Journal of Natural Resources and Environmental Management
http://dx.doi.org/10.29244/jpsl.14.3.525

RESEARCH ARTICLE

OPEN ACCESS

Check for updates

Calculation of Carbon Emissions and Sequestration to Support the Net Zero Emission Target of Central Java Province (Case Study: Cilacap and Brebes Regencies)

Khaerul Amru[a], Raissa Anjani[a], Melania Hanny Aryantie[b], Iif Miftahul Ihsan[a], Ressy Oktivia[a]

[a] Research Center for Environmental and Clean Technology, National Research and Innovation Agency (BRIN), South Tangerang, 15314, Indonesia
[b] Directorate of Policy Evaluation for Research, Technology, and Innovation, National Research and Innovation Agency (BRIN), Central Jakarta, 10340 , Indonesia

Article History
Received 15 June 2023
Revised 16 February 2024
Accepted
29 February 2024

Keywords
carbon emissions, net zero emissions, sequestration

ABSTRACT

Indonesia's net zero emission target is being achieved through greenhouse gas (GHG) inventories using the Intergovernmental Panel on Climate Change (IPCC) method. This study aims to determine the potential contribution of the Brebes and Cilacap Regencies using the net zero target of Central Java Province in terms of carbon sequestration in various types of land cover. Land-cover data were collected from the RBI. Land cover use data were then multiplied by the constant value of carbon stocks to determine the potencies of carbon sequestration and storage. The potential contribution of carbon sequestration in Brebes Regency reaches 3,882,850.81 tons of CO_2 eq or 4.60%, while Cilacap Regency has almost two times the potential for carbon sequestration in Brebes, which is 7,191,181.44 tons of CO_2 eq, or equivalent to 8.52% of the total carbon emissions of Central Java Province which reached 84,435,352.5 tons of CO_2 eq. This difference in carbon sequestration potential was most influenced by the presence of mangrove and terrestrial forests, with the highest value of carbon stock constants compared to other land uses. Overall, these two regencies can absorb almost 1/3 of the carbon emissions in Central Java Province; therefore, they can be prioritized in efforts to increase carbon sequestration at the provincial level.

Introduction

Global warming and climate change are major concerns globally. To control climate change, more than 100 countries have set net zero emission targets, including Indonesia. Indonesia has targeted carbon emission reduction in its Nationally Determined Contribution (NDC) since the Paris Agreement and has changed its target to 31.89% independently and 43.20% with international assistance [1]. To achieve this target, The Indonesian government conducted an inventory of greenhouse gases (GHG) by identifying carbon stocks using the Intergovernmental Panel on Climate Change (IPCC) method [2]. However, the results showed that Indonesia is one of the countries with slower target achievement than the global average [3].

GHG inventories are conducted in several sectors of a region [4]. This is also in line with Indonesia's commitment to reducing emissions from various sectors, including transportation, energy, food, industry, agriculture, and forestry [5]. Forests are one of the main sources of carbon accumulation and storage because of their availability to plants and trees [6,7]. Unfortunately, the deforestation rate in Indonesia is still high owing to land conversion into infrastructure, residential areas, mining, and plantations, which have an impact on global warming; therefore, a strategy is required to handle it [8].

Various studies have been conducted to determine the factors contributing to emissions in Indonesia, including economic growth, energy use, forest area, and urbanization [9]. Changes in land use are closely related to efforts to meet the population's needs. An increase in the population also increases the need for

Corresponding Author: Khaerul Amru kharul.amru@brin.go.id Research Center for Environmental and Clean Technology, National Research and Innovation Agency (BRIN), South Tangerang, Indonesia.

land and development [10]. Carbon stocks are not only found in forest vegetation, but also in agricultural land or plantations because soil is the largest organic carbon stock [11]. Management practices are one of the factors that affect the amount of carbon in soil.

GHG inventories from various activities have been conducted in Central Java Province, including waste management processes [12], agricultural land use [13], and waste incineration [14]. This is similar to the estimates of carbon sequestration from various land use types. However, no calculation or analysis of emissions versus sequestration has been conducted to determine the achievement of the net zero target. The study was conducted in two locations, Brebes and Cilacap, which are among the top five largest regencies with a total of 12.85% of the area of Central Java Province. Cilacap Regency has the largest area of 2,323.93 km^2, while Brebes Regency is the fifth largest with a total area of 1,742.81 km^2 under Grobogan, Blora and Wonogiri [15]. This study aims to determine the contribution of the Brebes and Cilacap Regencies to achieving the net zero target of Central Java Province in terms of carbon sequestration in various types of land cover.

Materials and Methods

Study Area

The research was conducted in two regencies in the Central Java Province: Brebes and Cilacap as can be seen in Figure 1. The research location was chosen based on data availability. In addition, the largest distribution of mangroves in Central Java Province is also in Brebes and Cilacap. The mangrove area has become one of the focuses of this research because its sequestration capacity is the highest compared to other land cover types. Choosing a location with a large mangrove area will provide an illustration of the high carbon sequestration potencies so that it can become an example for other areas in Indonesia. All data collection for this study was conducted between August 2022 and January 2023.

