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Estimation of Mangrove Forest's Carbon Stock in Kuala Indragiri Coastal Riau Province – Indonesia

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Abstract

Mangrove forest act as natural carbon stores, but the carbon will release if the trees were felled and the area were deforested. The amount of carbon stored within an area are varies according to the type of the vegetations, so it is need to develop the low carbon stock areas. Mangrove is one of the ecosystem's key in climate changes as the carbon's storage. Most of areas in Kuala Indragiri are low-lying areas (93.31%), such as, regional stream sediment, peat swamp areas with soil (peat), brackish forest areas (mangrove). Some of the area approximately 0-3 meters above sea level. The research design is the explorative research, by using nested quadrate method. There are 5 locations of carbon stocks sampling in Kuala Indragiri coastal: Sapat as station 1, Tanjung Lajau as station 2, Tanjung Melayu as station 3, Sei Bela as station 4 and Sei Buluh as station 5. Each station has three line transects consisting three plots of each transect. The total plots are 45 in each determined mangroves land. The methods followed the procedures developed by the Center for International Forestry Research (CIFOR) for mangrove forests. Based on the finding, mangrove vegetation in the Kuala Indragiri coastal consisted of fourteen species. In this study, the researcher developed a general allometric equation to estimate the individual tree biomass and soil carbon content. The finding showed that the estimation of the carbon stock in the whole mangrove forest in Kuala Indragiri coastal: the average ground mass C stocks at each observed station were estimated to be 767.28 ton/ha (trees strata), 92.84 ton/ha (belta strata) and average soil carbon at each station to be 492 ton/ha respectively. estimation of mangrove forest's carbon stock at above ground biomass and soil biomass in Kuala Indragiri coastal Riau province – Indonesia totally to be 1.352,31 Ton/Ha.

Keywords: Carbon stock, Mangrove forest, Kuala Indragiri coastal

Introduction

Coastal ecosystems are critical in maintaining human being and global biodiversity. In particular, mangroves, tidal salt marshes, and sea grasses provide benefits, services and contribution to the people's ability in mitigate and adapt to the impacts of climate change. Many of these services are essential for climate adaptation and resilience along coasts, including protection from storm surge, sea level rise, erosion prevention along shorelines, coastal water quality regulation, nutrient recycling, sediment trapping, habitat provision for numerous commercially important and endangered marine species, and food security for many coastal communities around the world (Kauffman *et al*., 2011).

Conservation and restoration of these coastal ecosystems has been increasingly addressed in international and national climate change mitigation policy and finance mechanisms. However, to date, countries have not incorporated coastal blue carbon into their portfolio of climate change mitigation or coastal management policies and actions, largely because the mechanisms for assessing blue carbon were not well defined or standardized (Onrizal et al., 2005).

Kuala Indragiri is one of the districts that are in the Riau province. Most of the area (93.31%) in Kuala Indragiri is low-lying areas, such as: regional stream sediment, peat swamp areas with soil (peat), brackish forest areas (mangrove) and consists of islands large and small with the average height of approximately 0-3 meters above sea level.

Kuala Indragiri has 24 334 hectares of mangrove forest area. Mangrove forest is a forest that grows in coastal areas, usually located in the bays' areas and estuaries with trait, not influenced by climate, but the sea tide, sea water flooded soils, low soil beach. There is no canopy structure for protections, and has the specific trees.

Mangrove has significant roles in the ecosystem which is known as high carbon storage. However, it is surprisingly invented that the available data on carbon storage for mangrove forest in Kuala Indragiri coastal are insufficient. Mangrove is well known for high C assimilation and flux rates, there is surprisingly lack of available data on the carbon storage.

Study Area

Indonesia is the largest *archipelago* in the world. It consists of five major islands and about 30 smaller groups. The study area is located in the Mangrove forest of Kuala Indragiri coastal, Indragiri Hilir district area of Riau province (Sumatera island) Indonesia.

