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Analysis of Carbon Economic Value Potential

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Abstract

The study aimed to assess the potential economic value of carbon within PT Strata Pacific's IUPHHK-HA area. The methodology involved collecting, processing, and analyzing numerical data using statistical methods. Sampling techniques included stratified systematic sampling or simple random sampling, with a maximum allowable sampling error of 20%. The study found that the carbon content reserve in tree stands within PT Strata Pacific's IUPHHK area in East Seram Regency, Maluku Province, is 44.95 tonnes per hectare. Assuming a conservative carbon value of US$ 5 per tonne, the total potential economic value of tree stands and the root shoot ratio in this area ranges from US$ 12,962,231.50 to US$ 15,221,643.25. Direct benefits for the local community include improved access to agricultural and plantation roads, social management activities (CSR) by businesses, and job opportunities. These benefits are estimated to have a direct value of Rp 3,525,000,000 per year.

Keywords: Economic Potential, Carbon Economy, CSR

Introduction

The green economy represents a significant potential for Indonesia's future economic development that must be fully leveraged. Globally, we face two major challenges: achieving high economic development and ensuring environmental conservation. Environmental issues have become a central concern for both developed and developing nations, as environmental degradation has heightened worries about global warming and climate change, largely driven by greenhouse gas (GHG) emissions (Pratiwi, 2021).

According to the 2014 Fifth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC, 2022), climate change has detrimental impacts across various sectors, threatening economic stability worldwide. The rise in the Earth's average surface temperature leads to heat waves that diminish human productivity. Due to industrial activities, technological advancements, and population growth, carbon dioxide levels are increasing rapidly, while green spaces are diminishing. Consequently, the rate of carbon dioxide (CO2) production significantly outpaces oxygen (O2) production. Environmentally, emissions with high carbon dioxide content from the combustion of carbon-containing compounds such as smoke from burning petrol, diesel, wood, leaves, LPG gas, and other hydrocarbon fuels severely damage the environment. These emissions are among the largest contributors to global climate change and have adverse effects on the environment and human survival.

Forests have a role as carbon sinks and have become a serious concern when the earth is faced with the greenhouse effect problem in the form of an increasing trend in air temperature commonly referred to as global warming. Indonesia's forests store enormous amounts of carbon. According to FAO, the total amount of Indonesian forest vegetation is more than 14 billion tonnes of biomass, which is equivalent to 20% of the biomass of all tropical forests in Africa. This amount of biomass roughly stores 3.5 billion tonnes of carbon (Lewis, 2006).

Forests function as carbon sinks and have garnered significant attention due to the greenhouse effect, manifesting as a rising trend in air temperature known as global warming. Indonesia's forests hold vast quantities of carbon. According to the FAO, the total biomass of Indonesian forest vegetation exceeds 14 billion tonnes, accounting for

approximately 20% of the biomass of all tropical forests in Africa. This biomass stores an estimated 3.5 billion tonnes of carbon (Lewis, 2006).

Carbon trading is a concept that originated with the Kyoto Protocol in 1997 and was further developed through the Paris Agreement, where 195 governments agreed to a global climate accord (Kolk et al., 2017). Article 17 of the Kyoto Protocol and Article 5 of the Paris Agreement highlight that a crucial approach to climate mitigation is a market-based mechanism, specifically emissions trading. Similarly, the Government of Indonesia ratified the Paris Agreement through Law Number 16 of 2016, which concerns the Ratification of the Paris Agreement under the United Nations Framework Convention on Climate Change. This law mandates the government to contribute to reducing nationally determined greenhouse gas emissions, aiming to limit the increase in global average temperature to below 2ºC, ideally to 1.5ºC, above pre-industrial levels (Katadata Insight Center, 2022).