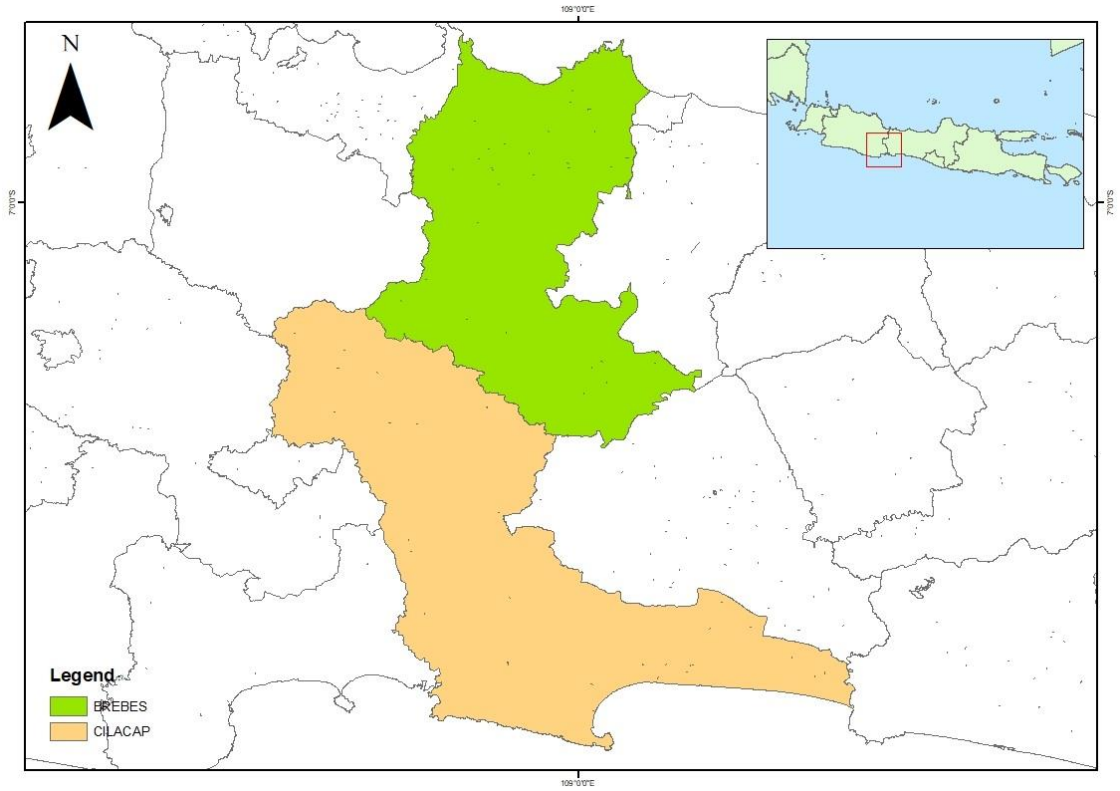

Figure 1. Study area.

Data Collection

Land use cover data were collected from the *Rupa Bumi Indonesia* (RBI) 2022 land use map. In addition, Mawardi et al. [5] found that the ability of land-cover vegetation to sequester carbon is based on three factors: (1) terrestrial ecosystems, including forests, plantations, shrubs, grasslands, and agricultural land; (2) coastal ecosystems, including mangrove forests, seagrass beds, animal husbandry, lakes, and seas; and (3)

individuals per plant or tree. This calculation is particularly useful for estimating the potential registration of urban parks and areas, and the potential for carbon dioxide absorption and storage from the area/area can be calculated. Secondary data in the form of CO_2 emission values, per capita Indonesia obtained through https://edgar.jrc.ec.europa.eu/report_2023?vis=co2pop#emissions_table (accessed on march 26 2023). Data on the population of Cilacap and Brebes Regencies in 2022 were obtained from *Badan Pusat Statistik* (BPS) data.

Data Analysis

Land-cover use data were then multiplied by the constant value of carbon stocks to determine the potential for carbon sequestration and storage in an ecosystem. This can be formulated using the following equation:

$$Carbon\ sequestration\ potencies = Land\ cover\ area\ x\ Constant\ value\ \ of\ carbon\ stocks \quad (1)$$

Data on carbon sequestration potential were then used to determine the contribution of each regency to reducing emissions in Central Java Province using the following equation:

$$Carbon\ sequestration\ contribution = \frac{Regency\ Ssquestration}{Emission\ in\ Central\ Java\ Province}\ x\ 100\% \quad (2)$$

Results and Discussion

Central Java Province Emissions

The total emissions of Central Java Province are listed in Table 1. Based on data obtained from the Emissions Database for Global Atmospheric Research (EDGAR) of the European Commission website, it is known that the total emissions produced by Indonesia are 2.50 tons CO_2 eq $year^{-1}$. An individual carbon footprint calculation approach was then used to determine the emissions in each district. The individual carbon footprint value was obtained from the total emissions of Central Java Province divided by the population.

