The potential of carbon deposits to residual stand in Tongkonan lembang Buri' garden of Tana Toraja

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Abstract. Home garden is one of the traditional farming systems consisting of the composition of annual plants and seasonal crops. Tongkonan garden is one of the traditional farming systems that can be found in Toraja, specifically Tana Toraja, Rembon District. With the tree composition, Tongkonan garden is also able to absorb carbon and reduce CO2 emissions from the air. This study aims to determine the carbon storage at Tongkonan Garden in Lembang Buri'. The sample plot was using the method proposed by Matthew Delaney, which was to select ten plot of Tongkonan Garden with a size of 25 x 25 m. The sample plot based on purposive sampling method with consideration of having many trees in the Tongkonan Garden stand. Each of which was divided into eight subplots, namely four subplots in each corner of the Tongkonan Garden and four subplots in the middle, each of which has a diameter of 8 m. To find out the value of tree biomass, using the allometric equation by measuring the diameter of trees at breast height and measuring tree height specifically for palm species. Measurements of litter biomass and undergrowth were carried out in 1 x 1 m subplots of 3 times in the sample plot. The results showed that the average value of carbon storage in trees was 37,031 tons / ha (98,239%), undergrowth 0,246 tons / ha (0,652%) and litter 0,418 tons / ha (1,110%).

1. Introduction

The increasing, the concentration of Greenhouse Gases (GHG), is currently at an alarming rate so that GHGs must be controlled immediately. Efforts to overcome global warming can be made by reducing carbon dioxide (CO2) emissions in the atmosphere. Carbon is stored in an organism, such as a tree. Carbon dioxide in plants is collected as carbon in plant tissue, where if the plant dies, carbon and oxygen from carbon dioxide will return to the atmosphere, with that statement, it can be said that if the plants die then the amount of carbon dioxide in the atmosphere will increase, and the greenhouse effect will be more real. The tree is planted again, then carbon dioxide will be absorbed again through photosynthesis, and returned to carbon in the body tissues of the plant so that carbon dioxide in the atmosphere decreases [1].

Agroforestry is a term from traditional land-use practices that have elements such as land use or land use systems by humans, application of technology, components of annual crops, components of annual crops and or livestock or animals, in the same time period or take turns in a period specified and in it there are ecological, social and economic interactions [2]. One of the advantages of
agroforestry systems for the environment is storing and absorbing carbon. Carbon absorption itself takes place based on chemical processes in plant photosynthetic activity which CO$_2$ from the atmosphere and water from the soil produces oxygen and carbohydrates which in turn will potentially become extractive substances, hemicellulose, cellulose and lignin as carbon stocks. Carbon stock (C-Stock) is the amount of C stored in components of biomass and necromass both on the ground and in soil (soil organic matter, plant roots, and microorganisms).

The agroforestry system that is often carried out by most people is the home garden agroforestry system. The home garden is one of the traditional farming systems, which is a combination of annual plants with seasonal plants that are located on the land around the community's house. The home garden agroforestry system is one example of a complex agroforestry system [3]. With its vegetation, the home garden also has an essential role in reducing carbon emissions in the air.

Lembang Buri in Rembon Tana Toraja district is one of the areas where most of the residents carry out activities as farmers. The use of land in this sub-district uses a variety of systems, one of which is the agroforestry system in the garden plot of land called a home garden. Tongkonan in Tana Toraja has a large yard that is covered with several types of vegetation. The type of woody vegetation can absorb the most carbon, because of that, it is necessary to do research that aims to determine the potential of carbon storage in the Tongkonan garden in Lembang Buri.

2. Research methods
This research was conducted from March to April 2018 in Lembang Buri 'Rembon Tana Toraja District and Silviculture Laboratory and Tree Physiology, Hasanuddin University, Makassar. Tools and materials: Tape meters, Rope, Roll Meters, GPS, Hagameter, Cameras, Machetes / Sickles, Tally sheets, stationery, Labels, Oven Scales, and Plastic clips.

3. Research Implementation Method
This research used a purposive sampling method in determining plots by selecting 10 out of 21 tongkonan or locations categorized as tongkonan gardens with more criteria found in trees as yard plants and having an area greater than 0.625 hectares. Data collection for estimating carbon deposits and tree biomass was done by collecting tree data, understorey data, and necromass data. Collecting tree data is done by non-destructive sampling (without damaging the sample), where each plot was divided into eight subplots while for the lower plants using destructive sampling.

