The Distribution and Soil Carbon Stock on Land Utility Types of Bush, Moor, Mixed Garden and Rainfed Rice Fields on Dry Land in Aceh Besar Regency

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Abstract
This study aims to determine the potential of soil carbon on dry land in Aceh Besar regency. This study uses a descriptive method based on field results and surveys and laboratory analysis. Soil sampling at various depths was carried out for carbon and bulk density analysis. Composite soil samples were taken at a depth of 0-5, >5-10, >10-20, >20-30, >30-70, and >70-100 cm. The type of land use is bush covering an area of 96,962.2 ha, moor 313.03 ha, rainfed rice fields 4,478.67 ha and mixed gardens 15,052.09 ha. The highest percentage of soil carbon is in the mixed garden land utility type (3.40%) compared to other types of utility. The highest carbon potential is found in the bush land utility type (137.68 tons/ha) compared to other types of utility. The highest soil carbon stock is in the type of land use of bush compared to other types of land utility. This is because the bush land utility type has soil carbon potential and a large area compared to other land utility types.

Keywords: Climate Change; Renewed Resources; Soil Quality.

Introduction
Carbon absorption in the soil is the process of transferring CO2 from the air into the soil through plants, plant remains, and other organic parts stored in soil organic matter units (Olson, 2013). Soil organic carbon is a functional component of soil organic matter (SOC). SOC is important for soil conservation, ecosystem balance, and raising soil fertility and crop plant productivity (Seely et al., 2010). SOC is also affected by land use like agriculture. About 45% of the world's land was expanding for agriculture is used for agriculture, both in the form of cropland or grassland (Paustian et al., 2019).

Cultivation of agricultural land, as one of the major land-use types, covers nearly one-third of the world's land surface and replaces the majority of natural vegetation on the planet's surface (Godfray et al., 2010). The IPCC estimates that agricultural land has the potential to absorb up to 1.2 billion tons of carbon per year (IPCC, 2014). Agricultural land has the potential to absorb at
least 10% of annual emissions of 8–10 Gt/year (Hansen et al., 2013) and acts as a C sink to reduce CO2 levels in the atmosphere (Abdullahi et al., 2018; Pham et al., 2018).

Soil carbon sequestration on agricultural land had a chief influence on climate change mitigation if land management applied optimally (Smith, 2016). Soil organic carbon is stored properly through the collection of soil organic matter in the topsoil by carrying out correct soil management practices (conservation soil management) in agricultural cultivation activities (Lal, 2008). SOC contributes significantly to the benefits of biological, physical, and chemical processes in soil ecosystems, so the more SOC stored in the soil, the better the soil quality. Land use and growing vegetation have a significant impact on SOC.

In general, the types of land use are bush, mixed garden, moor and rainfed rice fields are some one of the main components that contributed to dry land in Aceh Besar Regency between forest land utility types and open land. This types of land use is almost evenly distributed in Aceh Besar. Dryland is an area that has a drought index (the ratio of mean annual rainfall to mean annual potential evapotranspiration) less than 0.65 (Prăvălie, 2016). SOC on dry land can drop significantly due to the conversion of native forest to agricultural land and or grazing land (Jafarian & Kavian, 2013) and livestock grazing and or removal of bushes (root plowing) (Daryanto et al., 2013). However, carbon stock may increase in cases of afforestation of degraded agricultural land and sandy soil (Hbirkou et al., 2011; Yang et al., 2014; Shang et al., 2017, Liu & Li, 2019). The practice of farming in dryland, such as crop rotation, cover crop, straw mulch, reduced tillage, and/or no-tillage gain benefit from maintaining or increasing SOC stock (Plaza-Bonilla et al., 2015; Kuhn et al., 2016). The low content of SOC in drylands can affect by limited biomass productivity, lack of groundwater, and characteristic soil physiochemical properties (Weil & Brady, 2017). SOC losses and greenhouse emissions from degenerated drylands can be improved by limiting quality of soil, SOC content, and biomass productivity (Arshad et al., 2016).