Table 1. Total carbon emissions in Central Java Province.

Province	Population (person) *	Individual carbon footprint (ton CO_2 eq $person^{-1}$)	Province total emission (ton CO_2 eq)
Central Java	33,774,141	2.50	84,435,352.5

*[15].

Carbon Sequestration of Brebes Regency

Brebes Regency is located on the north coast of Java Island and has a mangrove ecosystem with a carbon potential that has been monitored quite well. In Kaliwlingi Village, Brebes Regency, the mangrove area increased during 1996 to 2019, causing an increase in carbon stocks [16]. This is an anomaly of decreasing mangrove forest area in the regency. Carbon storage occurs not only above ground (trees and biomass) but also underground in the form of sediment [16,17]. Studies have shown that older mangrove trees do not show an increase in carbon stocks in stands [18] or sediments [17].

In addition to mangrove forests, Brebes Regency has extensive agricultural land (rice fields) and has undergone land conversion into built-up land (settlements, toll roads, and industry) and other land cover types (community forests, moor, and water bodies) [19]. Agricultural land plays an important role in the maintenance of carbon storage [20]. This causes the carbon sequestration potential in Brebes Regency to change, according to the coefficient of each type of land cover.

Carbon sequestration and storage are generally carried out in both terrestrial and aquatic natural ecosystems [21,22]. Forests are considered global carbon sinks [23], with wetlands (peatlands and mangrove forests) having greater mitigation potential than drylands (forest and non-forest) [21]. As for water, studies refer more to blue carbon, which consists of mangrove forests, seagrass beds, and tidal swamps [22,24]. Further studies on inland waters are required.

In addition to natural ecosystems, artificial areas store carbon. For example, housing still uses wood as a furniture or home material [25]. Carbon storage is found in furniture, frames, windows, doors, and so on. The agricultural and plantation sectors have potential in terms of GHG emissions [26–28], including rice fields and fields. Based on these findings, each land cover type has potential for carbon sequestration and storage, as shown in Table 2.

Table 2. Brebes Regency land cover use.

Land cover use	Area (Ha)	Percentage (%)	Constant value of carbon stock (ton CO2 eq)*	Carbon sequestration potencies (ton CO2 eq)
Forest	3,283.62	1.82	98.80	324,421.66
Mangrove forest	15.34	0.01	188.30	2,888.52
Shrubs	5,547.39	3.07	30.00	166,421.70
Meadow/grassland	1,273.82	0.71	4.00	5,095.28
Plantation	50,779.90	28.12	63.00	3,199,133.70
Rice field	56,430.59	31.25	2.00	112,861.18
Rainfed-Rice field	15,988.81	8.85	2.00	31,977.62
Field	16,020.46	8.87	2.50	40,051.15
Pond	8,196.34	4.54	0	
Settlement	20,391.03	11.29	0	
Building	21.83	0.01	0	
Land	44.03	0.02	0	
Lake	135.99	0.08	0	
Reservoir	415.87	0.23	0	
River	2,040.61	1.13	0	
Other Non-Cultivated Vegetation	2.40	0.00	0	
Total	180,588.02	100.00		3,882,850.81

*[29].

As shown in Table 2 and Figure 2, the percentage of vegetation cover in Brebes Regency was still higher than that in built-up land. Land in the form of plantations in Brebes Regency has the greatest potential for carbon absorption and storage, followed by forests, shrubs, rice fields, fields, rainfed rice fields, meadow/grasslands, and mangrove forests. Although mangroves have the smallest levels of absorption and storage, their carbon sequestration coefficient is the largest, followed by forest forests. This is in line with a study by Novita et al. [21], who stated that mangrove forests have a greater mitigation density potential than dryland ecosystems.