The sampling plot was made with the following procedure:

a. The sample plot is made with a size of 25 x 25 m using a rolling meter.
b. Each plot is divided into eight subplots with a diameter of 8 meters, four subplots are placed in each corner of the garden yard, and four subplots are placed at the midpoint of the Tongkonan garden plot.
c. Giving wood pegs, then attaching the ropes as boundary markers.

3.1. Data retrieval
The data needed to estimate tree biomass are tree diameter, total height, and tree species obtained by:

a. Measure the circumference of a tree with a meter tape at an altitude of 1.3 m above ground level or breast height (dbh)
b. Measuring the total height and height of free tree branches using hagameter.
c. Each measurement result and tree type is recorded on the tally sheet.

3.2. Lower Plant and Litter Collecting Data.
Biomass estimation for understorey taken as an example is all living plants that are < 3 cm in diameter (herbs and grasses) [4]. Samples of understorey and litter are taken separately in the plot. The lower plant sampling plot was made by placing 1m x 1m wood/bamboo quadrants, where each plot contained three quadrants of understorey and litter samples based on density (high, medium and low) of litter and understorey.
A sampling of the understorey is done in the following ways:

a. Subplots establish used quadrants of size 1 m x 1 m in a plot of 25 m x 25 m by purposive sampling.
b. Take all the understorey found in the quadrant, weigh the wet weight, label it according to the sample point, and record it in a tally sheet.
c. Take sub-samples around 100 grams. If the understorey is less than 100 grams, it is weighed all and used as a sub-sample.
d. Dry sub-sample sub-plants in an oven at 80°C for 48 hours or until they reach a constant dry weight.
e. Consider the constant dry weight and note it in the tally sheet.

To estimate litter biomass sampling is carried out with the following procedure:

a. Determine subplots using quadrants of size 1 cm x 1 cm in a plot of 25 m x 25 m by purposive sampling.
b. Take all the litter contained in the quadrant, weigh the wet weight, label it according to the sample point, and record it in a tally sheet.
c. Take sub-samples around 100 grams. If the sample litter is less than 100 grams, then weigh all weighed and used as a sub-sample.
d. Dry the litter sub-sample in the oven at 80°C for 48 hours or until it reaches a constant dry weight.
e. Measure the constant dry weight and record it in the tally sheet.

3.3. Data analysis

Calculation of Tree Biomass.

The measurements of the tree were carried out on a 25 m x 25 m plot by measuring height and DBH (diameter at breast height). For estimating tree biomass in agroforestry systems, allometric models are used with the equation:

\[ Y = \exp\{-2.134+2.530 \times \ln(D)\} \]

For the palm type, the following equations are used:

\[ Y = 4.5 + 7.7 \times H \]

Information:

- \( Y \) = Biomass (kg)
- \( H \) = Tree Height (m)
- \( D \) = Tree diameter at chest height (cm)

For banana and bamboo types, the following equations are used [4]:

\[ W = 0.131 \, D^{2.48} \] (For banana types)
\[ W = 0.030 \, D^{2.43} \] (For bamboo types)

Information:

- \( W \) = Biomass (kg)
- \( D \) = Tree diameter at chest height (cm)

Calculation of Biomass in Litter and Lower Plant

Calculation of biomass in serasah and lower plants used the following equations [4]:

\[ W = \left( \frac{\text{Dry Weight}}{\text{Wet Weight}} \right) \times \text{Total BB} \]
Information:
W = Biomass (kg)
BK = Dry Weight (g)
BB = Wet Weight (g)

Calculation of Carbon Trees

Carbon is suspected through biomass by converting half of the amount of biomass, because nearly 50% of the biomass in forest vegetation is composed of carbon elements. The amount of carbon stored in plant seeds is as follows:

\[ C = W^{0.5} \]

Information:
C = Carbon (kg / ha)
W = Biomass (Kg / ha)

Calculation of litter carbon and understorey.

