Biomass analysis and carbon reserve on some cocoa planting systems in Bantaeng district

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Abstract. Cocoa plantations have ecological functions as carbon sinks and depositors. Cocoa absorbs CO₂ during photosynthesis, then converts it to carbohydrates by storing it in the form of biomass in roots, trees, and leaves. The purpose of this study was to determine the carbon uptake of cocoa trees and tree growers, undergrowth, necromasses, carbon uptake at the root and carbon uptake in soils in several cocoa planting systems implemented in Bantaeng Regency, South Sulawesi. Sampling is done by a purposive sampling method with the basic consideration of the type, density and cropping system applied. Biomass estimation is used the non-destructive method by measuring the diameter at breast height (DBH, 1.3 m) and height of cacao and shade plants. Carbon storage in cocoa plants is distinguished by several cropping systems, namely K1 (monoculture harvesters) and K2 (multistara harvesters). The results showed that carbon reserves in Bantaeng Regency were 32.38 tons/Ha.

1. Introduction

The history of human civilization is a decisive transition. A world marked by environmental degradation in various dimensions has sent danger signals that threaten the sustainability of life. As a result of human activity, the earth, sea and air that support life of living things are now increasingly unfriendly. Wasteful consumption of fossil energy, on the one hand, has created comfort in life. But on the other hand, has made the earth's atmosphere like a giant vessel filled with exhaust gases whose volume is getting bigger. Emissions of greenhouse gases called greenhouse gases (GHGs) make the temperature on earth rise. It is estimated, this century the earth's temperature rose by one to three degrees Celsius [1]. That has the potential to change climate patterns in the extreme.

The final change due to global warming has become a common vocabulary in everyday community conversation, especially among scientists. However, this phenomenon is still not properly understood by the public so it is not uncommon for misunderstandings or difficulties to distinguish between climate change and climate variations that sometimes occur with rather extreme symptoms. As we have often experienced the existence of the dry season or the rainy season which is very long. The issue of global warming is warm, given the emergence of a very large impact on life in the world that is suspected to be the cause of global climate change with various consequences it causes.

Greenhouse Gases (GHGs) are widely discussed along with the issue of global warming (global warming). GHG is a gas found in the atmosphere that is as a greenhouse (emitting infrared irradiation). The relationship between GHG and global warming is solar radiation in the form of short
waves received by the surface of the earth, then emitted back into the atmosphere in the form of long waves (infrared radiation) into space, but by GHG re-emitted to the surface of the earth, causing heat called the greenhouse effect. The main GHGs in the atmosphere are carbon dioxide (CO$_2$), methane (CH$_4$), nitrogen oxides (N$_2$O), and ozone (O$_3$) [2]. Global warming is a global phenomenon that is triggered by human activities, especially those related to the use of fossil materials and land use change activities. This activity produces gases that are increasingly increasing in number in the atmosphere, especially carbon dioxide (CO$_2$) gas. This CO$_2$ gas is the culprit of global warming through a process called the greenhouse effect. The increase in the concentration of CO$_2$ in the atmosphere is very prominent, in 2017 it reached 405.5 ppm which increased from 403.3 ppm in 2016 and 400.1 ppm in 2015 [3].

One of the efforts made to help reduce CO$_2$ emissions is to maintain the plantation ecosystem. Plants have a role in mitigating climate change, which can reduce the amount of emissions and / or increase CO$_2$ absorption and carbon sequestration. Long-lived trees that grow in the forest and in mixed gardens (agroforestry) are a large carbon storage or storage area compared to annual crops [4]. Cocoa as one of the many plantation commodities developed in Indonesia has a strategic position in efforts to increase carbon sequestration to reduce the rate of global warming [5].

As a woody plant, cocoa can absorb CO$_2$ from the air and stored in the form of carbon (C) in its body (biomass). The process of CO$_2$ absorption also influences the rate of plant photosynthesis as the main ingredient in the decomposition of carbon in the body of the plant, especially cocoa. Thus measuring the amount of C levels stored in the body of living plants (biomass) in a field can describe the amount of CO$_2$ in the atmosphere absorbed by plants. The greater the biomass of cocoa plants, the higher amount of CO$_2$ absorbed so that the CO$_2$ content in the air will decrease.

