Carbon stock and vegetation estimation the abandoned pond, 
Pulau Sembilan, North Sumatra, Indonesia

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Abstract. The purpose of the study was to determine the species vegetation and carbon stock assessment derived from abandoned aquaculture ponds. Analysis of plant (tree, sapling, and seedling) was performed at Pulau Sembilan, Langkat, North Sumatra, Indonesia. The stage of the seedlings, saplings, and trees was analyzed from four transects. Each transect contained 100 m in length. Each estimated plot of a total of four transects comprised of 30 plots. The abandoned pond was dominated by Rhizophora apiculata and Bruguiera parviflora, the lowest on the species of Morinda citrifolia and Rhizophora mucronata. The diversity index of Shannon-Weiner was 1.44-1.72. The total biomass in the pond was 4,557.43 k/ha with a carbon potential of 2.10 tons/ha.

1. Introduction

Mangroves as one of the components of the coastal ecosystem play a crucial function, both in terms of preserving coastal function and of improving residents' lives [1]. For coastal regions, the occurrence of mangrove forests, a green belt along the coast or river estuaries is especially important. Mangroves provide for the supply of firewood, fish, and shrimp, as well as for protecting the agriculture, fishery, and settlement ecosystems that surround it from abrasion and intrusion. [2,3].

Mangrove ecosystems have been destroyed as a result of extensive deforestation for a variety of economic purposes, including several activities such as aquaculture, agriculture, and industry [4,5]. This is a common occurrence in North Sumatra's coastal regions. The decrease in shrimp and fish in this region reduces the revenue of small fishermen who typically work along the coast, as well as shrimp fishermen and crab seekers [2,6]. Because of the decrease in fish catch on North Sumatra's east coast, some fishermen have switched professions as loggers in the mangrove forest or cut down the wood as an unusual activity over the off-season. [2,7]. It has been shown the ecology status of Pulau Sembilan was categorized as damage to the good condition [8]. Therefore, studies on species diversity and carbon stocks estimation existed in abandoned ponds in Pulau Sembilan village, Langkat, North Sumatra are critical to getting more understanding of the impact of mangrove conversion. This work provided information about the vegetation of abandoned ponds in Pulau Sembilan, North Sumatra.
The study was conducted to analyze the species vegetation and carbon stock assessment from abandoned aquaculture ponds.

2. Materials and Method

2.1. Study location and plant measurement
The plant stage (tree, sapling, and seedling) was studied in Pulau Sembilan Village, Langkat, North Sumatra, Indonesia. Aquaculture ponds were used as sampling sites, and they were located in a variety of locations, at 4° 10' 26" N, 98° 15' 58" E. Transects are used to create sample plots that run from the sea's edge to the mainland, with the subsequent monitoring stages in the sampling plots: subplot 10 example x 10 m for three-stage (diameter ≥ 10 cm), subplot example 5 m x 5 m for sapling term (5-10 cm in diameter), and sample subplot 2 m x 2 m for the seedling stage. Every plot contained 30 plots, for a total of four transects as shown in Figure 1. Data obtained from field measurements are estimated to analyze the parameters listed below. [2]. This information was obtained to determine the importance value index (IVI) and the diversity index (H') of mangrove plants.

![Figure 1](image.png)

**Figure 1.** Map location of abandon aquaculture ponds consisting four transects in Pulau Sembilan

2.2. Carbon stock estimation
The biomass of mangrove plant in aquaculture ponds in Pulau Sembilan village was measured as previously described [9]. Plots were determined as previously reported [4]. The final calculation of carbon potential (C) stored was estimated by the formula: 

\[ C = \text{Total biomass (kg ha}^{-1}) \times 0.46. \]

3. Results and Discussion

3.1. Plant diversity and density
Based on the level of growth found in 22 sample plots, the vegetation analysis depicted the stage of biodiversity and density of mangrove species dervied aquaculture ponds. Eight species of vegetation were found in the aquaculture pond at all levels of growth, including seedlings, saplings, and trees, as shown in Table 1.

| Individual-level |
|------------------|
|                   |

**Table 1.** Plant composition at an individual level

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Prominent species are detected in *R. apiculata* and *B. sexangula* species at seedling and *M. citrifolia* at tree stage, with *B. parviflora*, dominated sapling stage, by contrast the lowermost is in *R. mucronata* at seedling and sapling development levels, and the bottommost tree growth levels are in *R. mucronata* and *L. racemosa*. Because the propagules can germinate attached to the trees, they are very beneficial to the species' broad dispersal process. [10]. At the tree stage, *M. citrifolia* dominated at the abandoned pond. Unlike the case with the number of minority vegetation, this small amount is due to the ecology of *A. marina* that grows on brackish soils and high salinity. Furthermore, the characteristics of the research location where the majority of the soil is influenced by freshwater. On the other hand, the non-mangrove species (*M. citrifolia*) have an ecology where they grow, which requires a large amount of freshwater input. Rehabilitation activities have been done, this plant is a minority because it has been dominated by mangrove plants from land rehabilitation [8].

| Species               | Family          | Seedling | Sapling | Tree |
|----------------------|-----------------|----------|---------|------|
| *Avicennia marina*   | Acanthaceae     | 15       | 7       | 7    |
| *Bruguiera parviflora* | Rhizophoraceae  | 14       | 93      | 11   |
| *B. sexangula*       | Rhizophoraceae  | 21       | 13      | 1    |
| *Lumnitzera racemosa* | Combretaceae    | 4        | 43      | 1    |
| *Rhizophora apiculata* | Rhizophoraceae  | 21       | 30      | 14   |
| *R. mucronata*       | Rhizophoraceae  | 0        | 0       | 1    |
| *Morinda citrifolia* | Rubiaceae       | 3        | 12      | 31   |
| *Xylocarpus granatum* | Meliaceae       | 2        | 1       | 6    |
| Total                |                 | 80       | 199     | 72   |