Literature Review

The availability of soil carbon in bush, moor, mixed garden and rainfed land utility types needs to be studied, to carry out sustainable agricultural activities and environmental conservation actions for optimal land resources. The study of the potential for soil carbon in this land use can be used as an effort to create and monitor in the future for revegetation and soil protection in order to raise soil carbon stocks. Previous research from Lamidi et al. (2018) divided soil depth on a scale: 0-15, 15-30, 30-45, and 45-60 cm for SOC sequestration studies. Research by Susanti et al. (2021) also conducted a study of SOC in the Blang Bintang sub-district in Aceh Besar district. Then this research was carried out throughout Aceh Besar and the soil depth was carried out on a scale of 0-5, 5-10, 10-20, 20-30, 30-70, and 70-100 cm. This study was to determine the potential of soil carbon in bush, moor, mixed garden and rainfed land utility types in Aceh Besar regency.

Research Methods

Time and place

This research was conducted from July to December 2020. Soil sampling on dryland bush, moor, mixed garden and rainfed land utility types in Aceh Besar. Soil analysis was carried out at the Soil and Plant Research Laboratory, Faculty of Agriculture, Syiah Kuala University.

Soil Sampling
The research sample was taken randomly and deliberately limited to dryland bush, moor, mixed garden and rainfed land utility types in Aceh Besar regency. Sampling was carried out based on a digital map obtained from an overlay of land use maps, slope maps, soil types maps, and Aceh Besar regency administrative maps. The land slope is limited to a slope of 25%. The use of the slope is done so that the samples taken are considered representative of land that can still use for cultivation and environmental conservation efforts. The samples were composite soil, which was carried out at different depths, namely 0-5, 5-10, 10-20, 20-30, 30-70, and 70-100 cm. The soil depth differences aim to compare the carbon content and bulk density analysis. Soil sampling at composite sample points at a distance of 50 m from the sample point in the north, south, west and east directions (SNI. 2011).

Table 1

Soil carbon sample point in bush, moor, rainfed rice field and mixed garden land utility types in Aceh Besar Regency

<table>
<thead>
<tr>
<th>No</th>
<th>Land utility types</th>
<th>sampel points</th>
<th>X</th>
<th>Y</th>
<th>area (ha)</th>
<th>Location</th>
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</thead>
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<td>5.486482</td>
<td>15,052.09</td>
<td>Gp. Nusa</td>
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<td>5.486641</td>
<td></td>
<td>Gp. Nusa</td>
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<tr>
<td></td>
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<td></td>
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<td>5.499303</td>
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<td></td>
<td></td>
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<td>5.546445</td>
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</tr>
<tr>
<td>2</td>
<td>Raifed rice field</td>
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<td>5.533485</td>
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<td>95.409695</td>
<td>5.533269</td>
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<td>Lampuja</td>
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<tr>
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<td></td>
<td>95.408261</td>
<td>5.536167</td>
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<td></td>
<td>95.410181</td>
<td>5.529444</td>
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<td>5.547478</td>
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<td>5.556546</td>
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<td></td>
<td></td>
<td></td>
<td>95.39 5059</td>
<td>5.1554985</td>
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<tr>
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<td></td>
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<td>5.1555315</td>
<td></td>
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<tr>
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<td></td>
<td></td>
<td>95.39 50165</td>
<td>5.1556057</td>
<td></td>
<td>Jalin 1</td>
</tr>
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<td>Moor</td>
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<td>5.517119</td>
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<tr>
<td></td>
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<td></td>
<td>95.404955</td>
<td>5.517662</td>
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<td>Cot Madhi</td>
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<tr>
<td><strong>Total</strong></td>
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<td><strong>116,805.89</strong></td>
<td><strong>116,805.89</strong></td>
<td><strong>116,805.89</strong></td>
<td><strong>116,805.89</strong></td>
<td><strong>116,805.89</strong></td>
</tr>
</tbody>
</table>
Data analysis