Simulation results from the Ministry of Finance's research indicate that carbon trading could contribute non-tax state revenue (PNBP) of 7.5-26.1% of the annual goods and services revenue (revenue of the General Service Agency/BLU) for the period 2011-2018, amounting to around Rp. 350 trillion, assuming a strong governmental commitment to reducing forest deforestation and developing policies supporting forest conservation (Kementerian Komunikasi dan Informatika, 2022). Additionally, data from the Coordinating Ministry for Maritime Affairs and Investment reveals that Indonesia possesses the third-largest tropical rainforest globally, covering 125.9 million hectares and capable of absorbing 25.18 billion tonnes of carbon emissions. Indonesia's mangrove forests span 3.31 million hectares, which can absorb approximately 950 tonnes of carbon per hectare, totaling around 33 billion tonnes of carbon (Kementerian Komunikasi dan Informatika, 2022). Furthermore, Indonesia has the world's largest peatland, covering 7.5 million hectares and capable of absorbing about 55 billion tonnes of carbon emissions. In total, Indonesia can absorb approximately 113.18 gigatonnes of carbon emissions. If the Indonesian government can sell carbon credits at an assumed price of USD 5 in the carbon market, the potential revenue for Indonesia could reach USD 565.9 billion, equivalent to Rp. 8,000 trillion.

Carbon trading in Indonesia presents a compelling area for research due to its substantial potential economic value, motivating forestry concession holders, including those with Business Permits for the Utilization of Timber Forest Products in Natural Forests, to

transition to the carbon business. Thus, it is crucial to calculate the potential value of carbon and its economic significance. This study focuses on the area managed by PT. Pacific Strata, situated in East Seram Regency, holds a forest concession covering 73,386 hectares, of which 57,674 hectares are forested. PT. Pacific Strata is a business management unit for timber forest product utilization that has currently ceased operations, indicating that the company is not engaged in the carbon business. Consequently, this study serves as a preliminary investigation, lacking comparative data on carbon potential and its economic value in this area. The findings can provide baseline comparative data for future carbon business endeavors. Therefore, the presented benefit values are derived from scientific analysis.

To situate this study within the current research landscape, a review of previous studies on carbon stock assessment and economic valuation is imperative. Earlier research provides a foundation for understanding the methodologies and insights derived from such investigations. For example, Rikardoa et al., (2015) conducted a detailed study on the biomass and carbon stocks within the Pondok Buluh Education and Training Forest. Their analysis revealed a biomass content of 376.95 tons/ha and a carbon stock of 173.40 tons/ha, resulting in an estimated total carbon stock of approximately 190,737.70 tons. The economic value of this carbon ranged from IDR 30,431,700 to IDR 40,575,600 per hectare, leading to a comprehensive economic valuation between IDR 33,474,466,350 and IDR 44,632,621,800.

Similarly, the study by Betani et al., (2016) advanced the discussion on carbon economic valuation. Their research, focusing on pole and tree levels within the Special Purpose Forest Area (KHDTK) of Bukit Tinggi Suligi Training Forest, provided detailed insights into carbon stock assessment. Utilizing 20m x 20m plots and the Stratified Random Sampling method, they estimated carbon stocks using valuation methodologies established by Van Beukering et al., (2003), valuing carbon at US$ 5 per ton of absorbed carbon. Their findings revealed a total carbon stock of 83,957.52 tons, which was economically valued at US$ 419,787.6, or approximately Rp 5,635,648,530.

This study represents a step forward in this field with the goal of determining the potential economic value of carbon and the direct and indirect economic benefits for communities surrounding forests in the IUPHHK-HA PT. Pacific Strata in Eastern Seram

Regency. Through rigorous analysis, the study aims to identify an average potential carbon content of 44.95 tons/Ha, derived from tree carbon content and its root-shoot ratio. With the current carbon market price around ±US$ 5 per ton, the primary objective of this research is to estimate the total potential economic value of carbon content from forested and non-forested areas covering an expanse of 67,727 hectares in PT. Pacific Strata's Eastern Seram Regency.

Theoretical Framework and Research Hypothesis Development

Forest Carbon Biomass

In tree vegetation, all components of the tree, including aboveground logs, foliage, large and small branches, and belowground coarse roots, store the tree's biomass and carbon content (Christoph Fischer & Berthold Traub, 2019). This biomass accumulation in trees is a result of photosynthesis, where CO2 is absorbed from the atmosphere. Forest biomass plays a crucial role in biogeochemical cycles, particularly the carbon cycle, with approximately 50% of forest carbon stored in forest vegetation. Forests mitigate and retain CO2 through a process called sequestration, wherein carbon is absorbed from the atmosphere and stored in various compartments such as plants, litter, and soil organic matter. The total amount of carbon stored in biomass at any given time is referred to as carbon "stock" or "reserve" (Sianturi & Masiyah, 2018).