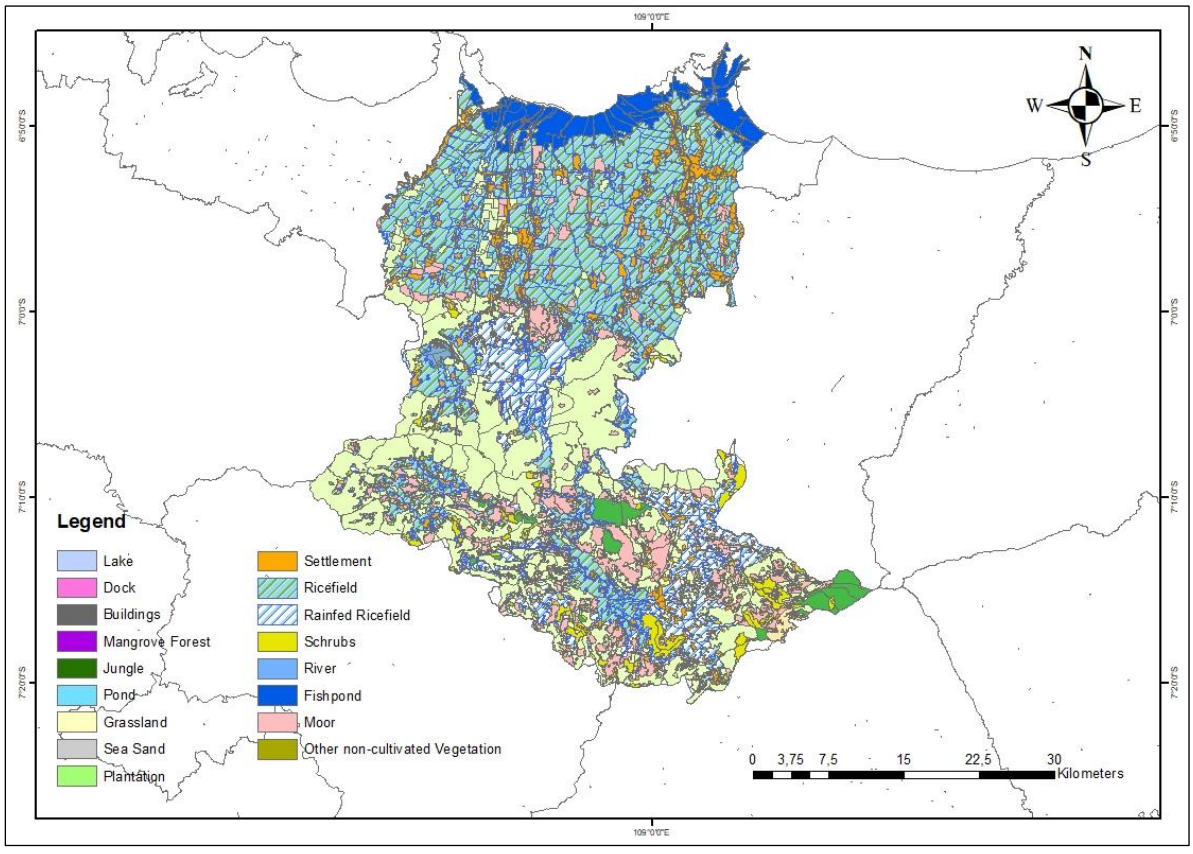

Figure 2. Land cover map of Brebes Regency.

Mixed gardens with agroforestry systems have greater biomass potential than monoculture fields [28]. This is because vegetation biomass becomes restless and is a source of nutrients for soil organic substances [28]. This was indicated by the constant value of the garden's carbon stock being greater than that of the field or higher. For built-up land cover, it is necessary to refer to the current reference, which contains the carbon sequestration coefficient so that the resulting value is complete. The absorption potential in the settlement can be expressed using a coefficient [20]. Inland water (lakes, reservoirs, and rivers) has zero sequestration coefficient [20].

Carbon Sequestration of Cilacap Regency

Cilacap Regency is the largest regency in Central Java which has a total area of 2,249.28 km^2 or 6.48% of the total area of Central Java Province. Cilacap is a regency in Indonesia that continues to experience development in terms of economic, community welfare, and regional development. However, Cilacap Regency has the potential to increase GHG emissions concentrations. The energy, forestry, and other land use (FOLU) sectors still contribute significantly to GHG emissions. Power plants are still responsible for increasing GHG emissions.

Table 3. Cilacap Regency land cover use.

Land cover use	Area (Ha)	Percentage (%)	Constant value of carbon stock (ton CO2 eq)*	Carbon sequestration potencies (ton CO2 eq)
Forest	11,665.34	4.71	98.80	1,152,535.59
Mangrove forest	7,759.44	3.13	188.30	1,461,102.55
Shrubs	6,639.13	2.68	30.00	199,173.90
Meadow/grassland	66,110.94	26.70	63.00	4,164,989.22
Plantation	74,482.19	30.08	2.00	148,964.38
Rice field	6,626.82	2.68	2.00	13,253.64
Rainfed-Rice field	16,118.16	6.51	2.50	40,295.40
Field	2,716.69	1.10	4.00	10,866.76
Pond	51,080.20	20.63	0	
Settlement	94.50	0.04	0	
Dock	1.19	0.00	0	
Tambak	193.85	0.08	0	
Sea sand	175.54	0.07	0	
Lake	1.63	0.00	0	
Reservoir	31.06	0.01	0	
River	3,929.02	1.59	0	
Other Non-Cultivated Vegetation	2.09	0.00	0	
Total	247,627.77	100.00		7,191,181.44

*[29].

One tactic that people in Central Java, especially the Cilacap Regency, can use to support the government in achieving net zero emissions is to reduce carbon emissions from anthropogenic activities or reduce the use of carbon sources that can increase carbon emissions in the atmosphere. Other techniques, including the deployment of low-carbon technologies, absorb carbon released into the atmosphere to decrease the creation of carbon emissions [29]. Increasing the ability of vegetation to absorb carbon through photosynthesis is one way to promote carbon sequestration using vegetation or plants [30]. Based on Table 3 and Figure 3, rice fields are the largest area that can be optimized for carbon sequestration, with an area of 74,482.19 hectares or 30.08% of the total area of 247,627.77 hectares. The other largest areas are plantations, settlements/places of activity, and fields, with areas of 66,110.94, 51,080.20, and 16,118.16, respectively. The smallest area is the pier, with an area of 1.19 hectares.