Soil organic carbon analysis has been performed using Walkley and Black method and the Soil Research Institute's analysis guide (2005). Firstly, create a reaction between 0.5 grams of fine soil samples (<0.5 mm) and 5 ml of K2Cr2O7 and 10 ml H2SO4 solutions on a hotplate. After it cools down, add 5 ml of H3PO4 and 50 ml of distilled water, and then let it stand for a while. Afterward, it was titrated with 0.025 M FeSO4 solution using a burette until the color turned clear green. Subsequently, the volume of the FeSO4 solution used is recorded. The variance in the volume of the FeSO4 solution used throughout the experiment and that used in blank is often used to calculate the organic carbon content in soil (without soil). The soil Organic carbon score criteria are as follows: very low (1.00), low (1.00-2.00), moderate (2.00-3.00), high (3.00-5.00), and very high (> 5.00) (Soil Research Institute, 2005).

To find out the quantity of carbon in the soil is by multiplying the observed parameters. The calculation of soil carbon density is done using the following formula (National Standardization Agency, 2011):

\[ Ct = \text{Depth} \times \rho \times \% \text{ C organic} \]

Where:

- \( Ct \): soil carbon content (g/cm2)
- \( \text{Depth} \): the depth of soil sample (cm)
- \( \rho \): bulk density (g/cm3)
- \( \% \text{ C organic} \): the percentage of carbon content as much as 0.47 or using the carbon percentage obtained from the measurements in the laboratory.

\[ \text{Csoil} = \text{Ct} \times 100 \quad \text{(ton/ha)} \quad \text{(Edwin, 2016)} \]

Where:

- \( \text{Csoil} \): Soil organic content per hectare, expressed in tonnes per hectare (ton.ha-1)
- \( \text{Ct} \): Soil carbon content (g/cm2)

100 : Conversion factor of g/cm2 to ton/ha.

The data from measurements and laboratory testing are presented in the form of soil C distribution, which is then transformed into acreage (hectare). Soil carbon stocks are transformed to each location and conveyed in tons per acre. Following that, it will be statistically analyzed using a descriptive analysis method to evaluate the carbon stocks to the existing carbon content.

**Results and Discussion**

Figure 1 Map of land use types for bush, moor, rainfed rice field and mixed garden in Aceh Besar Regency
In Figure 1 it can be seen that the type of land use is bush covering an area of 96,962.2 ha, moor 313.03 ha, rainfed rice fields 4,478.67 ha and mixed gardens 15,052.09 ha. Vegetation on the land utility types bush with at size <2 cm is dominated by Teki (Cyperus rotundus) and Putri Malu (Mimosa pudica). For bush vegetation, the size of 2 cm -10 cm is dominated by Acacia mangium plants. The vegetation in mixed gardens includes: Alstonia villosa, Acacia mangium, Tectona grandis, Murraya koenigi, Areca catechu, Acacia leucophloea, Syzygium aromatium, Aluerites moluccanus, Mangifera indica, Gnetum gnemon, Lannea coromandelica, Artocarpus heterophyllus, and Nephelium lappaceum. In moor vegetation it is Mucaceae and the undergrowth is Cyperus rotundus, while in rainfed rice fields it is Oryza sativa and Cyperus rotundus.
In general, the deeper a soil sample is taken, the less carbon will be in the soil. This is due to the accumulation of residual organic matter in the form of weathering which decomposes first on the soil surface. Donovan (2015) states that carbon in the soil varies according to depth. Soil sampling on the land utility type with a depth of 0–10 cm, 10–25 cm, and 25–40 cm. The sampling result stated that the carbon content in the layer 25–40 cm was higher than that in the 10–25 cm layer (Donovan, 2015).

Figure 2 shows that the highest percentage of soil carbon is in the mixed garden land utility type (3.40%) compared to other types of use. This is in accordance with the research of Edwin et al (2016) which shows that there is a lot of vegetation and there are some woody trees that produce litter which will later accumulate in the soil can increase soil carbon in mixed garden land use types. Based on the research results of Sufardi et al. (2020), showed that soil organic carbon content in dry land in Aceh Besar regency varied from low to very high (0.23-8.20%) depending on soil type (or soil order). Soil C values in several types of land use in Aceh Besar regency have various C content values. Natural forests and mixed gardens are the highest carbon sinks (C) when compared to agricultural land use systems, due to their high tree diversity, with a lot of understorey and litter on the ground (Hairiah, K, et al., 2007).