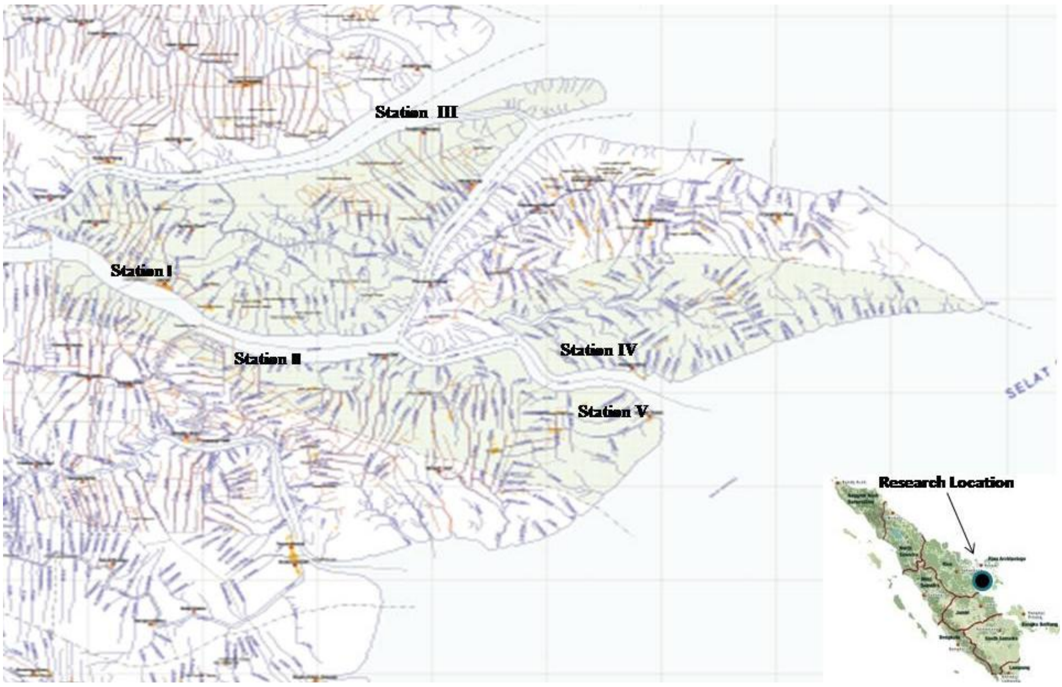

Figure 1: Location of the study site and sampling points in the mangrove forest of Kuala Indragiri coastal

Material and Methods

The design of the research is explorative by using nested quadrat method. There were 5 locations for carbon stocks sampling in Kuala Indragiri coastal, i.e.: Sapat as station 1, Tanjung Lajau as station 2, Tanjung Melayu as station 3, Sei Bela as station 4 and Sei Buluh as station 5. Each station has three line transects consisting three plots of each transect so that total plots are 45 in each determined mangroves land. Research sampling used for the plot was purposive random sampling by considering elevation equal to 100 m from sea level. Sample units were done by stratified sampling. Map of representative study sites were presented on Figure 1.

The field procedure was based on the protocols for measurements of carbon stocks in mangrove forest, to determine the biomass of tree from each plot, the measured parameters were diameter at breast hight (dbh). The values of measured parameters were used in the published allometric equations. The down wood volume was calculated from line intercept data using scaling equations. In each sample of mangrove ecosystem, a transect was laid on vertical from the river or coast shoreline with no prior knowledge of forest composition or structure. The Measurements and the collection of C-Stocks sampling were conducted as described below.

Above-Ground Biomass and Carbon

All the trees were stem by diameter at breast height (DBH) greater than 10 cm (tress strata). The DBH (cm) and height (m) were measured, and the species identified within radius 5 m from the sampling of plots. Trees with stem diameters between 5 and 10 cm (belta strata) were measured in radius 5 m subplot, as located in the center of the main plot. To calculate the above-ground tree biomass, we developed a general allometric equation for all species found in the study area (Sitoe et al., 2014: Jones et al., 2014: Steven et al., 2013) Soil carbon stock per sampled interval was calculated using equation:

$$\text{Carbon stock} = \text{Biomass x } \%C_{\text{Organik}}$$

Soil Biomass and Carbon

Every sample was collected at 0–30, 30–60 and 60–100 cm depth using a corer with a volume of 100 cm^3. Undisturbed samples for bulk density estimation and disturbed samples for carbon content estimation were collected from each of the three depths. Bulk density for undisturbed soil samples was determined by dividing oven-dried samples (at 100°C for 48 h or until constant weight) by the volume of the corer. The soil carbon per sampled depth interval was calculated using equation:

$$\text{Soil Carbon} = \text{bulk density} \times \text{soil depth interval} \times \%\text{Carbon}$$

Results

The finding showed that mangrove vegetation in the Kuala Indragiri coastal consisted of fourteen species: Three spesies from genus *Sonneratia* were: *S.caseolaris*, *S.alba*, S.*ovata*. two species from genus Avicennia: *A. alba* and *A. Marina*; Two spesies from genus Bruguiera were: *B. parviflora* and *B. gymnorhiza*. *Rhizophora sp*, *Kandelia candel*, *Xilocarpus granatum*, *Nypa fruticans*, *Hisbiscus tiliaceus*, *Achantus sp*, and *Acrostichum aureum.*

The source of the carbon (carbon pools) measured through field measurements. Carbon measurement methods in the field by placing the sample plots have been developed (IPCC, 2006: Kridiborworn, et al., 2012: Hairiah, et al: 2011: Lugina, 2011). The estimates data of biomass carbon stocks in trees level mangrove vegetation in the area of Kuala Indragiri coastal conducted through nondestructive sampling at five observation stations are listed in Table 1.

