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Potential and Absorption of CO_2 in Various Types of Dry Land Use in Aceh Besar Regency

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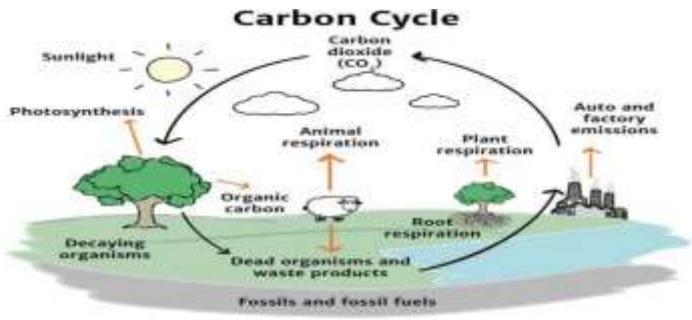
Abstract
This study was carried out on a 239,439.63 ha unit of dry land in the Aceh Besar Regency. The Soil and Plant Science Laboratory and the Soil Physics Laboratory at the Faculty of Agriculture, Universitas Syiah Kuala, analyzed soil and biomass samples. Twelve different land use types in the Aceh Besar Regency's dry land are the research locations. Utilizing a methodology with the number SNI 7724:2011, the Indonesian National Standards Agency established the biomass measuring and sampling procedure in 2011. According to the study's findings, the primary forest land use type has the greatest potential for absorbing CO2 in the forest land use type, followed by the following. Pine forest, secondary forest, teak forest, eucalyptus forest, and bush forest, in that order. In contrast, the land use categories of mixed gardens, moors, bushes, grassland, rainfed rice fields, and bare ground have the highest potential for absorbing CO2. Primary forests have the largest overall carbon dioxide absorption among the many forest land use types. These are followed, in order, by secondary forests, bush forests, eucalyptus forests, pine forests, and teak forests. The primary forest land use type has the largest total CO2 absorption among the non-forest land use types, followed by grasslands, shrubs, mixed gardens, rainfed rice fields, moorland, and bare ground, in that order. The Aceh Besar Regency's numerous dry land uses can benefit from enhanced natural and environmental sustainability due to the wide stem diameter and abundance of woody plants, which can also increase CO2 absorption.
Highlights

- High CO2 potential and sequestration are critical in controlling climate change
- Humans play an important role in regulating and maintaining the availability of plants to maintain environmental stability.
- Forest protection plays an important role in maintaining the biodiversity of plants, animals, and endangered species in protected forest areas.



Keywords— Dryland, Absorption CO2, Bare Land, Grasslands

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Introduction

Globally, dry land is defined as land that experiences water scarcity in a land condition found in an area where rainfall is balanced by evaporation of water from the surface and by transpiration by plants (Rojas, 2020). In Indonesia, dry land is interpreted as an expanse of land that is utilized without waterlogging, either permanently or seasonally, with a water source in the form of rain or irrigation water (Notohadiprawiro et al., 2022). According to (Stolt & Needelman, 2015), dry land is an expanse of land that is not inundated or waterlogged during most of the year which can be found from the lowlands (0 - 700 asl) to the highlands (> 700 asl). Theoretically, dry land in Indonesia is divided into two categories, namely: dry land with a dry climate, found mostly in the eastern region of Indonesia, and dry land with a wet climate, found mostly in the western region of Indonesia. Many typologies of dry land development areas fall into these two categories. However, the dominant dry land development areas in Indonesia are differentiated based on their potential and vegetation dominance (Laplaza et al., 2018). Land cover modification, which occurs gradually within a single land cover class, is one way that land use influences patterns of dry land use (Lambin et al., 2006). Loss of vegetation due to deforestation, overgrazing, burning of land, or leaving the land open will be a factor that drives the expansion of this sub-optimal land (Osman et al, 2018; Roden et al., 2016). Thus, initiatives are required to get past these constraints, either by restoring the role of producers of organic biomass and carbon to land quality and soil fertility.