Litter in mixed gardens is one of the components which stores carbon. the area that tightly titled has a carbon content soil organic matter is greater because the soil at the area has more litter compared to the land in the medium and rare. Litter defined as a leaf or small twig who had fallen and was on the floor of the mixed forest and garden (Syam’ani et al., 2012). According to Juniariani (2011) carbon level soil is influenced by several factors including climatic conditions, air temperature, humidity, precipitation, soil type, type vegetation, biomass yield, management fertilization, and land topography.
The figure shows that the highest carbon potential is found in the bush land utility type (137.68 tons/ha). This is in accordance with the research of Edwin (2016) which states that the potential for soil carbon is directly proportional to the depth of the soil, the percentage of soil carbon and the bulk density of the soil. The results of this study indicate that the bulk density of the bush land use type is very high ranging from 1.72 to 1.82 at a depth of 1 meter, so that the potential for soil carbon in the bush land utility type is higher than other land utility types.

### Table 2

<table>
<thead>
<tr>
<th>Land Utility Type</th>
<th>Carbon potential (ton/ha)</th>
<th>Area (ha)</th>
<th>Carbon stock (ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bush</td>
<td>137.68</td>
<td>96,962.2</td>
<td>13,349,949.62</td>
</tr>
<tr>
<td>Moor</td>
<td>75.48</td>
<td>313.03</td>
<td>23,628.44</td>
</tr>
<tr>
<td>Rainfed rice field</td>
<td>106.98</td>
<td>4,478.67</td>
<td>479,103.98</td>
</tr>
<tr>
<td>Mixed garden</td>
<td>130.08</td>
<td>15,052.09</td>
<td>1,958,028.55</td>
</tr>
</tbody>
</table>

| Total            | 450.22                    | 116,805.89 | 15,810,710.59     |

In table 2 it can be seen that the highest soil carbon stock is in the type of land use of bush compared to other types of land utility. This is because the bush land utility type has soil carbon potential and a large area compared to other land utility types.
Efforts to reforest and plant annual crops need to increase soil carbon stock. Other environmental preservation efforts can optimally for agricultural cultivation so that it is likely to have an impact on increasing food production. Widiatmaka et al. (2012) stated that the reduced vegetation cover, the less soil organic carbon would also decrease. The percentage of soil organic carbon content varies between layers. Nearly 45% carbon was obtained in layers greater than 25 cm. Soil organic carbon stock at a depth of 0-20 cm is estimated to have a value of 15.68 x 106 tons in 1989, decreased by 24.43.61% to 11.85 x106 tons in 2004, soil organic carbon content at a depth of 20-40 cm is estimated 10.30 x 106 tonnes in 1989 decreased 16.6% to 8.59 x 106 tonnes in 2004. If averaged, changes in land use and cover in Bogor Regency reduced the total soil organic carbon by 21.33% from 25, 99 x 106 tonnes in 2004, 1989 to 20.44 x 106 tonnes in 2004. This suggests that in Bogor Regency there had been significant soil carbon emissions for 2 decades due to changes in land use and cover (IPCC, 2013). Planting an area with a variety of vegetation will affect wider land cover, reduce weathering and thus increase soil carbon stock. This will also have an impact on the stabilization of the global climate

**Conclusion**

The type of land use is bush covering an area of 96,962.2 ha, moor 313.03 ha, rainfed rice fields 4,478.67 ha and mixed gardens 15,052.09 ha. The highest percentage of soil carbon is in the mixed garden land utility type (3.40%) compared to other types of utility. the highest carbon potential is found in the bush land utility type (137.68 tons/ha) compared to other types of utility. the highest soil carbon stock is in the type of land use of bush compared to other types of land utility. This is because the bush land utility type has soil carbon potential and a large area compared to other land utility types.

**References**


chemical properties]. Bogor: Soil Research Institute.