For the calculation of understorey and litter carbon, it can be obtained by diverting by convention factor 0.46 because the carbon content in serasah and understorey is 46% [4]:

\[ C = W^{0.46} \]

Information
C = Carbon (kg / ha)
W= Dry Biomass (Kg / ha)

4. Results and Discussion

4.1 Basic Field Distribution

Baseline Area Data (LBDS) was obtained from tree diameter data measured using a meter band. The base field is a cross-section of a tree trunk measured at breast height of 1.3 m above the ground. Primary area derived from the diameter of the tree whose measurements can use meter tape, calipers, and other diameter measuring devices. Based on the results of the study, data on the distribution of the basal area in Tongkonan Gardens can be seen in Table 1.

| Plot                        | LBDS (cm²) | Estimation  |
|-----------------------------|------------|-------------|
| Buri’ Tongkonan             | 188.20     | 25.79 - 555.11 |
| Rimbua Tongkonan            | 310.70     | 39.94 - 679.75 |
| Tanete To’Ao Tongkonan      | 306.13     | 20.12 - 2579.61 |
| Tandung Tongkonan           | 917.40     | 31.84 - 13383.75 |
| Ta’ba Tandung Tongkonan     | 200.14     | 35.11 - 644.90 |
| Tinakka Tongkonan           | 646.71     | 23.00 - 7671.03 |
| Rumenden Tongkonan          | 195.65     | 37.49 - 818.62 |
| To’Ao Tongkonan             | 182.46     | 11.65 - 1472.61 |
| Bambala Tongkonan           | 292.93     | 56.33 - 1912.81 |
| Bamba Tongkonan             | 98.46      | 31.52 - 484.39 |

The base area distribution of each Tongkonan garden plot in Table 3 varies. This base was because the number and type of tree constituents also vary. The most significant average base area values were found in the Tongkonan Tandung garden plot, which is 917.40 cm², while the lowest average value is found in the Tongkonan Bamba garden plot which was equal to 98.46 cm². Biomass had a linear
relationship with the increase in tree diameter, where the more significant the tree diameter, the higher the biomass content in the tree.

4.2 Carbon Potential

**Carbon Potential Stored in Trees**

Tree stands can store more carbon compared to understorey and litter. Tree biomass is assumed by using allometric equations. To estimate the potential of carbon deposits per hectare is calculated by entering the diameter value at breast height (Dbh) in each plot into the allometric equation for each type and for the Palm type calculated by entering the total value height in allometric equations so that tree biomass is obtained.

The calculation results of biomass and carbon deposits in stands ranging from the lowest value carbon stores to the highest value of carbon deposits in Lembang Buri’ Tongkonan 'garden can be seen in Table 4.

| Plot                    | Biomass (ton/plot) | Biomassa (ton/ha) | Carbon (ton/ha) |
|-------------------------|-------------------|-------------------|-----------------|
| Buri’ Tongkonan         | 2.929             | 46.865            | 23.432          |
| Rimbua Tongkonan        | 3.048             | 48.782            | 24.391          |
| Tanete To’Ao Tongkonan  | 8.039             | 128.627           | 64.313          |
| Tandung Tongkonan       | 10.848            | 173.582           | 86.791          |
| Ta’ba Tandung Tongkonan | 2.051             | 32.821            | 16.410          |
| Tinakka Tongkonan       | 6.862             | 109.802           | 54.901          |
| Rumenden Tongkonan      | 3.344             | 53.503            | 26.751          |
| To’Ao Tongkonan         | 3.132             | 50.113            | 25.056          |
| Bambala Tongkonan       | 4.460             | 71.501            | 35.750          |
| Bamba Tongkonan         | 1.563             | 25.016            | 12.508          |
| **Total**               | **46.276**        | **740.612**       | **370.303**     |
| **Average**             | **4.628**         | **74.061**        | **37.030**      |

The results showed that the value of carbon deposits in Tongkonan garden plots had different carbon storage values for each plot. In the table, two it can be seen that the Tandung Tongkonan plot has the highest value of carbon deposits, that is, 86,791 tons/ha, while Tongkonan Bamba has the lowest carbon deposit value, 12,508 tons / ha.

Differences in tree species cause the difference in the value of carbon deposits in each yard plot, number of trees, density, and diameter of the dominant types of stands. The difference in tree species will affect the differences in carbon deposits in each type. The carbon deposits contained in stands are closely related to the growth of stands, carbon deposits tend to increase until the stand growth reaches optimal then relatively stable. The amount of carbon potential converted from biomass is strongly influenced by the size of the tree diameter. The stand density and the number of trees are also factors that determine the carbon stock of the area; besides the stand density indicates the quality of the growing place [5].