Table 1: Estimation of Carbon Stock Mangrove Forest Biomass in Coastal Zone Kuala Indragiri at Trees Strata

Station	Line Transect	Biomass (ton/ha)	Carbon (ton/ha)
I	1	2563.92	1205.04
	2	917.00	430.99
	3	1394.81	655.56
	Total	**4875.73**	**2291.59**
II	1	806.47	379.04
	2	787.97	370.35
	3	296.46	139.33
	Total	**1890.89**	**888.72**
III	1	1127.42	529.89
	2	240.47	113.02
	3	710.37	333.87
	Total	**2078.26**	**976.78**
IV	1	1944.54	913.94
	2	3044.71	1431.01
	3	2910.21	1367.80
	Total	**7899.47**	**3712.75**
V	1	3496.05	1643.14
	2	2644.68	1243.00
	3	1602.51	753.18
	Total	**7743.24**	**3639.32**
Σ			**11509.17**
Average/Station			**2301.83**
Average/Plot			**767,28**

Data from estimates of biomass carbon stocks in belta level of mangrove vegetation in Kuala Indragiri coastal area conducted through nondestructive sampling at five observation stations are listed in Table 2.

Table 2: Estimation of Carbon Stock Mangrove Forest Biomass in Coastal Zone Kuala Indragiri at Belta Strata

Station	Line Transect	Biomassa (ton/ha)	Carbon (ton/ha)
I	1	55.00	25.85
	2	85.38	40.13
	3	50.07	23.53
	Total	**190.45**	**89.51**
II	1	193.11	90.76
	2	163.93	77.05
	3	48.69	22.89
	Total	**405.74**	**190.70**
III	1	151.97	71.43
	2	201.73	94.81
	3	180.05	84.62
	Total	**533.76**	**250.87**
IV	1	394.44	185.39
	2	282.44	132.75
	3	283.57	133.28
	Total	**960.45**	**451.41**
V	1	322.72	151.68
	2	276.74	130.07
	3	273.00	128.31
	Total	**872.46**	**410.06**
	Σ		**1392.55**
	Average/Station		**278.51**
	Average/Plot		**92.84**

Soil organic carbon is one of the important soil chemistry characteristics in mangrove ecosystems. These soil properties can be used to estimate the organic matter content in the soil. The Data from estimates of biomass and soil carbon stocks conducted through nondestructive sampling from the five stations are listed in Table 3.

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Table 3: Bulk Density and Soil Carbon Stock Mangrove Forest in Kuala Indragiri Coastal

Station	Line Transect	Bulk Density (ton/ha)	Soil Carbon (gr/cm²)	Carbon (ton/ha)
I	1	1.96	4.61	449
	2	1.82	4.28	
	3	1.95	4.58	
	Average		**4.49**	
II	1	2.05	4.82	480
	2	2.01	4.72	
	3	2.07	4.86	
	Average		**4.80**	
III	1	2.10	4.94	479
	2	1.98	4.65	
	3	2.03	4.77	
	Average		**4.79**	
IV	1	2.17	5.10	530
	2	2.05	4.82	
	3	2.54	5.97	
	Average		**5.30**	
V	1	2.34	5.50	523
	2	2.18	5.12	
	3	2.16	5.08	
	Average		**5.23**	
Σ				**2461**
Average				**4.92**

The differences of the carbon stocks ratio for each station were affected by the compilers of mangrove vegetation. The value of carbon stocks in the structure of the station has a density of mangrove vegetation, whereas the strata tall tree also has the high carbon stock values as well. This is relevant with research made by Heriyanto & Endro (2011). Comparison of total carbon stock in mangrove vegetation of above ground biomass (tree strata, Belta strata) and carbon stock at soil biomass included Figure 2.

