Mapping of carbon absorption based on land use in upstream of Jeneberang watershed

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Abstract. This study aims to map land cover based on satellite imagery and identify carbon absorption in various land-use patterns. Data is collected by the observation method in the field and direct measurement based on the diameter of the tree to get the value of biomass. Biomass calculations are done using allometric equations, while carbon absorption values are calculated using IPCC GL 2006 software. The results of the study show that the upstream area of the Jeneberang watershed based on Alos imagery is dominated by dry land agriculture 48.94%, paddy 17.79%, shrubs 13.77%, and secondary forests 8.94% of the total area. Primary forest, secondary forest, and plantation forest are the biggest carbon storage areas in the upstream area of the Jeneberang watershed. Based on the IPCC GL 2006 software, primary forests, secondary forests, and plantations have carbon sinks of 42.08, 14.42, and 5.23 tons/ha/year, respectively.

1. Introduction

Global warming is defined as an increase in the earth's surface temperature by greenhouse gases (GHGs) due to human activities [1], which results in climate change. This results in various disasters, such as flash floods, landslides, whirlwinds, drought, and other disasters that can threaten human lives. In addition to the bio-geophysical impact, global warming also impacts on the socio-economic community, such as disruption to the function of coastal areas and coastal cities, disruption to the functioning of facilities and infrastructure, disruption to residential settlements, and reduction of agricultural land productivity [2]. In an article on global warming written by Green Indonesia [3], global warming also affects human health. The emergence of various disasters causes the emergence of various diseases, especially those related to heat (heat stocks). In addition, disruptions to human settlements have resulted in many displacements that can accelerate the spread of plague and disease.

Greenhouse gases (GHGs) have occurred since the early formation of the earth, where this serves to maintain the earth's temperature. However, the current GHG phenomenon is caused by increasing uncontrolled exhaust gases into the atmosphere due to human activities [4]. According to the Framework Convention on Climate Change (UNFCCC) in [1], which includes GHG compounds include Carbon dioxide (CO₂), Methane (CH₄), Nitrous oxide (N₂O), Perfluoromethane (CF₃), Perfluoroethane (C₂F₆), Perfluorobutane (CH₂C₂F₁₀), Sulfur hexafluoride (SF₆), HFC-23 (CHF₃), HFC-32 (CH₂F₂), and other compounds. Chemically, most of the GHGs contain carbon. However, the concern is the major air pollutants, namely Carbon monoxide (CO) and Carbon dioxide (CO₂).

The main cause of the increase in CO and CO₂ in the atmosphere is the increase in emissions of fossil fuels (exhaust gases from industry and motor vehicles), as well as a large number of forest area functions. Both causes have a very close relationship. The development of the industry and the
increasing number of motor vehicles that produce CO and CO$_2$ are accompanied by the reduction of forest area that functions as CO and CO$_2$ absorbers cause an imbalance of the carbon cycle, where the carbon produced is greater than that absorbed.

One of the ways to reduce and prevent uncontrolled increases in CO and CO$_2$ is good land management. Forest land management is one of the watershed management activities. This is related to human activities in the context of meeting the needs of life and the continued use and availability of natural resources. However, the existence of natural resources is also needed in ecological services (the function of forests as carbon sinks). This explanation is the reason for this research, which is to find out and map carbon absorption in various types of land use found in the upstream Jeneberang watershed.

Upstream of the Jeneberang watershed, there are two Sub-watersheds, namely the Malino Sub-watershed and the Lengkese Sub-watershed, and a portion of the Jeneberang downstream watershed. Jeneberang watershed is a source of life for people who live in the Makassar city area. In addition to being a source of life for the community, the Jeneberang watershed is also included in the Mamminasata area, which is an integrated city development planning area for the Makassar region and surrounding areas.

2. Research Methodology
The study was conducted in the upstream area of the Jeneberang watershed. This activity is based on mapping, which is classified as non-experimental research using survey methods. Data will be analyzed using spatial analysis with overlay techniques. The data source in this activity is in the form of primary data and secondary data. Primary data is data obtained through direct observation and measurement in the field, in the form of tree biomass, age class, and stand type data in forested areas. While, secondary data is data concerning the general condition of the research location obtained from literature studies and other data, directly and indirectly, related to the research, including satellite imagery, administrative maps, Jeneberang watershed maps, soil type data, land capability classes, and data climate. The stages of the study consisted of field orientation, land use mapping, and measurement of stand biomass.

