Estimation of the potential of understorey and litter carbon on the shrub bush vegetation in Aceh Besar District

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Abstract. The distribution of shrub vegetation is almost evenly distributed in Aceh Besar district. The desire to see the carbon potential in this vegetation and treat it - future treatment will be carried out both reforestation and soil management to increase carbon stock for the future. Therefore, it is necessary to research and determine how much carbon potential is in scrub vegetation in the district Aceh Besar by making plots according to field conditions. Then, decided each vegetation growth on seedling plot sizes with a minimum area of 4 m2 (growth rate woody vegetation < 2 cm in diameter with a height = 1.5 m) and minimal stake plot area 25 m² (growth rate of woody vegetation with a diameter of 2 cm to <10 cm). Each plot, both seedling and sapling plots, was repeated five times. Vegetation Shrubs <2 cm in size are dominated by Teki grass (Cyperus rotundus) and Putri Malu (Mimosa pudica). For shrub vegetation measures 2 cm - 10 cm across dominance by Acacia mangium plants. The total amount of plant carbon biomass is 2,053,546.33 tonnes/ha, a C value of 964,990.26 tonnes/ha, and the potential for CO2 absorption at plants amounting to 3,540,455.15 tonnes/ha on shrub vegetation in the district Aceh Besar.

1. Introduction.
The problem faced by many developing countries is the condition of environmental degradation due to uncontrolled CO₂ emissions in the atmosphere [1]. Many parts of the world are experiencing drought, and land cannot be used for agricultural management due to climate change. Continued changes in temperature and rainfall will lead to increased soil and water degradation. Human activities in land management have a more significant impact on soil conditions than make the indirect impacts of climate change [2]. Anthropogenic CO₂ emissions can occur directly in the forestry sector, and other land uses, such as deforestation, land clearing for agriculture, and land degradation [3,4].

Global warming is due to the energy imbalance between the earth and the atmosphere. This balance is influenced, among other things, by an increase in carbonaceous gases or better known as greenhouse gases. The concentration of GHG in the atmosphere increases as a result of burning coal and petroleum and is followed by deforestation and improper land management, which is currently growing. As a result, the need for raw materials is increasing to encourage excessive exploitation of natural resources [5]. Environmental damage is a disturbance in the balance of natural ecosystems, which results in the obstruction of various forms of life, thus affecting the life and survival of other creatures in the ecosystem. On the other hand, the United Nations international disaster reduction strategy defines environmental degradation as the reduction in the ability of the environment to meet environmental objectives and social and ecological needs.
One way to control climate change is by reducing greenhouse gas emissions (CO$_2$, CH$_4$, N$_2$O), namely by maintaining the natural forest’s integrity and increasing the density of tree populations outside the forest. Total carbon stock between fields varies depending on the diversity and density of existing plants, soil types, and management methods. Carbon storage in the land becomes more significant if the soil fertility condition is good because tree biomass increases. Above the soil (plant biomass) is determined by the ground's amount (soil organic matter). Therefore it is necessary to measure the amount of carbon stored in each land [6].

Carbon sequestration can be defined as the process of capturing and removing atmospheric CO$_2$ and other forms in the long term to reduce and delay global warming. It can be done through biological, chemical, and physical methods or mechanisms, including artificial mechanisms. This process involves biomass production by capturing CO$_2$ by several photosynthetic mechanisms to produce energy [7]. Atkin and colleagues noted in their study that the sequestration action depends only on the carbon-absorbing properties achieved through several methods and forms. Storing CO$_2$ and other carbon forms can help reduce various greenhouse gas effects [8].

Backer stated that there is a variety of biodiversity in the forest, both wild animals and plants. The diversity of biological resources in the woods is not only limited to woody plant species. Still, it is also covered by a wide variety of understorey, high species diversity [9]. Lower vegetation is a type of primary vegetation found under forest stands, except for tree saplings. Shorter plants include grasses, herbs, shrubs, and ferns [10]. Besides, understorey vegetation plays an essential role in the forest ecosystem and determines the microclimate [11].

Biomass is a significant attribute of forests because it is directly related to ecosystem productivity and several ecological services such as windbreaking, sand fixation, and carbon storage [12]. The empirical forest modeling approach has been widely used by estimating bush's biomass using the biomass allometric equation [13-15]. However, this equation can also be used to estimate biomass growth. Reliable estimation of bush biomass under dynamic growing conditions can provide relevant information useful in making decisions while monitoring bush conditions. There are several components to consider when monitoring bush biomass, including total biomass (TB), aboveground biomass (BAPT), stem biomass (SB), foliage biomass (FB), and root biomass (RB).

This study is based on previous research conducted by Hao Xu et al. (2020), who stated that accurate scrub biomass estimation is fundamental in natural resource management. The area condition of vegetation is an essential factor influencing the dynamics of scrub biomass [17]. The difference is that Hao Xu et al.'s research was carried out in areas with high and cold rainfall. Meanwhile, this research was conducted in the Aceh Besar district with tropical rain and dryland areas.

