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Article

Growth rate and carbon storage capacity of mangroves along the Tambakrejo Coastal Zone

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Abstract. The existence of mangroves is essential as a mitigation agent of the impacts of climate change. Mangroves serve as abrasion protection and a carbon storage agent, reducing greenhouse gas emissions. This study aimed to examine growth rate and carbon storage of mangroves as a determination of a rehabilitation potential for abrasion-exposed degraded mangroves. This study used a quantitative approach. Data was collected in November 2021 at the Tambakrejo coast, located in the north coast of Semarang. The results showed that the highest growth rate occurred in the 5–6-year period with the diameter of 0.11 cm (about 0.04 inch)/month and in the 4–5-year period with the height of 3.54 cm (about 1.39 inch)/month. The regression analysis showed moderate level of relationship between diameter and height values. This was used to determine both height and diameter values. Among different tree age classes, the age class of 72 showed the highest storage capacity, reaching 45.6 kg CO2eq, with average annual addition of 7.5 kgCO2eq/year. This indicates biomass addition is positively related to the storage capacity. Thus, anything that can alter the mangrove tree biomass will affect its carbon storage capacity.

Keywords: Carbon Stock, Growth Rate, Mangrove ecosystem

INTRODUCTION

Indonesia, a country with a coastline of 81,000 km, possesses abundant natural resource potential. However, its vast coastal areas, vulnerable to climate change, experience significant losses due to increasingly massive abrasion and erosion (Alansori et al., 2022). Coastal erosion occurs due to an ecosystem's inability to withstand the balance of material input triggered by various natural factors, in this case climate factors (Ramadhani, 2020).

Environmental degradation in coastal areas makes erosion increasingly uncontrollable due to the loss of natural physical structures that originally existed, one form of natural physical structure that is protective in coastal areas is the mangrove ecosystem (Ramadhani, 2020). Mangrove planting activity is one of the efficient ways of preventing coastal erosion and abrasion. Successful mangrove planting activity can guarantee the success of coastal abrasion and erosion prevention (Arifin et al., 2019). Mangrove forests are commodities as well-known as tropical coastal vegetation communities that have the privilege of growing in intertidal and subtidal areas where salinity and tides play a significant role. Mangrove forests with their specific features will be found in many coastal areas, including around beaches, bays, estuaries, deltas and protected coastal areas (Farhaby, 2017).

In addition to its protective role in coastal areas, mangroves also have excellent carbon assimilation and sequestration capabilities compared to most other terrestrial forest types. Photosynthesis processes determine the carbon content of mangroves. During photosynthesis, CO_2 from the atmosphere is captured by vegetation and stored as biomass. Measuring the amount of carbon content stored in mangrove forests could illustrate the amount of atmospheric CO_2 that is absorbed by the forest (Donato, 2011).

The northern Semarang coastal area has experienced a very alarming level of deforestation in the 2018-2020 range (Winaz et al., 2023). Therefore, the existence of mangroves is needed as a mitigation agent from the effects of climate change, one of which is abrasion. Additionally, mangroves carbon storage plays a significant role in reducing greenhouse gas emissions. This study aimed to to examine growth rate and carbon storage of mangroves as a determination of a rehabilitation potential for abrasion-exposed degraded mangroves in conservation projects in the Tambakrejo coastal area.

MATERIAL AND METHODS

This research was conducted in November 2021 at the Tambakrejo coastal site located on the north coast of Semarang (Figure 1). Data collection was conducted using a quantitative approach. Samples were taken at 7 different mangrove age groups (1) mangrove seedlings at planting (2) age 1 year (3) age 2 years (3) age 3 years (4) age 4 years (5) age 5 years and (6) age 6 years, each age class is represented by 10 mangrove samples. Data collected consisted of tree height and tree diameter using meter strap and tabulated into worksheet (Primavera, 2012). Data collection was conducted using survey methods, and the research results will be used to develop growth projections and quantify the carbon storage potential of mangroves in this area.