Carbon Economic Value

According to Presidential Regulation Number 98 of 2021, Carbon economic value refers to the value assigned to each unit of greenhouse gas emissions generated by human and economic activities (Salinan Persetujuan Paris Atas Konvensi Kerangka Kerja Perserikatan Bangsa Bangsa (PBB) Mengenai Perubahan Iklim, 2016). This value serves as a measure to incentivize the "polluters pay principle," where those responsible for emissions bear the associated costs. Carbon economic value, or carbon pricing, involves the pricing or valuation of greenhouse gas (GHG) emissions/carbon. Carbon pricing mechanisms encompass trading instruments like emission permit trading and emission offsets, as well as non-trading instruments like carbon levies and results-based payments. The objectives and benefits of carbon pricing include reducing GHG emissions, promoting green investments,

addressing climate change financing challenges, ensuring fairness, and fostering sustainable growth.

Carbon Trading and Carbon Market

According to Titus O. Kusumajati, (2023), carbon trading and carbon markets play crucial roles in global initiatives to mitigate the impacts of climate change by curbing greenhouse gas emissions. These mechanisms are structured to offer economic incentives to businesses and nations to restrict their carbon dioxide (CO2) and other greenhouse gas emissions. In a carbon trading system, a government or regulatory entity establishes a maximum threshold for total emissions permitted within a specified timeframe. This limit is then subdivided into units of value, with each unit representing a specific quantity of emissions.

The carbon market serves as the platform where these emission units are bought and sold, encompassing both domestic and international transactions. The Indonesia Carbon Exchange (IDX Carbon), inaugurated by President Joko Widodo on 26 September 2023, marks a significant initiative to incentivize the industrial sector to reduce carbon emissions (Bursa Karbon Indonesia, 2023). The Indonesia Stock Exchange, as the organizer, provides four carbon exchange trading rooms: the regular market, negotiated market, auction market, and marketplace (non-regular). These trading rooms offer exchange participants various avenues to contribute to efforts aimed at mitigating the impacts of greenhouse gases and safeguarding the environment.

According to Presidential Regulation Number 98 of 2021, the Carbon economic value serves as a tool for businesses to reduce greenhouse gas (GHG) emissions and encourages their active involvement in GHG emission control through its implementation (Presiden Republik Indonesia, 2021). Engaging in carbon-related businesses is expected to bring both direct and indirect benefits to the local community, leading to positive impacts on economic growth and environmental quality enhancement within the community.

Research Methods

The type of research design used is a combination of quantitative and qualitative research design to draw general conclusions as evidence of the enormous potential of

carbon economic value. The author utilizes quantitative techniques for primary data processing, including data collection, processing, and analysis of numerical data from research instruments such as chest height tree diameter (DBH) data and tree species names used for estimating biomass content. Additionally, a mix of quantitative and qualitative methods is applied for secondary data analysis, involving classical assumption testing alongside direct face-to-face interviews with the local community residing around the research area.

Primary data will be gathered using research instruments like tree diameter at breast height (DBH) and tree species names. These data will be used to calculate biomass content estimation using the Biomass Expansion Factor (BEF). This calculation will ultimately determine the potential volume (in tonnes) of carbon content per hectare and the resulting total carbon content volume (in tonnes) in the research area. Data processing will focus on computing the carbon content of trees and poles with diameters ranging from 10 cm upwards, as well as the carbon content of the tree root shoot ratio. These are the two key variables used in estimating carbon content. Ketterings et al., (2001) suggested a formula for calculating biomass content estimation;

$$B=0.11\rho D2.62$$

Description:

B = Tree dry biomass (kg)

p = Specific gravity of the tree

D = Diameter of the tree at breast height (cm)

Furthermore, Carbon reserves or content (C in kg) were estimated by multiplying biomass by the conversion factor proposed by (Murdiarso et al, 2002) with the equation:

$C=0.5B$

Description:

C = Carbon content (kg)

B = Tree dry biomass (kg)

(Half of the biomass is carbon content)

Based on the Regulation of the Minister of Environment of the Republic of Indonesia Number 15 of 2012 concerning Guidelines for Economic Valuation of Forest Ecosystems,

which is multiplying the quantity of natural resources with their market prices. The equation is:

Value of natural resources = natural resources x price

Furthermore, secondary data in the form of classical assumption testing with face-to-face interviews directly with the surrounding community, the method used is the survey method which is held to obtain facts from existing symptoms and seek factual information either about social, economic, or political institutions of a group or an area From classical assumption testing in the form of interviews and filling out questionnaires by the surrounding community, the value of direct and indirect benefits from carbon business activities will be obtained, namely from the impact of opening access to agricultural and plantation roads, social management activities (CSR) and opportunities for local labor. The calculation of the direct benefit value of the impact of the opening of agricultural and plantation road access is obtained from the community's livelihood of farming and gardening with the calculated variables:

P access = (P non access + (% PDP x P non access)

Description:

Income per year after road access = P access (Rp)
Income per year before road access = P non-access (Rp)
Increased production impact = PDP (%)

To get the value of benefits with the calculation

NML = (P access - P non access) x N

Description:

NML = Direct Benefit Value (Rp)
N = Number of people who use road access

The direct benefit value of the opportunity for local labor can be calculated with the following variables:

NML = (RPB x TK) x (BK+1)

Description:

NML = Direct Benefit Value (Rp)
RPB = Average Monthly Income (Rp) TK = Total Labour (people)

BK = Number of Working Months

1 = Added Value of Working Month for THR

Discussion

General State of the Region

Maluku Province covers an extensive area of 712,480 km2, comprising 54,148.48 km2 or 7.6% as land and 656,331.52 km2 or 92.4% as ocean. Within Maluku Province, there are 1,412 islands, including four major islands: Seram, Buru, Yamdena, and Wetar. Seram Island, with an area of 18,625 km2, is administratively divided into three regencies: Central Maluku, West Seram, and East Seram (BPS Provinsi Maluku, 2022).

The area of interest for PT Strata Pasific is within the East Seram Regency, encompassing Bula, West Bula, and Tutuk Tolu Districts. East Seram Regency has a sea area of 14,877.771 km2 and a land area of 5,779.123 km2. Geographically, the PT Strata Pacific area is situated on Seram Island at coordinates 130º 26' 56.27" E and 3º 17' 21.97" S, covering a total area of 73,386 hectares. This area includes Production Forest (HP), Limited Production Forest (HPT), Conversion Production Forest (HPK), and Non-Forest areas.

The research area is situated in the PT Strata Pacific region within East Seram Regency, Maluku Province. As per the Minister of Forestry's Decree numbered 772/Menhut-II/2013, this area spans 73,365 hectares of forest land, categorized into Protected Areas, Ineffective Areas, and Effective Areas. The study involves collecting and processing carbon stock data using quantitative methods to estimate the potential economic value of carbon. The focus is on five sample plots within the effective areas of primary and secondary forests, as well as non-forest areas suitable for reforestation. These sample plots, named F.37, G.36, E.32, K.33, and K.34, each cover one hectare.

Secondary data collection and processing involve both quantitative and qualitative methods, including interviews and questionnaires with 50 garden farmers from Fesan Hamlet and Kilbaren Hamlet in Waru Village, Bula District, East Seram Regency. Quantitative methods analyze direct benefits, while qualitative methods assess indirect benefits.

Potential Carbon Economic Value

The data available in the field includes the volume of wood/trees, which can be used with the Biomass Expansion Factor (BEF) equation based on the Brown formula from 1997. The BEF equation calculates the biomass of the tree top divided by the biomass of the trunk, resulting in a value of 1.49 for secondary forest vegetation, as referenced by Wahyu Catur Adinugroho et al. (2006). Specific gravity data is obtained from the Indonesian Timber Atlas following the SNI 7973:2013 standard. The carbon content is then calculated using the allometric equation as follows:

C-tree = (0.5 * 22/7 * (diameter/2)2 * height * number of forms (0.7) * wood specific gravity * BEF (1.49) * carbon fraction (0.5))/1,000.