Each vegetation or land cover type had a different carbon sequestration ability. The area and carbon sequestration coefficient play a role in determine the carbon sequestration rate of each vegetation or land cover type. Mangrove forests have the highest carbon sequestration coefficient of 188.3 tons CO_2 eq, followed by forest forests and plantations with coefficients of 98.8 tons CO_2 eq and 63 tons CO_2 eq, respectively. Table 3 shows that although rice fields are the largest area in Cilacap Regency, the potential absorption produced is only 148,964.38 tons of CO_2 eq. This is because of the small value of the rice-field carbon absorption constant of 2 tons of CO_2 eq.

Mangrove forests are one of the vegetation types with the largest carbon absorption potential, namely 1,461,102.55 tons of CO_2 eq, with an area of 7,759.44 hectares. The carbon sequestration constant of mangrove forests plays a major role in determining the carbon sequestration potential. The total potential for carbon sequestration in the Cilacap Regency from various types of land cover is 7,191,181.44 hectares from an area of 247,627.77 hectares. Data on the potential for carbon sequestration in the Cilacap Regency can be used to determine the contribution of carbon absorption to the emissions produced by Central Java Province. The calculation results showed that the contribution of carbon absorption by Cilacap Regency was 22.5% of the emissions produced by Central Java Province.

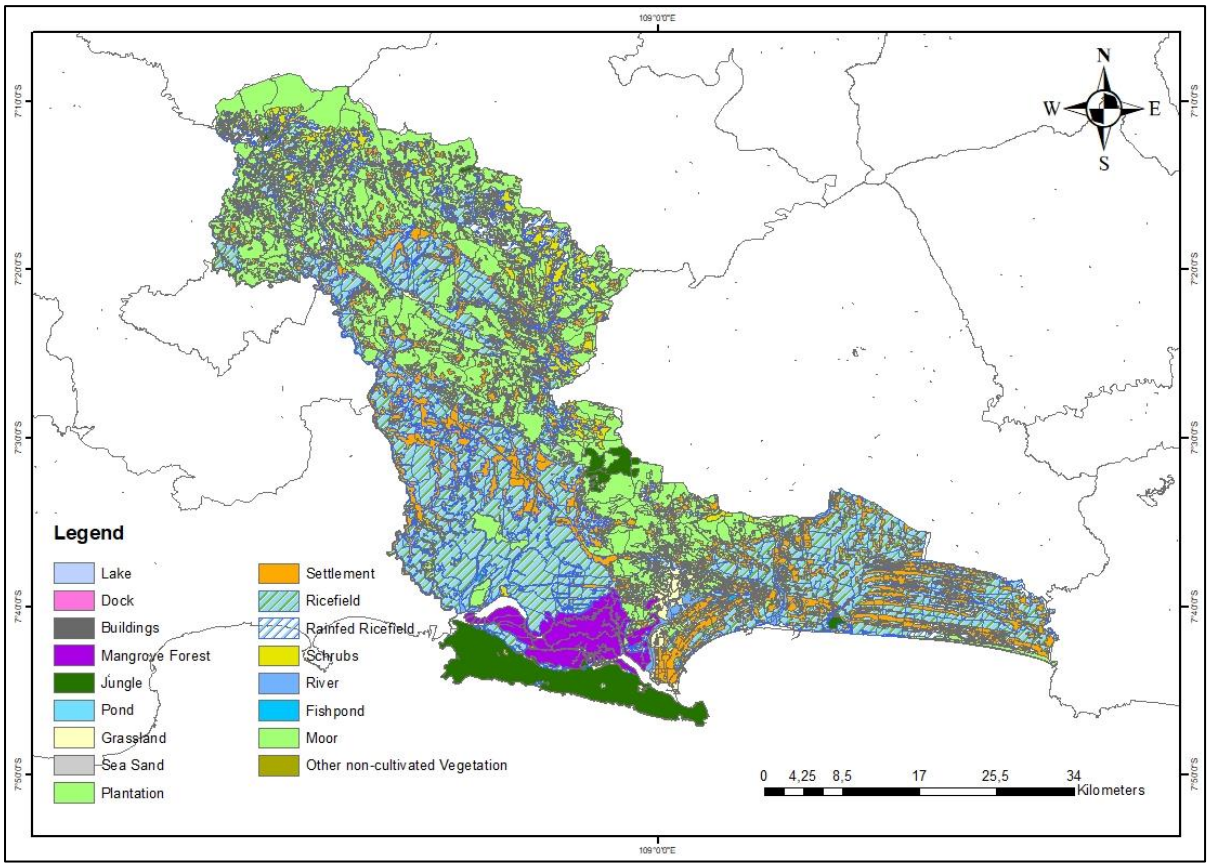

Figure 3. Land cover map of Cilacap Regency.