4.3 Stored Carbon Potential in Lower Plants.

The lower plant is one component in the forest ecosystem that grows to occupy the lowest strata of stands. Lower plants are plants which are not stands or trees but are located under stands or trees. The lower plants can be shrubs, lianas, herbs, and grasses. In Tongkonan garden plots, types of understorey found include melastoma, sweet potatoes, grasses, ferns, and herbaceous plants.
Understorey carbon Measurement is carried out by taking samples in quadrants of size 1 x 1 meter in a plot size of 25 x 25 m. The placement of quadrants is done by showing the thickness of the understorey, which is tinny, medium, and low thickness. In this study, which includes understorey is a plant that has a diameter of $\leq 3$ cm. Sampling by taking into account the thickness of the understorey is done in order to represent the heterogeneous conditions of the understorey in each Tongkonan plot. Based on the results of the study, the value of carbon content for lower plants can be seen in Table 3.

| Plot              | Biomass (g/m²) | Biomass (g/plot) | Biomass (ton/plot) | Biomass (ton/ha) | Carbon (ton/ha) |
|-------------------|----------------|-----------------|--------------------|-----------------|-----------------|
| Buri' Tongkonan   | 36.875         | 23046.600       | 0.023              | 0.369           | 0.170           |
| Rimbua Tongkonan  | 41.254         | 25783.806       | 0.026              | 0.413           | 0.190           |
| Tanete To'Ao Tongkonan | 52.385     | 32740.525       | 0.033              | 0.524           | 0.241           |
| Tandung Tongkonan | 41.627         | 26017.013       | 0.026              | 0.416           | 0.191           |
| Ta'ba Tandung Tongkonan | 53.111 | 33194.425       | 0.033              | 0.531           | 0.244           |
| Tinakka Tongkonan | 63.171         | 39481.738       | 0.039              | 0.632           | 0.291           |
| Rumenden Tongkonan| 67.202         | 42001.519       | 0.042              | 0.672           | 0.309           |
| To'Ao Tongkonan   | 69.479         | 43424.513       | 0.043              | 0.695           | 0.320           |
| Bamba Tongkonan   | 43.013         | 26883.106       | 0.027              | 0.430           | 0.198           |
| Total             | 533.764        | 333602.331      | 0.334              | 5.338           | 2.455           |
| Average           | 53.376         | 33360.233       | 0.033              | 0.534           | 0.246           |

The results showed that the value of understorey carbon deposits in each plot had different values. The highest value was found in the Tongkonan of To'Ao garden plot, which was 0.320 tons/ha, while the lowest value of carbon deposits in understorey was found in Tongkonan of Buri 'garden plot, which was 0.170 tons/ha. The average value of understorey carbon deposits in the Tongkonan garden in Lembang Buri 'has a value of 0.246 tons/ha. Tongkonan To'Ao has the highest carbon stock value because, in the Tongkonan garden, there were many types of understorey, such as sweet potatoes, grasses, and red shoots. Carbon deposits in Tongkonan gardens have not significantly different values. This is because the Tongkonan garden has an almost uniform understorey composition.

### 4.4 Carbon Potential Stored in Litter.

One of the components besides the trees and understorey that can absorb carbon is litter. Litter is a dead organic material that is above the ground or forest floor [6]. Litter is a layer consisting of dead plant parts such as leaves, twigs, flowers, fruit, bark, and other parts that spread above the surface of the soil before decomposition.

| Plot              | Biomass (g/m²) | Biomass (g/plot) | Biomass (ton/plot) | Biomass (ton/ha) | Carbon (ton/ha) |
|-------------------|----------------|-----------------|--------------------|-----------------|-----------------|
| Buri' Tongkonan   | 76.724         | 47952.219       | 0.048              | 0.767           | 0.353           |
| Rimbua Tongkonan  | 76.569         | 47855.769       | 0.048              | 0.766           | 0.352           |
| Tanete To'Ao Tongkonan | 87.449     | 54655.913       | 0.055              | 0.874           | 0.402           |
| Tandung Tongkonan | 86.434         | 54021.300       | 0.054              | 0.864           | 0.398           |
| Ta'ba Tandung Tongkonan | 82.614     | 51633.800       | 0.052              | 0.826           | 0.380           |
| Tinakka Tongkonan | 104.004        | 65002.188       | 0.065              | 1.040           | 0.478           |
| Rumenden Tongkonan| 98.546         | 61591.331       | 0.062              | 0.985           | 0.453           |
The results showed that the value of litter carbon deposits in each plot had different values. The highest value was found in the Tongkonan of Bambala garden plot, which was 0.543 tons/ha, while the lowest value of carbon deposits in the litter was found in the Tongkonan of Rimbua garden plot, which is 0.352 tons/ha.