One way to measure biomass in plants using destructive methods is by weighing the dry weight of the whole plant. However, it is not possible to measure productive and annual plants and large size so that an allometric approach is needed. Measurement of plant biomass using allometric equations is a method that has been developed to estimate carbon stored in plant bodies. Geometrically plant biomass has a relationship that is parallel to the diameter of the plant, the density of wood and plant height [6]. The basic principle of the allometric approach is that the plant canopy is assumed to be a tube so that the calculation of plant volume is based on the formula of plant volume. Measurement of plant biomass is reported to be approachable based on plant height [6] and stem diameter [7].

This research is expected to find out how many changes can be obtained from the existence of cocoa plantations in South Sulawesi and from what components cause changes in cocoa plantations in South Sulawesi.

2. Methodology

The research sites in the community cocoa plantations in the three regencies were selected 3 (three) sub-districts which became the research locations namely East Luwu District (Burau, Wotu and Mumpangana Districts), Pinrang District (Patampanua, Batulappa and Lembang Districts) and Bantaeng District (Gantarangkeke District), Tompobulu, and Eremerasa. The soil analysis was carried out at the Soil Science Laboratory of the Faculty of Agriculture, Universitas Hasanuddin.

2.1. Data analysis

There are three categories of cocoa plantations that become research indicators, namely (K0) cocoa plantations as a control (without rare shade / shade), (K1) cocoa plantations with monoculture shade and (K2) cocoa plantations which are generally diverse or multistrata. The measurement of dry weight is distinguished from the main plant biomass, biomass of shade plants or other trees and then also measured necromass and understory biomass.

Data analysis is in the form of identifying vegetation types of land cover both trees and understory and analyzing the potential for carbon storage of plants and soil organic C content. To estimate tree biomass, allometric models of Indonesian tropical tree species [7] are used, as shown in Table 1.
Table 1. Allometric equations for knowing the biomass of trees in a cocoa plantation.

| Tree    | P  | Allometric Formula       | Source |
|---------|----|--------------------------|--------|
| Cacao   |    | BK = 0.1208 D^{1.98}     | [8]    |
| Gamal   | 0.74 | BK = 0.11 \rho D^{2.62}  | [7]    |
| Clove   | 1.20 | BK = 0.11 \rho D^{2.62}  | [7]    |
| Coconut | 0.66 | BK = 0.11 \rho D^{2.62}  | [7]    |
| Banana  |    | BK = 0.030 D^{2.13}      | [9]    |

where BK = Dry weight (kg / tree), D = tree diameter or dbh (1.3 m), \( \rho \) = wood specific gravity (g/cm³)

2.2. Implementation stage

The activity begins with the preparation of sample plots and continues with data collection of trees, undergrowth, necromass (litter), and soil.

2.2.1. Making the sample plot. Sample plots were made with a size of 40 m x 5 m on land that contained the most types of plants. Observation plots were measured with a meter and pegged at each angle then wrapped around a raffia rope as a sample plot boundary.

2.2.2. Data collection of trees, plants, and necromass. For estimating tree biomass data needed is the diameter of the tree, tree height, tree species, and tree specific gravity. Thus all tree species in the sample plot are measured in diameter (without doing damage to plants / trees) at a height of 1.3 m from the ground surface (Diameter at Chest Height or Diameter at Breast Height = DBH) and height with a hetereter. For the estimation of biomass under plant data is needed is the wet and dry weight of the plant. Thus all lower strains in the 1 m x 1 m plot (by destroying / cutting plants) are recorded in their type and put on an envelope and labelled for each sample plot. Furthermore, weighing the plant wet weight. For the dry weight of plant biomass, it is enough to take 300g as a sub-sample and if the plant biomass is <300g, then all of it is made into a sub-sample to be dried at 800C for 48 hours or until it reaches constant dry weight. For estimating necromass and litter biomass data needed is the wet and dry weight of necromass. Thus all litter types (in 1 m x 1 m plots) representing thick, medium and rare necromass (10 samples) were put in a container and labeled, then weighed their wet weight. As for the dry weight of necromass biomass, it is enough to take 300g as a sub sample and if the necromass is <300g, then all the necromass is used as a sub sample to be dried at 800C for 48 hours or until it reaches a constant dry weight. Similarly, all dead trees in the sample plot were measured for diameter and length, and took samples of wood measuring 10 cm x 10 cm x 10 cm to weigh their wet weight, and dry weight after being ovulated for 48 hours at 800C.

