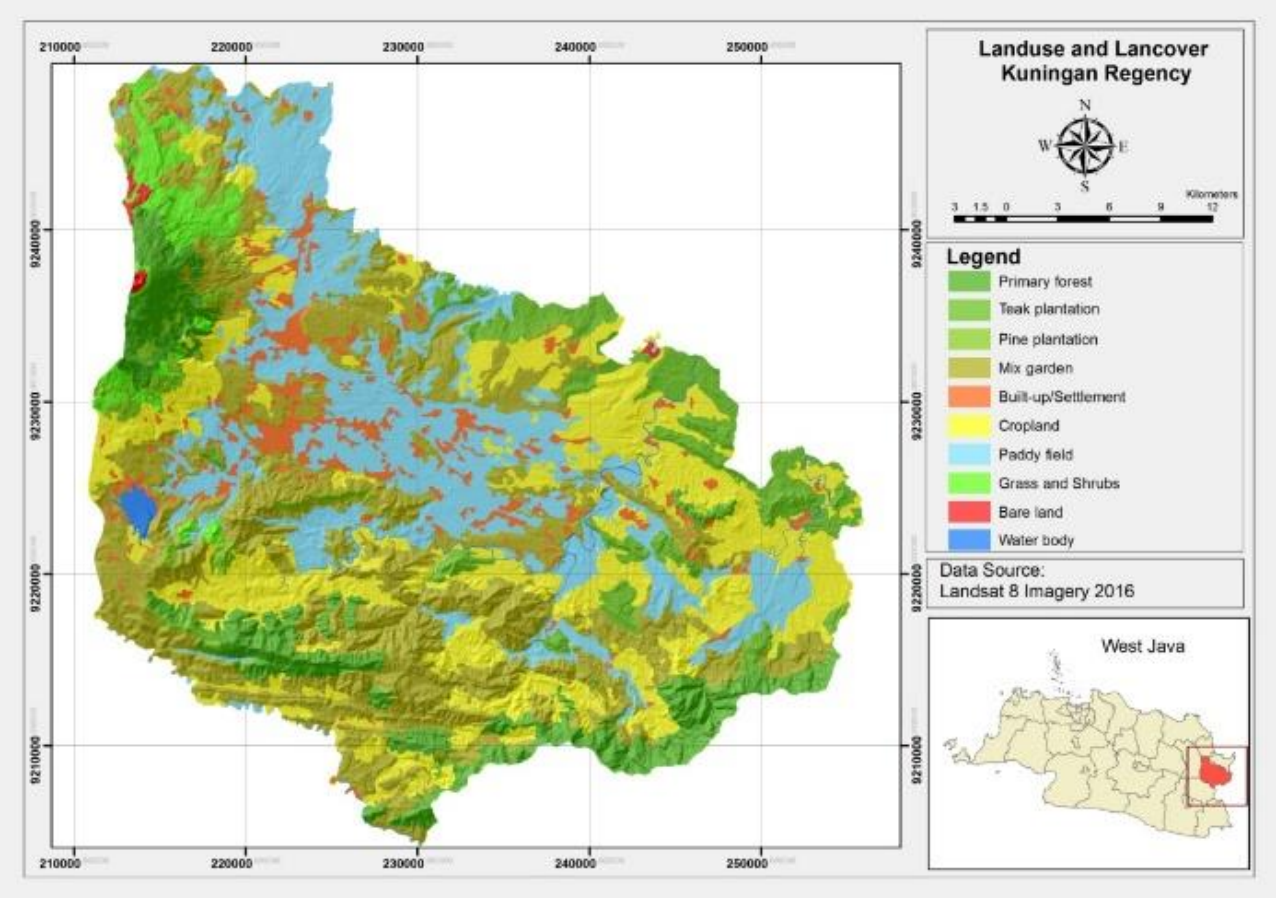

Figure 2. Land-Use and Land Cover Map of Kuningan Regency 2016

Land cover and land-use in Kuningan Regency dominated by mix garden 36,155.86 ha or 30.34% of total area of Kuningan Regency, and than cropland 26,019.11 ha (21.83%), paddy fields 24,383.17 ha (20.46%), and forest 21,777.78 ha (18.27%) covering primary forests, pine and teak forest/plantations. Spectral similarity causes the reflectance value of mix garden similar to natural forest and teak forest and vice versa (Prasetyo *et. al.* 2012) and on actual condition in field composition and vegetation structure of mixed garden have similarity with natural forest and teak plantation.

Table 2. Land Cover and Land-Use in Kuningan Regency 2016

No	Land Cover and Land -Use	Area (Hectares)	Percentage
1	Primary Forest	11,457.55	9.61%
2	Teak Forest Plantation	8,278.85	6.95%
3	Pine Forest Plantation	2,041.38	1.71%
4	Mix Garden	36,155.86	30.34%
5	Settlement	6,128.58	5.14%
6	Cropland	26,019.11	21.83%
7	Paddy fields	24,383.17	20.46%
8	Grass and Shrubs	3,445.23	2.89%
9	Bare land	320.62	0.27%
10	Water Body	937.53	0.79%
	Total	119.167.87	100%

Source: Landsat 8 Image Analysis

3.2. Above Ground Carbon Stocks

Total above ground carbon stocks in Kuningan regency reach 5,254,492.44 C tons. Carbon stocks for each land cover and land-use types are shown in table 3. Spatial distribution above ground carbon stock is shown in figure 2.