Biomass is something that identifies vegetation which is generally the case to be measured based on on weight of plant material within a particular area. Natural forests store storage highest carbon (C) when compared with land use systems and types of agricultural vegetation, due to the high diversity of trees and plants bottom and a lot of litter on the ground surface. Plants need light sun, carbon dioxide gas (CO2) which is absorbed from the air as well as water and nutrients absorbed from the soil for survival (Lal, 2018). Through the process of photosynthesis, CO2 in the air is absorbed by plants and converted into carbohydrates, then distributed throughout the plant body and finally buried in the plant body in the form of leaves, stems, twigs, flowers, and so on the fruit. The process of storing C in the bodies of living plants is called the sequestration process. Thus measuring the amount of C stored in body plant life (biomass) on something land can describe many CO2 in the atmosphere Which absorbed by plants, whereas the measurement of C still stored in dead plant parts (necromass) indirectly directly represents CO2 which is not released into the air through combustion (Rosmalia, 2021).

Results study by Mandarin et al. (2016) show that mark biomass in a can from research in the Bandar Bakau area amounting to 115.85 tons/ha shows a value that is not too high, so in the area, they still need more management intensive. High and low marks the biomass obtained at a time ecosystem caused because the level of fertility land and density of trees in the area. However at least, if 1 Ha of land in the area that is capable of producing biomass as big as 115.85 ton/ha and keeps as much as 57.91 tons C/ha, the area breadth reaches 21.5 ha here capable of producing biomass amounting to 2,490.77 tons/21.5 ha or capable keep reserve carbon as much 1,245.06 tons. So that the type of land use in this area can reduce the CO2 content in the atmosphere by absorbing and storing it in the form of carbon reserves, especially carbohydrates, through the process of photosynthesis. Research results (Arsalan et al., 2020) show that the potency average standing biomass eucalyptus pellita is 69,392 tonnes C/ha. Whereas potency stands for eucalyptus pellita in absorbing atmospheric CO2 range between 3,783 – 135,128 ton/ha/ year.

The recent disruption of the energy balance between the Earth and the atmosphere is to blame for the changes in the global climate. Known as greenhouse gases (GHGs), an increase in

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carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) gases affects this balance among other things. At this moment, GHG concentrations are high enough to threaten the balance of the earth's ecosystems and climate. Inappropriate land management practices, such as the large-scale simultaneous burning of forest vegetation and the drying of peatlands, are contributing to an increase in greenhouse gas concentrations in the atmosphere. These tasks are typically completed at the start of the process of turning forest land into agricultural land.

The amount of CO_2 in the air must be controlled to develop and create a clean environment. This can be done by maximizing plant uptake of CO_2 and minimizing CO_2 release (emission) into the atmosphere. Reducing excessive levels of CO_2 in the air requires preserving the integrity of natural forests, planting trees on agricultural land, and safeguarding peatlands. "C reserves" are another term for the quantity of "C stored" in each land use, such as plants, litter, and soil (Lal 2018). Research on the potential and absorption of CO_2 in various forms of dry land use in the Aceh Besar Regency is therefore required.

Literature Review

This research was conducted on a unit of dry land in the Aceh Besar Regency with a study area of 239,439.63 ha. Analysis of biomass samples and soil samples was carried out at the Soil and Plant Science Laboratory and Soil Physics Laboratory, Faculty of Agriculture, Universitas Syiah Kuala. The materials used in this research are: and the equipment that will be used in this research are: research location map, soil type map, and Google map. The materials used in the laboratory are digital scales, ovens, chamber furnaces, ovens, and biurettes. The tools used in this research are G.P.S. (Global Positioning System) to determine coordinate points when taking samples in the field, measuring tape (meter), knife, plastic, handboard, and writing utensils. The tools used for measuring biomass are raffia rope, a 1.3 m long wooden/bamboo stick, a 1 m long wooden stick, a police line, measuring tape for measuring stem girth, machete or plant scissors, tree height measuring tool (Hagameter, Clinometer, and other measuring devices).

Measurement and Taking Sample Biomass

Biomass measurement and sampling techniques use methods developed by the Indonesian National Standards Agency in 2011 with the number: SNI 7724: 2011. For biomass sampling, a rectangular or square sample plot is made with a size of 20 m * 20 m or 400 m2. Furthermore, each plot is divided into four subplots according to the level of vegetation, namely: Subplot A (size 2 m * 2 m or 4 m2). This subplot is also called the "seedling" subplot and is used to calculate the weight of litter and small plants with a diameter of ≤ 2.0 cm. Subplot B (size 5 m * 5 m or 25 m2). This subplot is also called the "stake" subplot and is used to calculate the amount and weight of biomass from plants with a stem diameter of 2 - 10 cm. Subplot C (size 10 m * 10 m or 100 m2). This subplot is also called the "pole" subplot which is used to calculate the amount and weight of plant biomass with a diameter of 10 - 20 cm. Subplot D (size 20 m * 20 m or 400 m2). This subplot is also called the "tree" subplot and is used to calculate the amount and weight of plant biomass with a diameter of > 20 cm. The shape and size of the biomass sampling plot can be seen more clearly in Figure 1.