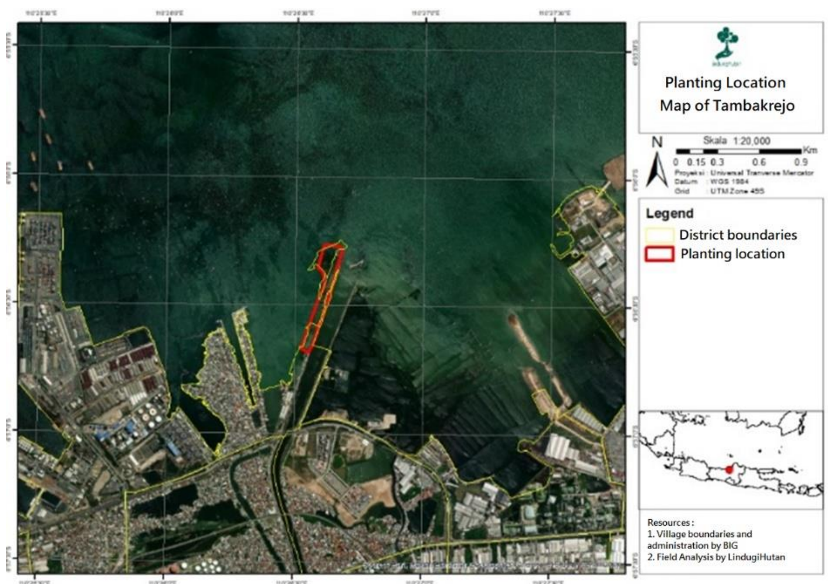

Figure 1. Research Station

Data Analysis

The height and diameter data was used to determine Growth Rate (GR) of each age differences (months). This could be used to project both height and diameter based on age data only in the future, specifically for this region. The GR was calculated using the following formula $GR = (X1-X0)/T$, where X1 is the value obtained during sampling and X0 is the value obtained at the time of planting, and T represents time.

Thereafter, the calculation of carbon storage was analyzed by calculating the volume of the stand with the following formula $V = 4.\pi.d2.t.f$. Where V is the volume of the tree (m^3), d is the diameter of the tree with heigh of 20 cm above the root (cm), t is the total height (m) and f is the shape number (0.6) and $\pi = 3.14$. Furthermore, the calculation of tree biomass is based on Dharmawan & Samsoedin (2012) with the formula of Biomass = tree volume x tree specific gravity. Tree specific gravity was determined as 0.92 because the existing mangroves in this area consist of Rhizophora species. Furthermore, the biomass value was converted into carbon (kg) and carbon dioxide equivalents (CO_2eq) with the following formula CO_2eq = Biomass x 0,47.

RESULTS

Growth Rate and Regression Value of Mangrove of Tambakrejo

Growth in height and diameter of mangroves initiated by the growth of the meristem tissue. This study showed the growth rate of mangrove diameter and height in the coastal region of Tambakrejo are 0.05 cm/month and 3.29 cm/month respectively from total 60 samples. The highest growth rate in this study occurred in the 5-6 year period with the diameter of 0.11 cm/month and the 4-5 year period with the height of 3.54 cm/month. Regression analysis was conducted to assess the relationship between the diameter and height variables (Figure 2). Regression analysis was carried out to see the correlation between height and diameter values. An R value above 0.5 indicates that the regression model is considered good and can be used for estimation between variables.