The Contribution of Brebes and Cilacap Regencies in Reducing Central Java Province Emissions

Climate change is a disastrous development for humans. One type of climate change caused by an increase in greenhouse gas emissions, such as CO_2 released into the atmosphere, is known as global warming. One way to reduce the amount of greenhouse gases in the environment is to release less CO_2 into the atmosphere. Consequently, reducing emissions and maximizing the amount of CO_2 absorbed by plants in the land cover are the only ways to reduce the quantity of CO_2 in the atmosphere. Forests absorb CO_2 through photosynthesis, which is carried out by the plants within the forest. The contribution of each regency shown in Table 4.

Table 4. Contribution of Brebes and Cilacap Regencies to carbon sequestration.

Regencies	Carbon sequestration (ton CO_2 eq)	Contribution (%)
Brebes	3,882,850.81	4.60
Cilacap	7,191,181.44	8.52

As part of *Rencana Pembangunan Jangka Menengah Nasional/Daerah* (RPJMN/RPJMD), Central Java is one of the provinces that has implemented the RPJMN/RPJMD policy [31]. One strategy used in Central Java to lower emissions is the preservation of trees, which, in theory, serve as a carbon storage facility [6]. Based on the calculation results, Central Java Province produces as much carbon emissions as 84,435,352.5 tons of CO_2

eq. Based on the calculation results, Brebes Regency contributed 3,882,850.81 tons of CO_2 eq to reducing emissions in Central Java Province. In other words, Brebes Regency managed to absorb 4.60% of carbon emissions from the total carbon emissions in Central Java Province. Similarly, Cilacap Regency succeeded in reducing carbon emissions by 7,191,181.44 tons of CO_2 eq in Central Java.

Cilacap Regency absorbs 8.52% of the total carbon emissions in Central Java. Reducing CO_2 emissions can be accomplished in a number of ways, including conservation, building carbon stores, and managing forests sustainably [32,33]. The contribution of carbon absorption in the Cilacap and Brebes Regencies can be increased through various efforts, especially from mangrove area utilization, which has higher carbon sequestration than terrestrial forests. The utilization of mangrove forests for natural tourism, along with planting, conservation, and rehabilitation activities, can be an alternative effort to maintain and increase carbon sequestration, as found in the Mangrove Sari, Brebes Regency. Apart from providing ecological benefits, sustainable mangrove utilization also provides economic benefits to the surrounding community [34].

Conclusions

The potential contribution of carbon absorption in Brebes Regency reaches 3,882,850.81 tons of CO_2 eq or 4.60%, while Cilacap Regency has almost two times the potential for carbon sequestration, which is 7,191,181.44 tons of CO_2 eq or equivalent to 8.52% of the total carbon emissions of Central Java Province which reached 84,435,352.5 tons CO_2 eq. This difference in carbon sequestration potential is most influenced by the presence of terrestrial and mangrove forests, which have the highest carbon stock constants compared to other land uses. Overall, these two regencies can absorb almost 1/3 of the carbon emissions in Central Java Province; therefore, they can be prioritized in efforts to increase carbon sequestration at the provincial level.

Author Contributions

KA: Conceptualization, Methodology, Data Analysis, Writing - Review & Editing; **RA**: Methodology, Data Analysis, Writing - Review & Editing; **MAH**: Writing - Review & Editing; **IIM**: Writing; and **RO**: Writing.

Conflicts of Interest

There are no conflicts to declare.

Acknowledgements

The authors would like to thank Prof. Dr. Ir. Moch. Ikhwanuddin Mawardi as a member of the Climate Change Adaptation Mitigation (PRLTB) research group, National Research, and Innovation Agency (BRIN) who has provided input in the preparation of this article. The author would also like to thank Mr. Zaenal Arifin from Darma Persada University, and Mr. Alimin Arisandi from Yayasan Mitra Pembangunan Kawasan Timur Indonesia for assisting in providing the data used in the preparation of this article.

References

1. Indonesian Government. Enchanced Nationally Determined Contribution Republic of Indonesia 2022. Available online: https://unfccc.int/sites/default/files/NDC/2022-09/23.09.2022_Enhanced%20NDC%20Indonesia.pdf (accessed on 18 February 2023).
2. Arifanti, V.B.; Dharmawan, I.W.S.; Wicaksono, D. Potensi cadangan karbon tegakan hutan sub montana di Taman Nasional Gunung Halimun Salak. *J. Penelit. Sos. dan Ekon. Kehutan.* **2014**, *11*, 13–31, doi:10.20886/jpsek.2014.11.1.13-31.
3. van Soest, H.L.; den Elzen, M.G.J.; van Vuuren, D.P. Net-Zero Emission Targets for Major Emitting Countries Consistent with the Paris Agreement. *Nat. Commun.* **2021**, *12*, 1–9.