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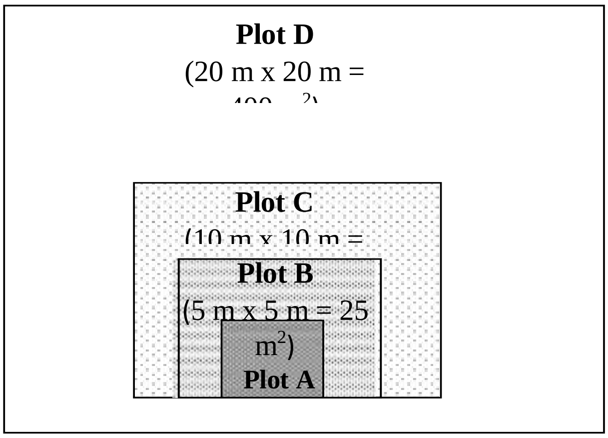

Figure 1 . Plot plan for designing plant biomass calculations for treed land use types.

To take soil samples in plot A (understorey) this is done by cutting the plants. Estimation of tree root biomass can be done using the default value, which is based on the ratio of crown to root. In general, the ratio between shoot and root biomass for wet tropical forests on dry land is 4:1. Medium for wetlands is 10:1 and for trees on poor soils 1:1 (Hairiah, Ekadinata, et al., 2011).

Litter collected in the field is calculated for dry weight during analysis in the laboratory. Meanwhile, for plots B, C, and D, calculations are made based on the stem diameter. This measurement also calculates the necromass according to the diameter of the stem. Technique for measuring trees on sloping land, place the tip of the stick 1.3 m on the upper slope. Trees branch before they reach a height of 1.3 m, so measure the DBH of all existing branches. If there is a bump at a height of 1.3 m, then take a DBH (diameter at breast height) measurement at 0.5 m after the bump. If at a height of 1.3 m, there are buttresses (board root boundaries) then take DBH measurements at 0.5 m after the buttresses. If at a height of 1.3 m there are supporting roots, then measurements are taken at 0.5 m after rooting (Hairiah and Rahayu, 2007). The allometric equation used depends on the type of vegetation found in the field (Niapele, 2013). The calculation of tree biomass in this study uses the allometric equation as presented in Table 1.

Table 1. Estimate biomass tree use equality allometric

No.	Type tree	Estimate Biomass tree, kg/tree	Source
1	Tree branching	$(AGB)est = 0.11\ p\ D^{2.62}$	Ketterings, 2001
2	Tree No branching	$(AGB)est = p\ r\ H\ D^{2}/40$	Hairiah et al, 1999
3	Coffee trimmed	$(AGB)est = 0.281\ D^{2.06}$	Arifin, 2001
4	Banana	$(AGB)est = 0.030\ D^{2.13}$	Arifin, 2001
5	Sengon	$(AGB)est = 0.0272\ D^{2,831}$	Sugiharto, 2002
6	Pine	$(AGB)est = 0.0417\ D^{2.6576}$	Waterloo, 1995

Source (Hairiah & Rahayu, 2007)

The total biomass tree is calculated from the summation of each part from plants/plants (Niapele, 2013) with the formula:

Biomass Total (Wt) = Ws + WB + Wl + Wr

Wt = total biomass (kg or tons), Ws

= biomass stem (kg or tons)

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Wb = branch/twig biomass (kg or tons)

Wl = biomass leaves (kg or tons)

Wr = biomass root (kg or tons),

Whereas density type wood (wood density) is calculated as follows:

Density wood = (weight dry discs/volumes disc)