Table 3. Carbon Stocks Based on Land Cover and Land-Use Types in Kuningan Regency 2016

No	Landuse and Land Cover	Carbon Stock (C ton)	Percentage
1	Primary Forest	1,523,739.04	29.00%
2	Teak plantation	814,473.07	15.50%
3	Pine plantation	200,831.06	3.82%
4	Mix Gardens	2,277,819.12	43.35%
5	Settlement	24,514.31	0.47%
6	Cropland	260,191.07	4.95%
7	Paddy fields	48,766.34	0.93%
8	Grass and Shrubs	103,356.87	1.97%
9	Bareland	801.55	0.02%
10	Water Body	0.00	0.00%
	Total	**5,254,492.44**	**100%**

The largest potential of above ground carbon stocks in Kuningan derived from mix garden and forest that contribute reached 4.81 million ton C or 91.67% of total carbon stock potential. Carbon stock from mix gardens reached 2.27 million ton C or 43.37 % and 2.53 million ton C form forest or 48.29% of the total potential carbon stock, covering primary forests 1.52 million tons C (28.98%), pine and teak plantations 813,058.76 ton C (15.49%) and 200,790.92 ton C (3.82%) respectively.

4. Conclusion

Land cover and land-use in Kuningan Regency 2016 dominated by mix garden 36,155.86 hectares (30.34%), cropland 26,019.11 hectares (21.84%), paddy fields 24,383.17 hectares (20.46%), and forest 21,777.78 hectares (18.27%) . The largest potential of above ground carbon stocks in Kuningan derived from mix garden and forest that contribute reached 4.81 million ton C or 91.67% of total carbon stock potential. Carbon stock from mix gardens reached 2.27 million ton C or 43.37 % and 2.53 million ton C from forest or 48.29% of the total potential carbon stock, covering primary forests 1.52 million tons C (28.98%), pine and teak plantations 813,058.76 ton C (15.49%) and 200,790.92 ton C (3.82%) respectively.

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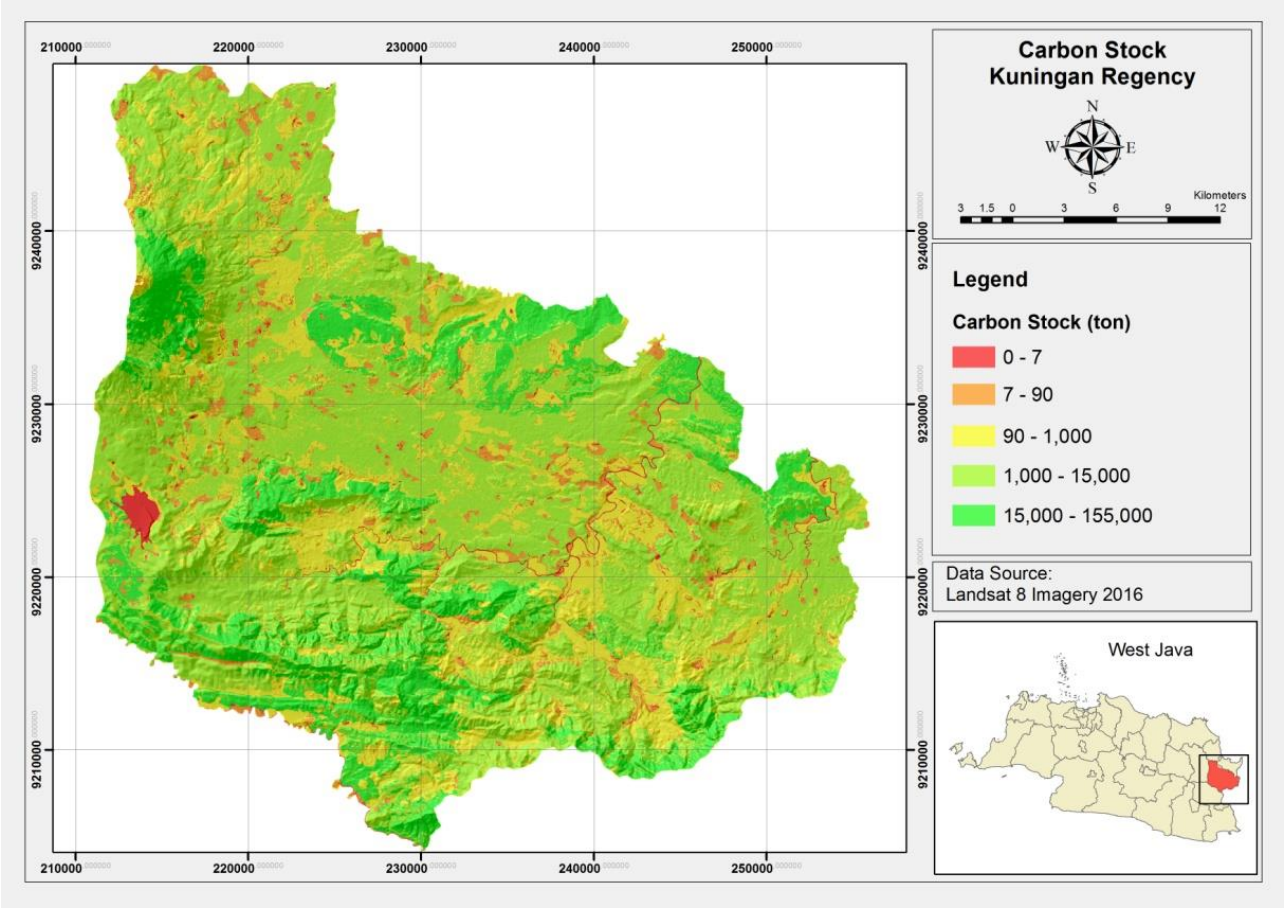

Figure 3. Spatial distribution of Carbon Stock in Kuningan Regency