4. Adinatha, I.K.; Arif, C. Inventarisasi Emisi Gas Rumah Kaca Berdasarkan Penggunaan Lahan Di Kota Bogor. *J. Tek. Sipil dan Lingkung.* **2022**, *7*, 49–64, doi:10.29244/jsil.7.1.49-64.
5. Mawardi, I.; Winanti, W.S.; Sudinda, T.W.; Alimin, A. Analysis of Achievements of Net Zero Carbon Emissions As Indonesia's Reference In Fulfillment Of Climate Change Mitigation Commitments. *J. Sains dan Teknol. Mitigasi Bencana.* **2022,** *16*, 71–89.
6. Putri, A.H.M.; Wulandari, C. Potensi Penyerapan Karbon Pada Tegakan Damar Mata Kucing (*Shorea Javanica*) Di Pekon Gunung Kemala Krui Lampung Barat. *J. Sylvia Lestari.* **2015**, *3*, 13–20.
7. Noormets, A.; Epron, D.; Domec, J.C.; McNulty, S.G.; Fox, T.; Sun, G.; King, J.S. Effects of Forest Management on Productivity and Carbon Sequestration: A Review and Hypothesis. *For. Ecol. Manage.* **2014**, *355*, 124–140, doi:10.1016/j.foreco.2015.05.019.
8. Wahyuni, H.; Suranto, S. Dampak Deforestasi Hutan Skala Besar Terhadap Pemanasan Global Di Indonesia. *JIIP: J. Ilm. Ilmu Pemerintah.* **2021**, *6*, 148–162, doi:10.14710/jiip.v6i1.10083.
9. Kurniarahma, L.; Laut, L.T.; Prasetyanto, P.K. Analisis Faktor-Faktor Yang Mempengaruhi Emisi CO_2 Di Indonesia (Analysis of Factors Affecting CO_2 Emissions in Indonesia). *Din. Dir. J. Econ.* **2020**, *2*, 369–385.
10. Herol; Nurhamidah; Andriani. Analisis Pengaruh Perubahan Tata Guna Lahan Terhadap Aliran Permukaan Dan Laju Sedimentasi Menggunakan ArcSWAT. *J. Civ. Eng. Vocat. Educ.* **2022**, *9*, 15–26.
11. Edwin, M. Penilaian Stok Karbon Tanah Organik Pada Beberapa Tipe Penggunaan Lahan Di Kutai Timur, Kalimantan Timur. *J. Agrifor.* **2016**, *15*, 279–288.
12. Prabowo, B.; Simanjuntak, F.S.H.; Saldi, Z.S.; Samyudia, Y.; Widjojo, I.J. Assessment of Waste to Energy Technology in Indonesia: A Techno-Economical Perspective on a 1000 Ton/Day Scenario. *Int. J. Technol.* **2019**, *10*, 1228–1234, doi:10.14716/ijtech.v10i6.3607.
13. Ariani, M.; Hervani, A.; Setyanto, P. Climate Smart Agriculture to Increase Productivity and Reduce Greenhouse Gas Emission-a Preliminary Study. *IOP Conf. Ser. Earth Environ. Sci.* **2018**, *200*, 012024, doi:10.1088/1755-1315/200/1/012024.
14. Prabowo, B.; Yan, M.; Syamsiro, M.; Setyobudi, R.H.; Biddinika, M.K. State of the Art of Global Dimethyl Ether Production and It's Potentional Application in Indonesia. *Proc. Pakistan Acad. Sci. Part B.* **2017**, *54*, 29–39.
15. BPS (Badan Pusat Statistik) Provinsi Jawa Tengah. *Provinsi Jawa Tengah Dalam Angka 2023*; Semarang: BPS Provinsi Jawa Tengah, ID, 2023.
16. Nugraha, F.W.; Pribadi, R.; Wirasatriya, A. Kajian Perubahan Luasan Untuk Prediksi Simpanan Karbon Ekosistem Mangrove Di Desa Kaliwlingi, Kabupaten Brebes. *Bul. Oseanografi Mar.* **2020**, *9*, 104–116, doi:10.14710/buloma.v9i2.30039.
17. Nainggolan, F.A.; Pribadi, R.; Trianto, A. Struktur Komposisi Dan Simpanan Karbon Di Sedimen Hutan Mangrove Pandansari, Kaliwlingi, Brebes. *J. Mar. Res.* **2022**, *11*, 529–538, doi:10.14710/jmr.v11i3.33393.
18. Albasit, L.Z.; Pribadi, R.; Pramesti, R. Estimasi Stok Karbon Mangrove Pasca Rehabilitasi Di Desa Kaliwlingi, Brebes Menggunakan Citra Sentinel-2. *J. Mar. Res.* **2022**, *11*, 620–640, doi:10.14710/jmr.v11i4.31734.
19. Zuhri, M. Alih Fungsi Lahan Pertanian Di Pantura Jawa Tengah (Studi Kasus Kabupaten Brebes). *J. Litbang Provinsi Jawa Teng.* **2018**, *16*, 119–130, doi:10.36762/litbangjateng.v16i1.756.
20. Rizaldi, B.M.; Setiawan, F.; Violando, W.A.; Muttaqin, A.D. Analisis Perubahan Stok Karbon Berdasarkan Perubahan Penutupan Lahan Dari Tahun 1990 – Tahun 2020 Di Wilayah Pesisir Kabupaten Lamongan, Provinsi Jawa Timur. *Prosiding FIT ISI* **2021**, *1*, 81–88.
21. Novita, N.; Subarno; Lestari, N.S.; Anshari, G.Z.; Lugina, M.; Yeo, S.; Malik, A.; Asyhari, A.; Putra, C.A.S.; Gangga, A.; et al. Natural Climate Solutions in Indonesia: Wetlands Are the Key to Achieve Indonesia's National Climate Commitment. *Environ. Res. Lett.* **2022**, *17*, 114045, doi:10.1088/1748-9326/ac9e0a.
22. Dencer-Brown, A.M.; Shilland, R.; Friess, D.; Herr, D.; Benson, L.; Berry, N.J.; Cifuentes-Jara, M.; Colas, P.; Damayanti, E.; García, E.L.; et al. Integrating Blue: How Do We Make Nationally Determined Contributions Work for Both Blue Carbon and Local Coastal Communities? *Ambio.* **2022**, *51*, 1978–1993.