The litter carbon deposits value is different for each Tongkonan garden plot caused by the density factor of each plot. The denser a stand and canopy are, the higher the level of competition for sunlight so that much litter is produced because the trees will release branches and leave starting from the bottom, because of the lack of light obtained for photosynthesis.

The factors that influence the potential of litter carbon are the age of the tree, canopy density, the amount of litter falling, and litter quality. The quality of litter is influenced by environmental factors (climate, soil fertility), type of plants, and time (season and age of stands)

4.5 Saved Carbon Potential by Type.

A land that consists of various types of trees, then the species has a value of different density. Species that have a high value of wood density, the biomass will be higher when compared with the value of low density [7]. Besides being influenced by the specific gravity of each type of wood, the diameter of a tree also affects biomass and carbon deposits. In Table 5, we can see the difference in carbon storage by type in the Tongkonan garden.

| No | Jenis     | Nama Latin                  | Jumlah Pohon | Karbon (ton/ha) | Persentase (%) |
|----|-----------|------------------------------|--------------|-----------------|----------------|
| 1  | Caccao    | Theobroma cacao             | 107          | 0.381           | 0.117          |
| 2  | suren     | Toona sureni merr           | 2            | 0.679           | 0.209          |
| 3  | Uru       | Elmerillia ovalis           | 8            | 14.895          | 4.580          |
| 4  | Durian    | Durio zibethinus            | 9            | 17.026          | 5.235          |
| 5  | Mango     | Mangifera Indica            | 9            | 36.236          | 11.141         |
| 6  | Coffee    | Coffea sp                   | 16           | 3.701           | 1.138          |
| 7  | Kecrutan  | Spatodhea campanulata       | 1            | 0.989           | 0.304          |
| 8  | White teak| Gmelina arborea             | 9            | 48.537          | 14.924         |
| 9  | Buangin   | Casuarina junghuhniana      | 9            | 7.355           | 2.261          |
| 10 | Coconut   | Cocos nucifera              | 6            | 4.559           | 1.402          |
| 11 | Jackfruit | Arthocarpus heterophyllus   | 4            | 4.454           | 1.369          |
| 12 | Sengon    | Paraserianthes falcatoria   | 9            | 55.617          | 17.100         |
| 13 | Banana    | Musa paradisiaca            | 9            | 0.743           | 0.228          |
| 14 | Cotton    | Ceiba pentandra             | 1            | 4.922           | 1.513          |
| 15 | Guava     | Psidium guajava             | 4            | 0.78            | 0.240          |
| 16 | Langsat   | Lanzium domesticum          | 3            | 3.133           | 0.963          |
| 17 | Palm Sugar| Arenga pinnata              | 4            | 4.203           | 1.292          |
| 18 | Bamboo    | Bambussa sp.                | 2 rumpun     | 106.968         | 32.889         |
| 19 | Rambutan  | Nephelium lappaceum         | 4            | 4.497           | 1.383          |
| 20 | Mangosteen| Garcinia mangostana         | 1            | 0.053           | 0.016          |
| 21 | Pangi     | Pangium edule Reinw         | 1            | 3.003           | 0.923          |
| 22 | Areca nut | Areca catechu               | 1            | 0.541           | 0.166          |
It is known that cocoa tree type dominates in Lembang Buri ‘garden Tongkonan, which was 107 trees, but the type of bamboo found in 2 clumps had the highest percentage of carbon storage compared to other types, namely 32.889%. This was because the inventory of bamboo diameter calculations was calculated based on one bamboo cluster so that it had a large diameter. While the tree species in the Tongkonan garden had the lowest value of carbon deposits, namely mangosteen with a percentage of 0.016%, this is influenced by the number of mangosteen species in stands in the garden and has a small diameter.