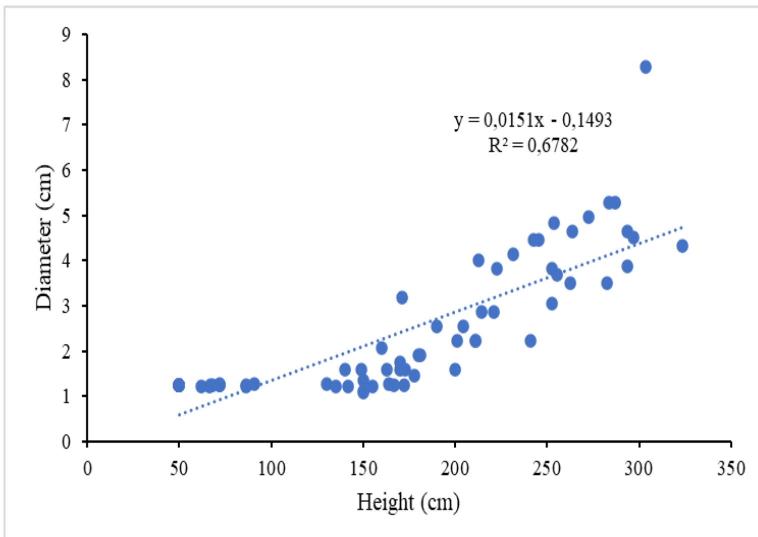

Figure 2. Regression analysis of mangrove diameter and height values

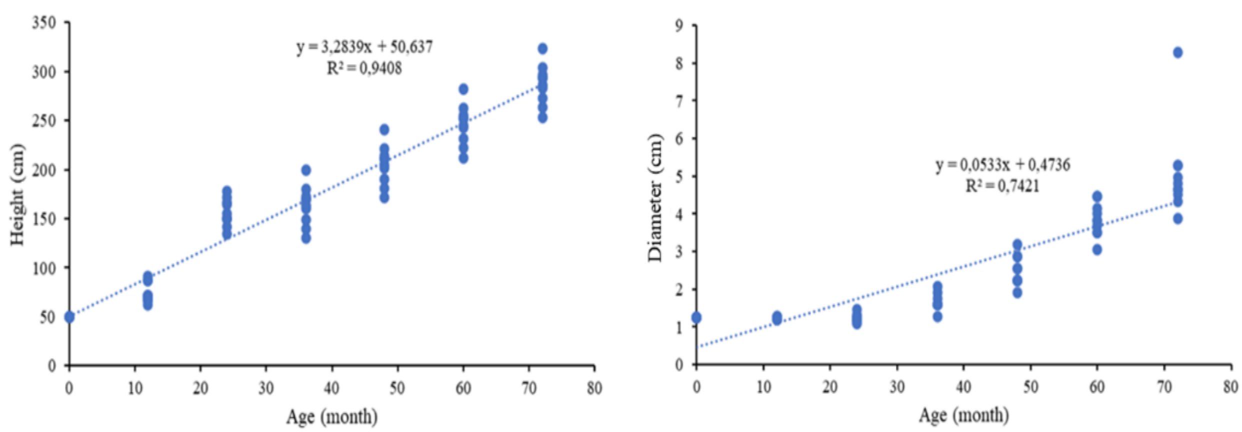

Figure 3. Regression of height values with mangrove age (left) and diameter values with mangrove age (right)

In Figure 3, it can be seen that the best regression value was obtained for the variable age and height (R2=0.7421).The linear relationship between the variable age and diameter was weak with the R2 value above 0.6 (R2= 0.9408).

Carbon Stock Storage Potential of Mangroves in Tambakrejo

The results of the calculation of mangrove carbon stocks at different ages in the Tambakrejo coastal area showed that at the age of 72 the carbon storage potential reached up to 45.6 kg with average annual addition of 7.5 kgCO2eq/year. The fluctuation of Carbon storage potential can be seen from (Figure 4).