Shrub vegetation is one of the main components in dryland contribution in the Aceh Besar district besides forest vegetation, dryland agriculture, and open land. The availability of carbon in scrub vegetation needs to be assessed to carry out sustainable agricultural activities and environmental conservation measures for optimal land resources. The distribution of scrub vegetation is almost evenly distributed in Aceh Besar district. The desire to see the potential carbon in this vegetation and future treatments will be carried out, reforestation, and soil management to increase carbon stock. It is necessary to research to determine how much carbon potential in scrub vegetation in the Aceh Besar district.

2. Methodology
To analyze the scrub vegetation area obtained from Bappeda Aceh sources, namely administrative maps, land use maps, slope maps, and maps of soil types. It will later be overlaid and digitized on the screen to obtain a map and research area. [18,19].

They were making plots according to field conditions. They then determined each vegetation growth on the seedling plot size with a minimum area of 4 m$^2$ (growth rate of woody vegetation < 2 cm in diameter with a height = 1.5 m) and staking plots with a minimum area of 25 m$^2$ (growth rate of woody vegetation with a diameter of 2 cm to <10 cm) [20,21]. Each plot, both seedling and sapling plots, was repeated five times.
Calculation of the total dry weight of understorey/litter per quadrant with the following formula:

\[ TotalBK(g) = \frac{Sub - sampleBK(g)}{Sub - exampleBB(g)} \times TotalBB(g) \] (1)

Where, \( BK \) = dry weight and \( BW \) = wet weight [6].

The tree biomass measurement stages are as follows: identification of tree species names; measure the diameter at breast height (dbh); record dbh data and type names into a tally sheet, and calculate tree biomass [19]. Then the tree biomass will be added with the leaf biomass (determined dry weight) and roots.

Calculate the volume and BJ of wood with the following formula:

\[ Volume(cm^3) = \pi R^2T \] (2)

BJ wood can be calculated with the formula:

\[ BJ(gr/cm^3) = \frac{DryWeight(g)}{Volume(cm^3)} \] (3)

**Table 1.** Estimation of tree biomass using allometric equations.

| Kind of tree                  | Estimated tree biomass, Source       |
|------------------------------|-------------------------------------|
| Branched tree                | \( BK = 0.11 \rho D^{1.62} \) Ketterings, 2001 |
| The tree is not branched     | \( BK = \rho HD^2/40 \) Hairiah et al., 1999 |

Tree root biomass estimation can be done using the installed value based on the crown and root ratio values. The estimated general ratio of the ratio between canopy biomass and root share for the wet tropical forest on dry land is 4:1 [22,23]. As for wetlands, it is 10:1 and for trees in poor soils [24-26].

The calculation of carbon from biomass uses the following formula:

\[ C_b = B \times %C_{organic} \] (4)

where : \( C_b \) is the biomass's carbon content, expressed in kilograms (kg); \( B \) is the total biomass, defined in (kg); \% C is organic is the percentage value of carbon content, amounting to 0.47 or using value percent of carbon obtained from measurements in the laboratory.

The potential for \( CO_2 \) uptake in plants per hectare can be formulated as follows:

\[ WCO_2 = Wtc \times 3.67 \] (5)

\( Wtc \) is the carbon content of each plant stand, and 3.67 the equivalent value of Carbon C to \( CO_2 \) [27,28].

3. Results and discussion

Aceh Besar District with the capital city of Jantho, consists of 23 Districts geographically located at a position of 5.2º-5.8º North Latitude and 95.0º-95.8º East Longitude, at an altitude ranging from 12 to 400 meters above sea level. The area of scrub vegetation can be seen in the following figure and table.
Figure 1. Spatial distribution of various vegetation types in Aceh Besar district.

Table 2. Table of shrub bush vegetation types in Aceh Besar district.

| SPL | Information | Type of soil | Slope | Area (ha) |
|-----|-------------|--------------|-------|-----------|
| 14  | Shrubs      | Andisol      | 0 - 8%| 10,683.24 |
| 15  | Shrubs      | Entisol      | 0 - 8%| 31,295.31 |
| 16  | Shrubs      | Ultisol      | 0 - 8%| 16,862.32 |

Shrub vegetation at size <2 cm is dominated by Teki (*Cyperus rotundus*) and Putri Malu (*Mimosa pudica*). For bush vegetation, the length of 2 cm -10 cm is dominated by *Acacia mangium* plants.

Table 3. Table of biomass values, C content and CO$_2$ conversion of shrub bush vegetation type in Aceh Besar district.

| Types of Plants | Biomass Plant (Tons / Ha) | Value C (Ton / Ha) | CO$_2$ Conversion Value (Ton / Ha) |
|-----------------|----------------------------|--------------------|-----------------------------------|
| Grass           | 1.68                       | 0.79               | 2.89                              |
| *Acacia mangium*| 33.22                      | 15.61              | 57.28                             |
| Total           | 34.90                      | 16.40              | 60.17                             |
| Shrubs          | 2,053,546.33               | 964,990.26         | 3,540,455.15                      |

4. Conclusion
Shrub vegetation at size <2 cm is dominated by Teki (*Cyperus rotundus*) and Putri Malu (*Mimosa pudica*). For bush vegetation, the length of 2 cm -10 cm is dominated by *Acacia mangium* plants. The total amount of plant carbon biomass was 2,053,546.33 tonnes/ha, a C value of 964,990.26 tonnes/ha, and the potential for CO$_2$ uptake in plants was 3,540,455.15 tonnes/ha in scrub vegetation in Aceh Besar district.
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