Table 2. Shannon-Weiner diversity index of plant stage

| Species               | Plant stage       |
|----------------------|-------------------|
|                      | Seedling | Sapling | Tree |
| *A. marina*          | 0.32      | 0.12    | 0.30 |
| *B. parviflora*      | 0.31      | 0.35    | 0.35 |
| *B. sexangula*       | 0.35      | 0.18    | 0.09 |
| *L. racemosa*        | 0.15      | 0.33    | 0.09 |
| *M. citrifolia*      | 0.06      | 0.11    | 0.09 |
| *R. apiculata*       | 0.35      | 0.29    | 0.37 |
| *R. mucronata*       | 0         | 0       | 0.09 |
| *X. granatum*        | 0.09      | 0.03    | 0.28 |
| Total                | 1.63      | 1.44    | 1.72 |

Table 3. Important value index (IVI) in an abandoned pond

| Species               | Growth rate       |
|----------------------|-------------------|
|                      | Seedling | Sapling | Tree |
| *A. marina*          | 32.33    | 18.97   | 45.53|
| *B. parviflora*      | 30.75    | 71.37   | 67.92|
| *B. sexangula*       | 46.54    | 22.08   | 21.08|
| *L. racemosa*        | 11.41    | 33.81   | 15.29|
The outcomes of species diversity (H') studies that have been conducted from an abandoned pond at 22 sample plots for a seedling, sapling, and tree-level development, shown in Table 2. The intended arrangement of flora in a forest category contains plants in the canopy layer at the top and vegetation in the bottom layer. It has been reported that Pulau Sembilan found 28 mangrove species consisting of the high rite of biodiversity in mangrove forests is affected by several factors, comprising the situations behind the distribution of the mangrove [8]. The Shanon-wiener diversity index in this work arrayed from 0 to 3 with the succeeding conditions: if H' (0 < 2) was classified as low, H' (2-3) is categorised as moderate, H' (> 3) or more high [3]. As displayed from Table 2, the biodiversity encompassed in each of these study sites was categorized as low (H' = 0 < 2). A previous study [8] showed A. marina dominated on the east and south coast, while on the west coast, A. marina, N. frutican, and R. stylosa

Table 3 depicted the leading species at the tree level were detected in R. apiculata (IVI = 75.48 %), and the bottom was in R. mucronata (IVI = 15.68%). At the sapling stage, the central species was detected in the species of B. parviflora (IVI = 71.37%), and the lowest was also in the species R. mucronata (IVI = 0%). Similarly, at the seedling stage, the foremost species were traced in the R. apiculata (IVI = 65.30%), and the lowermost was also in the R. mucronata (IVI = 0%) as displayed in Table 3.

The plant condition, which displays the size of the function of a species of obtainable society, can indicate whether or not mangroves are growing in a community.. [10]. The IVI, which belongs to a mangrove species, exemplifies this situation. [12]. Low IVI in certain types, on the other hand, suggested that this species is less able to play with the behind environment and other species.

3.2. Carbon stock estimation

Table 4 depicts that R. apiculata provided the most biomass stock with the equal of biomass (2,297.91 kg/ha), and the lowest is in R. mucronata showed biomass of 43.80 kg/ha. The total biomass of mangrove stands measured on the study's sample plot at the abandoned pond was 4,557.43 kg/ha, with a carbon stock of vegetation of 2.1 tons/ha.

| Species        | Total biomass (kg) |
|----------------|--------------------|
| A. marina      | 518.61             |
| B. parviflora  | 1,007.54           |
| B. sexangula   | 117.16             |
| L. racemosa    | 51.74              |
| M. citrifolia  | 59.44              |
| Rhizophora apiculata | 2,297.91 |
| R. mucronata   | 43.80              |
| X. granatum    | 461.23             |
| Total biomass  | 4,557.43 Kg/ha     |
| Estimated Carbon (C = total biomass kg / ha x 0.46) | 2,096.42 kg / ha |
It has been reported that conversion of mangrove to shrimp pond reduced less than half of the carbon stock of intact mangrove in Mahakam Delta [13]. The difference in carbon stock was caused by differences in plant density. To avoid global warming, the amount of carbon that is increasing at this time must be balanced with the amount of carbon absorption by plants. Therefore, it is possible to estimate the number of plants that must be planted on land to compensate for the amount of carbon released. [15]. The stored carbon value expresses the amount of carbon that plants can absorb in the form of biomass. [15]. Thus, it is possible to forecast how many plants will need to be planted on the land in order to balance the amount of carbon released.

It has been reported [17-19] that increasing carbon stocks can be done by (a) increasing natural forest biomass growth, (b) increasing timber reserves in existing forests by rehabilitation or restoration or avoiding timber harvesting, and (c) developing forest species for fast-growing trees, because the carbon absorbed by plants is stored in the form of woody biomass, planting and maintaining existing trees is the simplest way to increase carbon stocks.

4. Conclusions

R. apiculata and B. parviflora were dominated in pond locations with the lowest was M. citrifolia and R. mucronata. The carbon stock of the abandoned pond was low with a carbon stock of 2.10 tons/ha.

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