2.2.3. Land Data Retrieval. For soil C estimation data, soil sampling is performed on each sample plot and soil analysis is carried out in the form of soil texture, soil density, pH, CEC, and organic C.

3. Results and discussion

3.1. Carbon saved

The results of the calculation of stored carbon indicate that variations in the composition of plant species will provide variations in the amount of carbon stored in a planting area. Details of the amount of carbon stored in various plant species compositions in various cropping patterns are presented in Table 2.
Table 2. Amount of carbon stored in various patterns of plant type composition in South Sulawesi cocoa plantation.

| Locations               | Cropping Patterns | Carbon Sequestration | Total C |
|-------------------------|-------------------|----------------------|---------|
|                         |                   | C1   | C2   | C3   | C4   | C5   |
| Kec. Gantarangkeke Desa Gantarangkeke | K2               | 15.43 | 2.05 | 3.08 | 3.09 | 10.18 | 33.82 |
| Kec. Tompobulu Desa Patalassang | K2               | 19.21 | 2.20 | 3.30 | 3.84 | 12.99 | 41.54 |
| Tompobulu Desa Tombolo | K1               | 10.21 | 2.75 | 4.13 | 2.04 | 7.89  | 27.02 |
| Kec. Eremerasa Desa Barua | K1               | 8.99  | 2.45 | 3.68 | 1.80 | 10.24 | 27.15 |
| **Average**             |                   |       |      |      |      |       | **33.19** |

where C1 = Carbon Absorption of Cocoa + Shade Trees, C2 = Uptake Carbon Absorption, C3 = Nekromasa + Litter Carbon Uptake, C4 = Root Carbon Uptake, C5 = Carbon Absorption in the Soil

Table 2 shows that the composition of cocoa plantations in the K2 pattern absorbs the most carbon. This illustrates that the agroforestry cocoa cultivation pattern is right to support sustainable agriculture. Aside from making tangible and diverse contributions, agroforestry also functions as a conservation of the environment and social conditions so as to guarantee a wider economy and higher food security. Thus cocoa plantations have the potential to play a dual role, namely as producers of economic value commodities and as environmental conservation in terms of carbon sequestration.

3.2. Carbon emissions

Carbon emissions from land cover changes from plantations to plantations based on historical land use are the difference between carbon stored in plantations and carbon stored in plantations. The carbon stored in plantation forests in Sulawesi [8] is 92.65 t/ha. Thus carbon emissions that occur in Bantaeng Regency are:

$$\Delta CA = 92.65 - 32.38 = 60.07 \text{ t/ha}$$

Based on the above calculation, the composition of land cover that is quite dense will provide the lowest carbon emissions and vice versa land cover composition that provides the greatest carbon emissions. The carbon emissions in Bantaeng Regency are 60.07 t/ha.

3.3. Content of CO2

The amount of carbon dioxide absorbed in the sample plot area is calculated by multiplying the amount of carbon stored in the sample plot by the ratio of molecular weights of carbon dioxide and carbon elements, which is 44/12 or 3.67 [9]. The amount of CO2 content in the composition of land cover types in Bantaeng Regency is $3.67 \times 32.07 \text{ tons C} / \text{ha} = 117.70 \text{ tons CO}_2 / \text{ha}$.

4. Conclusions

Based on the results of the calculation of carbon stored in cocoa plantations in South Sulawesi, it can be concluded that the level of carbon sequestration in Bantaeng Regency is 32.38 tons C / ha. The amount of carbon emissions absorbed is 60.07 t/ha. In terms of CO2 content in the composition of land cover is 117.70 tons CO2 / ha. From the five components of carbon sequestration namely carbon uptake of cocoa trees and shade, carbon uptake of undergrowth, carbon uptake of necromase and litter,
uptake of root carbon, uptake of carbon in the soil that absorbs carbon the most is cocoa trees and its shade.

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