From the data obtained in the field as many as 5 (five) sample plots on 5 (five) different plots to obtain data on species, tree height, and diameter starting from 10 cm - up with the category of poles and trees, the average potential carbon content (tCO2e) is 44.95 tonnes/ha resulting from the volume of tree carbon content and the volume of the carbon content of the shoot-root ratio as shown in the table Recapitulation of Sample Plots and Carbon Data Processing as follows:

Carbon Content Data

No.	No. of Sample Plots	Plot Area (Ha)	No. of Plots	Plot Area (Ha)	Carbon Content (Tonnes/Ha)
1.	I	1	F.37	100	46,13
2.	II	1	G.36	44	43,22
3.	III	1	E. 32	100	46,21
4.	IV	1	K.33	100	44,95
5.	V	1	K.34	100	44,24
AveragetCO2e					**44,95**

Source; Data Processing Results, (2024)

According to Van Beukering et al., (2003) economic valuation in carbon trading is USD$5 per tonne of carbon, so with very dynamic value fluctuations, the authors in this study determine the price of carbon value per tonne at USD$5 per tonne of carbon. In general, there are two underlying assumptions for this, namely;

a. Assumption 1 with the current carbon market price of ±US$5 per tonne, for estimating carbon content in the forested area of 57,674 ha.

b. Assumption 2 with current carbon market price ±US$ 5 per tonne, for estimating carbon content in forested and non-forested areas after reforestation of 67,727 ha.

From the 2 assumptions above, it can be concluded that the carbon stock content obtained of 44.95 tonnes per Ha is still below the standard set by the Directorate General of Planology of the Ministry of Forestry and Environment for tropical rainforest areas in the Maluku Region, which is ± 111 tonnes per Ha, due to tree species and potential density factors. To increase the potential economic value of carbon content, reforestation steps can be taken for non-forest areas and regeneration/replanting of unproductive/dead plants with tree species that have greater carbon absorption.

Benefits of Carbon Enterprises to Neighbouring Communities

The potential value of direct benefits from opening the access road is more clearly presented in the following table:

Benefits of road access

No.	Activity	No Adequate Road Access	There is Adequate Road Access
A.	Transport Access		
1.	Seedling Transport	3 day	1 day
2.	Transport of Fertiliser and Insecticide	3 day	1 day
3.	Harvesting	10 day	5 day
4.	Sales	10 day	5 day
B.	Harvesting/year	2 times	3 times
C.	**Average**	**Rp. 18.000.000**	**Rp. 30.000.000**

Source; Data Processing Results, (2024)

Based on the analysis of data from the local village government whose communities were interviewed, namely in Fesan hamlet and Kilbaren hamlet, there are ± 200 heads of families whose livelihood is from farming and gardening around the company's area, so there is a difference in income increase, namely Rp. 30,000,000 – Rp. 18,000,000 = Rp. 12,000,000 x 200 heads of families = Rp. 2,400,000,000 in a year. This data is in the form of the results of scientific analysis in carbon business activities because the basic data comes from filling out questionnaires and face-to-face meetings with the surrounding community who make a living in farming and gardening.

Companies involved in the carbon business are assigned responsibilities in the form of Social Management or CSR activities by the government to benefit the surrounding community. These activities include supporting religious activities, healthcare, education, youth programs, agricultural and plantation assistance, and environmental management. The budget allocated for these activities varies based on business productivity and operations. According to face-to-face information gathered from the community and local village government, the potential value of these benefits ranges around Rp. 225,000,000 per year. However, these numbers are subject to change based on the business's performance.