The value of carbon deposits in forestry plants was higher than carbon deposits in plantation crops such as cocoa and coffee. This was because the diameter of plantation commodities had a small diameter that was around 5-10 cm, while the commodity of forestry plants had a large diameter ranging from 5-30 cm. Forestry plants have a more significant role in increasing carbon stocks compared to plantation types. The Lembang Buri community prioritizes planting crops and agriculture (annual crops) because it contributes more in the economic field.

### 4.6 Total Carbon Deposits and Carbon Content Contribution

The total value of carbon deposits is the sum of the value of carbon deposits contained in trees, litter, and understorey. Based on the results of the research, the total amount of carbon deposits can be seen in Table 6.

| Plot                     | Tree   | Carbon (ton/ha) | Litter |
|--------------------------|--------|----------------|--------|
| Buri’ Tongkonan          | 23.433 | 0.17           | 0.353  |
| Rimbua Tongkonan         | 24.391 | 0.19           | 0.352  |
| Tanete To’Ao Tongkonan   | 64.314 | 0.241          | 0.402  |
| Tandung Tongkonan        | 86.791 | 0.191          | 0.398  |
| Ta’ba Tandung Tongkonan  | 16.411 | 0.244          | 0.38   |
| Tinakka Tongkonan        | 54.901 | 0.291          | 0.478  |
| Rumenden Tongkonan       | 26.752 | 0.309          | 0.453  |
| To’Ao Tongkonan          | 25.057 | 0.32           | 0.42   |
| Bambala Tongkonan        | 35.751 | 0.198          | 0.543  |
| Bamba Tongkonan          | 12.508 | 0.302          | 0.404  |
| Total                    | 370.309| 2.456          | 4.183  |
| Average                  | 37.031 | 0.246          | 0.418  |
| Percentage (%)           | 98.239 | 0.652          | 1.110  |

Based on the research results, it can be explained that the amount of carbon in Lembang Buri, Rembon district was 376,948 tons/ha. With the details of each contributions, namely tree carbon 370,309 tons/ha or 98.239%, understorey carbon 2.456 tons/ha or 0.415% and litter carbon 4.183 tons/ha or 0.708%. In general, trees have the highest carbon stock compared to understorey and litter. This is consistent with the statement of [7] that the potential for tree deposits is far greater than for serasah and understorey because 50% of carbon deposits are found in stands.
5 Conclusion
Based on the research that has been done at the Tongkonan yard in Lembang Bu'ri, Rembon district, Tana Toraja, it can be concluded that:

a. The average carbon storage potential in the Tongkonan garden yard is 37,695 tons/ha
b. The most significant percentage of carbon deposits in Tongonan plantations in Lembang Bu'ri is found in stands of trees as much as 98.239%, lower plants 0.652% while the litter has the smallest percentage value of 0.110%.

References

[1] Darussalam D 2011 Pendugaan Potensi Serapan Karbon pada Tegakan Pinus Di Kph Cianjur Perum Perhutani Unit Iii Jawa Barat Dan Banten (Institut Pertanian Bogor) p 1-42
[2] Hairiah K, Ekadinata A, Sari RR R S 2011 Pengukuran cadangan karbon: dari tingkat lahan ke bentang lahan. Petunjuk praktis (Bogor: World Agroforestry Centre) p 1-110
[3] Paembonan S A, Millang S, Dassir M and Ridwan M 2018 Species variation in home garden agroforestry system in South Sulawesi, Indonesia and its contribution to farmers’ income IOP Conf. Ser. Earth Environ. Sci. 157 1-7
[4] Hairiah K and Rahayu S 2007 Pengukuran karbon tersimpan di berbagai macam penggunaan lahan World Agrofor. Centre. Bogor 77
[5] Tadesse E, Abdulkedir A, Khamzina A, Son Y and Noulékoun F 2019 Contrasting Species Diversity and Values in Home Gardens and Traditional Parkland Agroforestry Systems in Ethiopian Sub-Humid Lowlands Forests 10 266
[6] Martin, J. R., Álvaro-Fuentes, J., Gonzalo, J., Gil, C., Ramos-Miras, J. J., Corbi, J. G., & Boluda R 2016 Assessment of the soil organic carbon stock in Spain Geoderma 264 117–25
[7] Sutaryo D 2009 Penghitungan Biomassa Sebuah pengantar untuk studi karbon dan perdagangan karbon (Wetl. Int. Indones. Program.) p 1-48