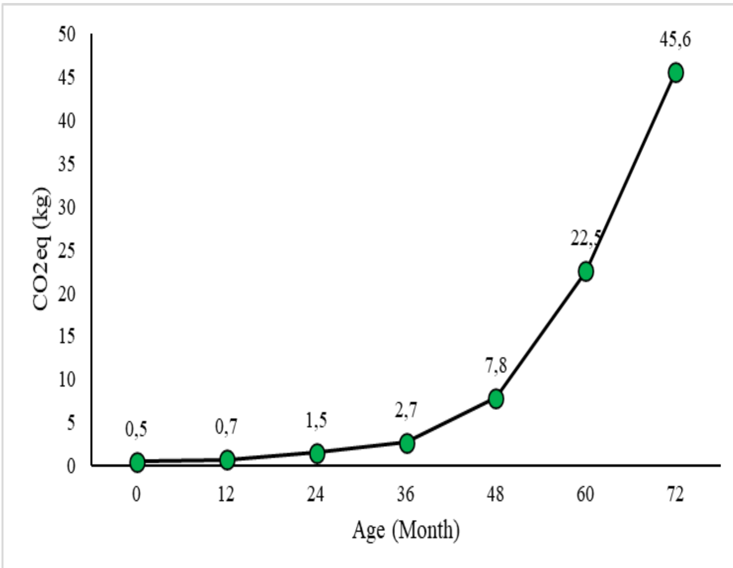

Figure 4. Coastal mangrove carbon stock Tambakrejo

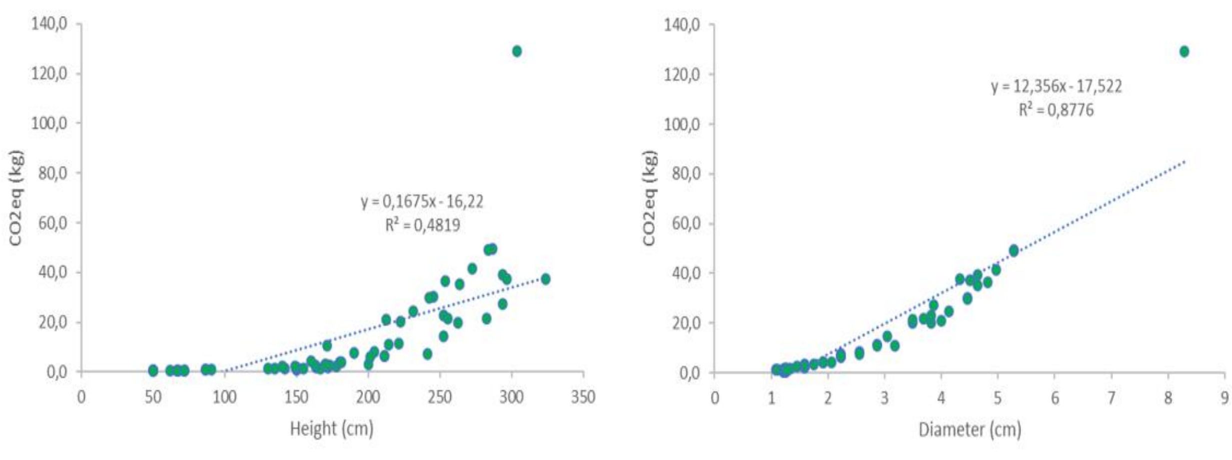

Figure 5. Regression of height value with carbon storage (left) and diameter value with carbon storage (right)

Regression of height and diameter values associated with carbon value showed that the regression model of height value with carbon value was the best model in this study (R2= 0,4819) (Figure 5). determination coefficient R2>0.40 shows strong relationship, thus the greater the value of R2 between height and stock carbon are better.

DISCUSSION

Mangrove height GR is influenced by the presence of nutrients in the surrounding waters. Nutrients are important inputs for mangroves because they can increase mangrove growth rates by 30-35% compared to without sufficient nutrient fulfillment conditions (Syakir et al., 2021). Differences of GR values in both diameter and height variables in different periods are thought to be due to differences in the ability of young mangroves to uptake nutrients. Height variations in the mangrove growth process can show differences in the physiological response of mangroves in adaptation to environmental factors (Raynaldo & Minsas, 2020).