The field orientation activity aims to provide an initial overview of the conditions of the study site so that the research activities are better directed and structured properly. Land use mapping is done by the interpretation and delineation of satellite imagery, land use classification based on [5] presented in Table 1.

| No. | Land use classification | Land category |
|-----|------------------------|---------------|
| 1   | Forest land (FL)       | Primary dryland forest  
|     |                        | Primary swamp forest  
|     |                        | Primary mangrove forest  
|     |                        | Secondary dryland forest  
|     |                        | Secondary swamp forest  
|     |                        | Secondary mangrove forest  
|     |                        | Plantation forest  
|     |                        | Other areas of use  
| 2   | Cultivated land (CL)   | Agriculture  
|     |                        | Shrub farming  

Table 1. Land use classification on IPCC GL 2006.
3. Result and discussion

3.1. Land use mapping

Based on spatial analysis using satellite imagery, it shows that the research site consists of several types of land use, namely primary forest, secondary forest, plantation forest, wetland agriculture, dryland agriculture, plantation, grassland, shrub, settlement, and body water. A map of land cover in the upstream Jeneberang watershed is presented in figure 1 and table 2.

Figure 1. Land use map in the upstream of Jeneberang watershed.
Table 2. Area and percentage of land use in the upstream of Jeneberang Watershed.

| No. | Land-use type         | Area (ha) | Percentage (%) |
|-----|-----------------------|-----------|----------------|
| 1   | Primary dryland forest| 141.54    | 0.37           |
| 2   | Secondary dryland forest| 3,444.33  | 8.94           |
| 3   | Plantation forest     | 1,343.54  | 3.49           |
| 4   | Rice field            | 6,852.24  | 17.79          |
| 5   | Meadow                | 182.93    | 0.49           |
| 6   | Settlement            | 409.95    | 1.06           |
| 7   | Agriculture           | 18,852.18 | 48.94          |
| 8   | Shrubs                | 5,304.54  | 13.77          |
| 9   | Plantation            | 173.94    | 0.45           |
| 10  | Water                 | 1,819.21  | 4.72           |
|     | Total                 | 38,524.40 | 100.00         |

Agriculture is the most dominant land cover, based on the results of the calculation of agriculture reached 50.53%, which is equal to 18,852.18 ha from the area of the study. In addition to agriculture, the area is dominated by the closing of rice fields and shrubs with an area of 6,852.24 ha (18.43%) and 5,304.54 ha (14.76%). In addition to the land cover that has been mentioned, there are several other land covers such as secondary dryland forests, plantation forests, settlements, meadow, plantations, and primary dryland forests.

3.2. Actual carbon absorption

Biomass is the total weight or volume of an organism in a certain area or volume. Biomass is also defined as the total amount of living matter on the surface of a tree and is expressed in units of tons of dry weight per unit area [6]. Biomass can be used as a basis for calculating forest management activities because forests can be considered as carbon sinks and sources [8].

Tree biomass is produced from an allometric equation based on measuring the diameter of the trunk at breast height; this is done to reduce damage during the measurement. Calculation of biomass in tons per hectare and annual biomass increase over land in each plot for the primary forest, secondary forest, and plantation forest are presented in Table 3 and Table 4.

Table 3. Above-ground biomass value.

| Plots | Primary dryland forest (ton/ha) | Secondary dryland forest (ton/ha) | Plantation forest (ton/ha) |
|-------|---------------------------------|-----------------------------------|---------------------------|
| 1     | 2,621.53                        | 328.03                            | 750.08                    |
| 2     | 2,700.71                        | 1,218.47                          | 219.40                    |
| Total | 5,322.24                        | 1,546.50                          | 969.47                    |
| Average| 2,661.12                        | 773.25                            | 484.74                    |

Table 4. Biomass value-added.

| Plot | Primary dryland forest (ton/(ha*year)) | Secondary dryland forest (ton/(ha*year)) | Plantation forest (ton/(ha*year)) |
|------|---------------------------------------|----------------------------------------|----------------------------------|
| 1    | 70.66                                 | 17.97                                  | 15.00                            |
| 2    | 85.47                                 | 35.52                                  | 4.39                             |
| Total| 156.13                                | 53.50                                  | 19.39                            |
| Average| 78.06                               | 26.75                                  | 9.69                             |
The results of biomass calculations on various land-use patterns are shown in Table 5.

### Table 5. Biomass value in various land-use patterns.

| No. | Land-use type             | Aboveground biomass per ha (ton/ha) | Total biomass per ha (ton/ha) |
|-----|---------------------------|-------------------------------------|-----------------------------|
| 1   | Primary dryland forest*   | 2,661.12                            | 2,927.23                    |
| 2   | Secondary dryland forest* | 773.25                              | 850.57                      |
| 3   | Plantation dryland forest*| 484.74                              | 533.21                      |
| 4   | Rice field**              | 4.80                                | 4.80                        |
| 5   | Meadow**                  | 31.40                               | 31.40                       |
| 6   | Settlement***             | 2.00                                | 2.00                        |
| 7   | Agriculture***            | 16.00                               | 16.00                       |
| 8   | Shrubs**                  | 50.97                               | 50.97                       |
| 9   | Plantation***             | 126.00                              | 126.00                      |
| 10  | Water***                  | 0                                   | 0                           |
|     | Grand total               | 3,032.93                            | 3,313.11                    |

Note: *) Calculations using the Allometric Equation and the IPCC GL 2006 Tool. ***) Values Based on Research from [9].