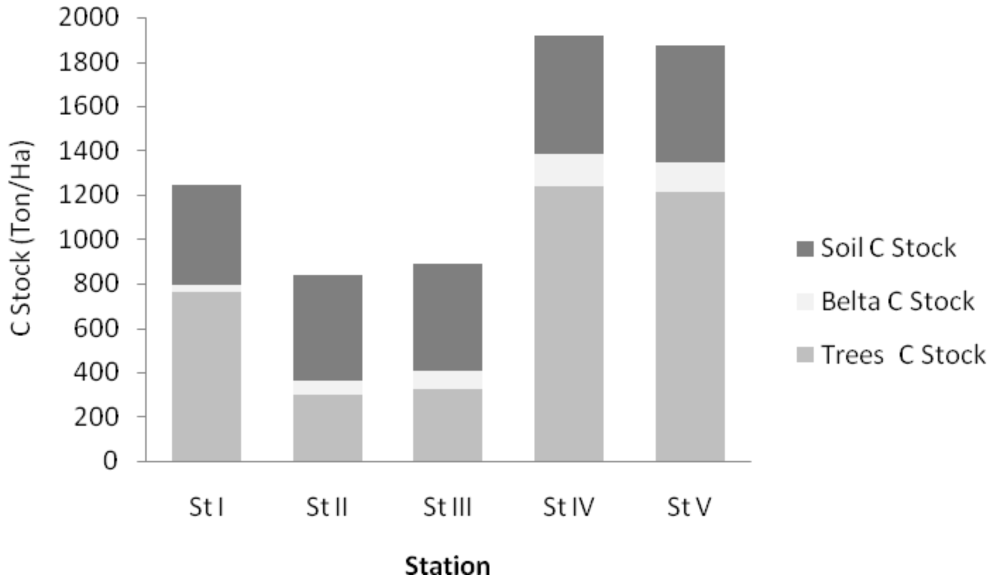

Figure 1: Acummulation of Carbon Stocks at Above-Ground Biomass and Soil Carbon

Biomass values listed in Table 1, 2 and table 3were the value of the biomass obtained from the conversion; by using diameter at breast height (dbh) were calculated by using allometric equations. From the calculation of biomass on each stem of the tree, the total value of the biomass obtained by summing all the results of the calculation of vegetation biomass all trees at each station. The value of total biomass can be identified from the value of biomass per area. The data obtained from the wide area 10 x 10 m plots were converted into units of acres, so that the value of biomass per area of carbon stock values obtained using the formula value of biomass 47%/area.

Discussion

Based on the allometric equation that used to calculate the biomass of the trees, the intensity of the tree biomass is proportional to the density of the trees. The value of tree biomass is also directly proportional to the carbon value, where the higher of the biomass value, will be higher the carbon value. This is due to the value of the carbon content of an organic material, 47% of the total biomass (National Standardization Agency, 2011). It is also expressed by Rachmawati, et al (2014), carbon stocks on a system of land use (primary forest, logged forest, and agro forestry) is influenced by the type of vegetation.

The mangrove forests and coastal areas in the districts of Kuala Indragiri has a great potential to be a storage area of carbon reserves on a large scale. In addition, according Lignon (2011) mangrove forest is one of the natural resources that have value and meaning is very important both in terms of physical, biological and socio-economic. Due to the increasing needs of human being, will intervention the ecosystem. It can be seen from the conversion of mangrove land into gardens, ponds, settlements, industrial areas and so on.

Carbon stocks are basically the large amount of carbon stored in vegetation, other biomass and in the soil. Reducing the greenhouse gas concentrations in the atmosphere (emissions) is to reduce the release of CO_2 into the air. Then, the amount of CO_2 in the air must be controlled by increasing the amount of CO_2, taken by plants as much as possible and suppressing the release of emissions as low as possible. This stored carbon reserves should be measured in order to determine the amount of carbon stocks in a time and the impact of the activities; increase or reduce the size of reserves. By measuring, it can be seen how the results of the acquisition of the absorbed carbon stocks and can be done as the basis of taking and releasing the carbon stocks. The development countries or the industry has an obligation to provide compensation to the state or anyone else who can reduce emissions or increase absorption (Hairiah, 2007).

Mangroves could become the strategies key in ecosystems, as the mitigation of climate changes through carbon storage. These ecosystems provide coastal protection, habitat, shelter, nursery and breeding grounds for many fish and crustaceous species and other sea and terrestrial fauna. Carbon storage is one of the most important environmental services provided by mangrove forest. The data shows that the total carbon storage in mangrove forests is exceptionally high if compared with most upland forest types, little has been done to quantify the amount of carbon stored (Kauffman & Donato, 2012: Sitoe et al., 2014).

Conclusion

In this study, the researchers present the estimation of carbon stocks mangrove forest in Kuala Indragiri coastal area. The finding shows that mangrove vegetation in the Kuala Indragiri coastal consisted of fourteen species. In this study, we developed a general allometric equation to estimate individual tree biomass and soil carbon content. The carbon stocks in the whole of mangrove forest in Kuala Indragiri coastal are above the ground mass and soil. The result showed the average from above ground mass C stocks at each observed station; were estimated to be 767.28 ton/ha (trees strata), 92.84 ton/ha (belta strata) and average soil carbon at each station to be 492 ton/ha respectively.

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