23. Gunawan, M.; Ortis, O. *Rencana Strategis: Pariwisata Berkelanjutan Dan Green Jobs Untuk Indonesia*; International Labour Organization: Jakarta, ID, 2012;
24. Ayostina, I.; Napitupulu, L.; Robyn, B.; Maharani, C.; Murdiyarso, D. Network Analysis of Blue Carbon Governance Process in Indonesia. *Mar. Policy.* **2022**, *137*, 104955, doi:10.1016/j.marpol.2022.104955.
25. Malik, J.; Supriyanto; Santoso, A.; Sulastiningsih, I.M.; Supriadi, A.; Trisatya, D.R.; Damayanti, R.; Basri, E.; Saefudin; Hastuti, N.; et al. Study on Wood in Houses as Carbon Storage to Support Climate Stabilisation: Study in Four Residences around Jakarta Municipal City. *Forests.* **2022**, *13*, 1–11, doi:10.3390/f13071016.
26. Hoppe, T.; Sanders, M.P.T. Agricultural Green Gas Demonstration Projects in the Netherlands. A Stakeholder Analysis. *Environ. Eng. Manag. J.* **2014**, *13*, 3083–3096.
27. Ariani, M.; Hanudin, E.; Haryono, E. Does Soil Type Hold a Role in the Dynamic of Carbon Dioxide (CO_2) Emission from Paddy Rice Fields? *IOP Conference Series: Earth and Environmental Science* **2021**, *200*, 012024.
28. Prayogo, C.; Arfarita, N. The Conversion of Monoculture Sugarcane to a Tree-Based Agroforestry System Increases Total Carbon Sequestration and Soil Macrofauna Population. *J. Degrad. Min. Lands Manag.* **2022**, *10*, 3933–3944, doi:10.15243/jdmlm.2022.101.3933.
29. Mawardi, M.I.; Winanti, W.S.; Sudinda, T.W.; Amru, K.; Saraswati, A.A.; Sachoemar, S.I.; Arifin, Z.; Alimin, A. Analysis of Net-Zero Emission Index for Several Areas in Indonesia Using Individual Carbon Footprint and Land Use Covered. *IOP Conf. Ser. Earth Environ. Sci.* **2023**, *1201*, 012058, doi:10.1088/1755-1315/1201/1/012058.
30. Mashoreng, S.; La Nafie, Y.A.; Isyrini, R. Cultivated Seaweed Carbon Sequestration Capacity. *IOP Conf. Ser. Earth Environ. Sci.* **2019**, *370*, 012017, doi:10.1088/1755-1315/370/1/012017.
31. Central Java Government. Peraturan Gubernur Jawa Tengah No. 43/2012 Tentang Rencana Aksi Daerah Penurunan Imisi Gas Rumah Kaca Provinsi Jawa Tengah Tahun 2010-2020. Available online: https://peraturan.bpk.go.id/Details/233954/pergub-prov-jawa-tengah-no-43-tahun-2012 (accessed on 18 February 2023).
32. Damanik, M.; Amru, K. Carbon Stocks Potential and Economic Value Valuation of Carbon Stocks in Ebony Stand. *J. Pengelolaan Sumberd. Alam dan Lingkung.* **2022**, *12*, 696–705.
33. Santosa, S.; Umar, M.R.; Amir, N.J. Analisis Kandungan N, P, K, Porositas Media Pembibitan Dan Pertumbuhan Bibit Sengon Paraserianthes Falcataria (L) Nielsen. *Biota J. Ilm. Ilmu-Ilmu Hayati.* **2020**, *5*, 61–68, doi:10.24002/biota.v5i1.3068.
34. Anjani, R.; Amru, K.; Herningtyas, W.; Aryantie, M.H.; Ikhwanuddin, M.; Winanti, W.S.; Sudinda, T.W. Penilaian Ekowisata Mangrovesari Di Kabupaten Brebes Melalui Studi Kelayakan Serta Perumusan Strategi Pengembangannya. *J. Teknol. Lingkung.* **2024**, *25*, 059–070.