Based on the calculation data above, it shows that primary dryland forests have the largest total biomass reserves of 2,661.12 tons/ha compared to secondary dryland forests, plantation forests, settlements, rice fields, agriculture, plantations, meadow, and shrubs. The waterbody biomass value of 0.00 is due to not overgrown by plants.

The biomass potential of a land cover is closely related to the carbon cover of the land cover. Carbon reserves are an indicator of land management to maintain land productivity and global environmental change. The carbon reserves at the location of this study can be seen in table 6.

### Table 6. Carbon stock value in different patterns of land use.

| No. | Land-use type       | Area (Ha) | Carbon stock Per ha (ton/ha) | Total Carbon stocks (ton) |
|-----|---------------------|-----------|-------------------------------|---------------------------|
| 1   | Primary dryland forest | 141.54    | 1,434.34                      | 203,017.00                 |
| 2   | Secondary dryland forest | 3,444.33  | 416.78                        | 1,435,529.98               |
| 3   | Plantation forest    | 1,343.54  | 237.52                        | 319,118.69                 |
| 4   | Rice field           | 6,852.24  | 2.40                          | 16,445.38                  |
| 5   | Meadow               | 182.93    | 15.70                         | 2,872.00                   |
| 6   | Settlement           | 409.95    | 1.00                          | 409.95                     |
| 7   | Agriculture          | 18,852.18 | 8.00                          | 150,817.46                 |
| 8   | Shrubs               | 5,304.54  | 25.49                         | 135,186.20                 |
| 9   | Plantation           | 173.94    | 63.00                         | 10,958.22                  |
| 10  | Water                | 1,819.21  | 0                             | 0                          |
|     | Grand total          | 38,524.40 |                                | 2,274,354.89               |

Carbon stocks in each land-use system differ, depending on the diversity and density of existing plants, soil types, and how they are managed [10], as in the results of analyzes using IPCC GL 2006 in
Table 6., it can be seen that primary dryland forests have the largest actual carbon stock value per ha than other land-use patterns, which is 1,434.34 tons. According to Sukmana [10], long-lived plants or trees that grow in forests are a place for storing carbon, which is much larger than annual crops or other land uses. Therefore, natural forests with a diversity of long-lived and littering trees are the highest carbon storage sheds. The lowest amount of carbon stock is the water, settlements, and rice fields, which is 0.00, 1.00, and 2.40 tons/ha. This is because it is not dominated by trees.

Biomass reserves, carbon stocks, plant age, climate, topography, land characteristics, and vegetation density determine the amount of carbon absorption from each land use. As for carbon absorption in various land uses contained in the location of this study presented in table 7.

| No. | Land-use type       | Area (ha) | Carbon absorption Per Ha (Ton/ha/year) | Total Carbon absorption (Ton/year) |
|-----|---------------------|-----------|---------------------------------------|-----------------------------------|
| 1   | Primary dryland forest | 141.54    | 42.08                                 | 5,955.46                          |
| 2   | Secondary dryland   | 3,444.33  | 14.42                                 | 49,659.37                         |
| 3   | Plantation forest   | 1,343.54  | 5.23                                  | 7,020.61                          |
| 4   | Rice field          | 6,852.24  | 2.40                                  | 16,445.38                         |
| 5   | Meadow              | 182.93    | 5.23                                  | 957.33                            |
| 6   | Settlement          | 409.95    | 0.20                                  | 81.99                             |
| 7   | Agriculture         | 18,852.18 | 8.00                                  | 150,817.46                        |
| 8   | Shrubs              | 5,304.54  | 5.10                                  | 27,037.24                         |
| 9   | Plantation          | 173.94    | 12.60                                 | 2,191.64                          |
| 10  | Water               | 1,819.21  | 0                                     | 0                                 |
|     | Grand total         | 38,524.40 |                                       | 260,166.49                        |

Based on the calculation results shown in Table 7, primary dryland forests have the highest amount of carbon absorption, which is 42.08 tons/ha/year. As for the overall carbon absorption, agriculture is the highest, amounting to 150,817.46 tons/year. This is because agriculture has the largest area in the upstream of the Jeneberang watershed, which reaches 50.53%. The lowest carbon absorption is found in settlements and water bodies, namely 0.20 and 0.00 tons/ha/year, with a total carbon absorption of 81.99 and 0.00 tons/year.

4. Conclusion
1. Land use patterns contained in the upstream of Jeneberang watershed are primary dryland forests, secondary dryland forests, plantation forests, settlements, rice fields, agriculture, plantations, shrubs, meadow, and water. The biggest land cover of the total area is agriculture, and the smallest is the primary dryland forest.
2. Agricultural is the biggest carbon sinks in the upstream of Jeneberang watershed and the lowest in the water.

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