Increment of diameter growth rate is more sensitive to temperature and precipitation variables. Diameter dilation is induced by growth in the vascular cambium and naturally drought conditions can reduce cell wall thickness which can further reduce the diameter of the mangrove itself (Qaderi et al., 2019).

The regression equation between diameter and height values is at a moderate level and can then be used for prediction to determine both height and diameter values. Research conducted by Purnamasari et al (2021) in the Bedul mangrove forest in Indonesia showed a positive correlation between aboveground carbon stock (AGC) and mangrove tree diameter at breast height (DBH) and tree height. The study also found that biomass content and AGC were influenced by the number of mangroves stands, with trees greater than 30 cm in diameter contributing significantly to AGC based on tree biomass. In addition, a study on mapping blue carbon stocks of mangroves in Penang, Malaysia, used allometric equations for trees and roots to estimate below-ground and above-ground carbon stocks based on DBH parameters. The study found that the biomass of each stand was multiplied by 0.464 gC to obtain carbon content, and a DBH-light relationship model was created using a polynomial regression equation and used to predict the entire above- and below-ground biomass of mangroves in the study area by plotting DBH values against light values (Sani & Hashim, 2018).

The increase in this biomass value is due to the addition of biomass content which has a positive relationship, thus anything that changes biomass value will directly affect the carbon stock of the mangrove itself (Chanan, 2012). Carbon content stock in a plant illustrates how much the ability of a plant in binding carbon in the atmosphere. Carbon itself will be the energy used by plants in physiological processes that stimulate the growth of plants (Heriyanto & Subiandono, 2016).According to Amanda et al (2021), mangroves that have a larger stem diameter will have a greater biomass and carbon stock value. In general, forests that are in the growing phase will be able to absorb more CO2 while forests in the stationary phase tend to be better at holding and storing extra CO2 supplies (Dharmawan & Samsoedin, 2012).

This study showed that the highest growth rate occured in the 5-6 year period with the diameter of 0.11 cm /month and in the 4-5 year period with the height of 3.54 cm / month. While the calculation of mangrove carbon stocks at different ages in the Tambakrejo coastal area showed that the highest CO2eq value is at the age of 72 months with a storage of 45.6 kg and an average annual addition of 7.5 kgCO2eq/year.

CONCLUSION

It can be concluded that the growth rate of height and diameter in mangroves observed in this study had the highest growth rate occurring in the 5-6 year period for the diameter variable of 0.11 cm/month and in the 4-5 year period for the height variable of 3.54 cm/month. Meanwhile, calculations of mangrove carbon stocks at different ages in the Tambakrejo coastal area show that the highest CO2eq value is at age 72 with deposits of 45.6 kg and an average annual addition of 7.5 kgCO2eq/year.

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AUTHOR CONTRIBUTIONS

Muthiah Aini Rahmi contributed to conceptualization, methodology, validation, analysis, investigation, data collection, draft preparation, manuscript editing and visualization. Alma Cantika Aristia contributed to

conceptualization, methodology, validation, analysis, investigation, data collection, draft preparation, supervision, project administration, funding acquisition manuscript editing and visualization. Fahriza Dwi Indahyati contributed to conceptualization, methodology, validation, analysis, investigation, data collection, draft preparation, manuscript editing and visualization. Muhamad Agung Triyudha contributed to conceptualization, methodology, validation, analysis, investigation, data collection, draft preparation, manuscript editing and visualization. Miftachur Robani contributed to project administration, supervision and funding acquisition. Aminul Ichsan contributed to project administration, supervision and funding acquisition. Chashif Syadzali contributed to project administration, supervision, software and funding acquisition. Nurhayati contributed to draft preparation, manuscript editing and visualization. Sarah Mutiara contributed to draft preparation.

CONFLICTS OF INTEREST

The authors declare there is no conflict of interest related to financial funding and authorship order for this article.

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