Results of the Analysis of the Potential Value of Benefits from Social Management

No.	Activities/Year	Cost (Rp)	Note
1.	Agriculture and plantation assistance in the form of work equipment and seed or seedling procurement.	50.000000	
2.	Youth activity assistance.	25.000.000	
3.	Religious assistance in the form of worship facility infrastructure and religious activities.	50.000.000	
4.	Educational assistance in the form of donations and scholarships.	25.000.000	
5.	Healthcare and medication assistance.	25.000.000	
6.	Environmental management assistance in the form of clean water facilities, sanitation, etc.	50.000.000	
	Total	**225.000.000**	

Source; Data Processing Results, (2024)

The direct benefits for local labor, in terms of recruitment from the surrounding community, are adjusted based on business needs and local community representation. It's assumed that the business can absorb approximately 25 local workers at various levels of need. If the average monthly income for each worker is Rp. 3,000,000, then in one year, it could generate a potential benefit value of approximately Rp. 900,000,000/year (calculated as Rp. 3,000,000 x 25 people x 12 months). This estimation excludes allowances for Hari Raya, annual leave, and bonuses.

Regarding the benefits derived from scientific analysis results, the author relies on data obtained from questionnaires and face-to-face interactions with the community. However, since no carbon business activities have been carried out in the area yet, the author lacks real data directly sourced from such business operations.

Carbon conservation efforts contribute to a balanced ecosystem, ensuring the preservation of both flora and fauna by maintaining their habitats. Additionally, there are indirect benefits for the surrounding community, including cleaner air, climate balance, reduced flood and landslide risks, and moderation of extreme temperatures and droughts. These improvements can significantly enhance the health of the community, which is particularly vulnerable to diseases caused by air and environmental pollution as well as extreme weather conditions such as dengue, diarrhea, tuberculosis, and malaria. Data from the East Seram Central Bureau of Statistics in 2023 provides insights into the distribution of diseases within the East Seram Regency in 2022.

Based on the outlined benefits of carbon business for the surrounding community, the direct benefits can be estimated at approximately Rp. 3,525,000,000 per year. This figure does not include the indirect benefits that arise from ecosystem balance and a pollution-free environment, which indirectly contribute to improving the health of the surrounding community.

Conclusion

The study's analysis concludes that the carbon content reserves in tree stands and the root shoot ratio in the IUPHHK area of PT. Strata Pacific in East Seram Regency, Maluku Province, is estimated at 44.95 tons per hectare. The total estimated carbon content of tree stands and the root shoot ratio ranges from 2,592,446.30 tons to 3,044,328.65 tons, depending on the cultivated area and the implementation of reforestation and planting activities.

Moreover, the carbon content reserves in PT. Strata Pacific's area is still below the standard set by the Directorate General of Planning of the Ministry of Forestry and Environment for tropical rainforest areas in the Maluku Region, which is approximately 111 tons per hectare. This is due to factors such as tree type and potential density. Assuming the lowest carbon value per ton at US$ 5, the total potential economic value of tree stands and the root shoot ratio in PT. Strata Pacific's area ranges from US$ 12,962,231.50 to US$ 15,221,643.25, equivalent to approximately Rp 200,914,588,250.00 to Rp 235,935,470,375.00 (based on an exchange rate of US$ 1 = Rp 15,500). This value varies

depending on the cultivated area and the implementation of reforestation activities and stand planting.

The carbon business operations will bring direct benefits to the surrounding community, including improved access to agricultural and plantation roads, social management activities (CSR) conducted by businesses, and job opportunities. Based on the analysis results, the direct benefit value is estimated at Rp 3,525,000,000 per year. Moreover, there will be indirect benefits for the community, such as cleaner air resulting from reduced pollution, climate balance, reduced risks of floods and landslides, and moderation of excessively hot temperatures and prolonged droughts. These indirect benefits will have a positive impact on the health of the surrounding community, which is vulnerable to diseases caused by air and environmental pollution, as well as extreme weather conditions like dengue, diarrhea, tuberculosis, and malaria.

Suggestion

The study suggests the importance of enhancing ecosystem sustainability in PT. Strata Pacific's area. This not only contributes to environmental sustainability but also holds significant potential economic value due to the substantial carbon content reserves in tree stands and a relatively high tree stand ratio. Further research is recommended to explore carbon content reserves from undergrowth, litter, dead wood, and carbon stored on the ground surface. This additional analysis can provide a more accurate determination of the total estimated potential carbon content, even though the contribution from these sources may not be as significant compared to the estimated carbon potential from tree stands.

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