Analysis Content Carbon Biomass

The biomass referred to in this research is all living organic material in the form of litter, live plants, and wood or twigs on the surface of the soil or in the soil (Kebede and Soromessa, 2018). Analyze the C content of biomass in plot A by measuring water content and analyzing biomass carbon in the laboratory. Understorey biomass is biomass whose stem diameter is < 2 cm. Measured using the destructive method in a plot measuring 2 m x 2 m. The way the work is carried out is: a) Cutting the undergrowth (stems < 2 cm in diameter, herbs or grasses in the plot, separating the leaves and stems, b) Putting it in a plastic bag, labeled according to the code, c) Putting it in in a large sack to make it easier to carry to the laboratory, d) Weigh the wet weight of the leaves and stems, and e) Take a biomass sample of around 100 – 300 g of leaves and stems, then dry the biomass sample in an oven at a temperature of 60 - 70 0C for 48 hours. Calculation of the total dry weight of undergrowth per quadrant using the following formula:

$$\text{Total BB (g)} = \frac{\text{Sub sample HD (g)}}{\text{HW Sub sample (g)}} \times \text{Total HW (g)}$$

Where: HD= Heavy Dry and HW= Heavy Wet.

Analysis content C Biomass on plots B, C, and D with convert amount biomass with multiplication 0.47 (National Standard Indonesia. 2011).

a) Calculation of carbon in biomass plant (plant life, litter, plant die /twig) on each type use land with use formula following:

TCP = FCp*Dp*Vp
TCP = total carbon (C) for every part plants/trees, or biomass (ton),
FCp = fraction carbon (C) or percentage C in every part plant (%C/100),
DP = wood density (kg dm -3 ~ t/m 3)
VP = volume wood or part biomass (m 3).

b) Lots of absorption of carbon dioxide (CO2) by vegetation is calculated as follows (Niapele, 2013):

WCO2 = Wtc * 3.67
WCO2 = many CO2 which absorbed (tons/ha)
Wtc = weight total stand certain (tons/ha)
3.67 = number equivalent (conversion) element carbon C to CO2.

Research Method

This research was carried out using descriptive methods through observation and data collection in the field and analysis in the laboratory. Field observations aim to measure plant biomass in various types of land use. Laboratory analysis aims to determine the C content in plant biomass. The study locations are 12 types of land use in the dry land of Aceh Besar Regency.

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Results and Discussion

The results of calculating CO_2 absorption by vegetation (biomass) and total CO_2 absorption in each type of land use in the Aceh Besar Dry Land can be seen in Table 2. In this table, it can be seen that the highest potential for CO_2 absorption and total CO_2 absorption is in the primary forest land use type, and the lowest is in open land. This CO_2 absorption is related to the weight of vegetation biomass present in each type of land use. In general, CO_2 absorption in various types of land use in Aceh Besar Regency is also divided into two parts, namely: forest land use type and non-forest land use type. In the forest land use type, the highest CO_2 absorption is in the primary forest land use type and the lowest is in the forest bush land use type. Meanwhile, the highest CO_2 absorption in the non-forest land use type is the mixed plantation land use type and the lowest is in the open land land use type. This is by research (Hairiah, Dewi, et al., 2011) that the potential for biomass, biomass carbon, and CO_2 absorption is directly proportional to the number of stands of vegetation or type of land use.

Primary forests which have the highest biomass compared to other types of use will certainly have the potential to absorb higher levels of CO_2. Likewise, the highest total CO_2 absorption is also found in the primary forest land use type because apart from having high absorption potential, the area is also wider. The role of primary forest land use as a carbon dioxide absorber is currently an important part of overcoming global warming caused by increasing levels of greenhouse gases, especially carbon dioxide in the atmosphere (Adinugroho et al., 2012). Today, climate change is a global concern, and primary forests play an important role in regulating and mitigating climate change by reducing CO_2 concentrations in the atmosphere (Ali et al., 2020; Ifeakor, 2023). Thus, the estimation of carbon stocks of different primary forests will help in making informed decisions about carbon management. This information contributes to atmospheric carbon reduction targets as part of international obligations (Sahu et al., 2016; Hermwille et al., 2017; Mayer et al., 2020). The total amount of biomass stored in a forest shows the amount of carbon (C) that can be absorbed to meet emission targets (Raha et al., 2020). The potential and total absorption of CO_2 in various types of dry land use in Aceh Besar can be seen in Table 2 and Figure 2.

Table 2. Potential and total CO_2 absorption in various types of dry land use in Aceh Besar

No	Type Land Use)	Distribution of CO_2 absorption potential (ton ha $^{-1}$)	CO_2 absorption potential (ton ha $^{-1}$)	Area (ha)	Total CO_2 absorption	
					(Mg)	(Gg)
1	Primary forest	1,616.45 – 2,218.74	1,840.64 ± 268.90	77,849.98	143,293,787.19	143,293.79
2	Forest secondary	808.17 – 1,854.71	1,157.57 ± 492.95	23,558.37	27,270,462.36	27,270.46
3	Forest pine	982.24 – 1,906.53	1,325.86 ± 412.89	53.85	71,397.56	71.40
4	Forest eucalyptus	805.01 – 1,414.01	1,138.33 ± 251.94	307.14	349,626.68	349.63
5	Forest teak	398.95 – 1,577.56	827.66 ± 532.14	58.50	48,418.11	48.42
6	Forest bush	43.58 – 1,760.13	537.84 ± 157.84	6,513.47	3,503,204.70	3,503.20
7	Shrubs	156.89 – 214.24	176.92 ± 26.41	96,962.20	17,154,552.42	17,154.55
8	Grasslands	89.46 – 128.45	109.03 ± 15.92	80.50	8,876.92	8,876.14
9	Mixed garden	371.77 – 1,580.53	716.29 ± 457.91	15,052.09	10,781,661.55	10,781.66
10	Moor	80.65 – 473.06	272.25 ± 156.08	313.03	85,222.42	85.22
11	Rainfed fields	30.74 – 36.84	34.44 ± 2.66	4,478.57	154,241.95	154.24
12	Bare land	0.87 – 1.15	1.03 ± 0.12	14,211.93	14,638.29	14.64
			Total	239,463.63	202,735,990.14	202,735.14

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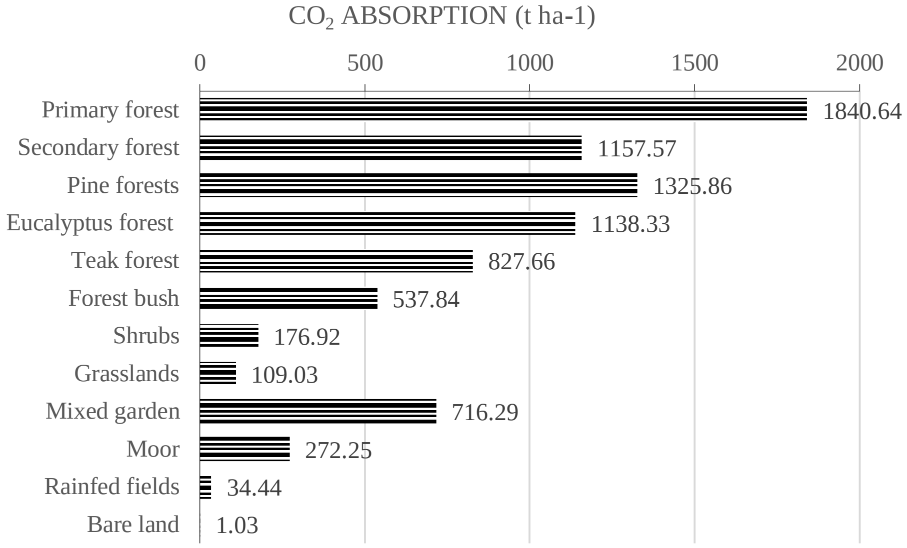

Figure 2. CO_2 absorption in various types of dry land use in Aceh Besar Regency

Conclusion

The primary forest land use type has the greatest potential to absorb CO_2 of any forest land use type. Pine, secondary, eucalyptus, teak, and bush forests are the next highest potential absorbers of CO_2. Conversely, the land use types of mixed gardens, moors, shrubs, grasslands, rainfed rice fields, and bare land have the highest potential for absorbing CO_2 in comparison to other non-forest land uses. Primary forests have the largest overall carbon dioxide absorption among the various forest land use types. These are followed, in order, by secondary forests, bush forests, eucalyptus forests, pine forests, and teak forests. The primary forest land use type has the highest total CO_2 absorption among non-forest land use types, followed by shrubs, mixed gardens, and rainfed.

Abbreviations

(AGB) est	aboveground tree biomass
C	Carbon
CO_2	Carbon dioxide
GHGs	greenhouse gases
DBH	diameter at breast height
Mg	Megaton
Gg	Gigaton
HD	Heavy dry
HW	Heavy wet
GPS	Global position system

SNI Standar Nasional Indonesia

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