An Assessment of Carbon Content in Land-use Changes for Rice Plants in IKN Buffer Areas

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ABSTRACT
The relocation of the national capital city from Jakarta to Nusantara, East Kalimantan as a program from the government for the transformation of Indonesia based on innovation, technology, and a green economy reaps many pros and cons. One of them is related to food security, this is because in 2024 according to the estimated population that will move to Nusantara Capital City (IKN) as many as 300,000 people, then the population increases to 1 million people, while IKN states that the IKN area only provides 10% of 75% of the open area to be used as a food supply area, while most of the land in East Kalimantan is plantations and peatlands. Increasing rice food is important for concerns about food security. Paser Regency is important in increasing the supply of rice food. Therefore, it is necessary to change the function of land from open fields to the agricultural field as a solution to the problem of food security which will also cause other problems, one of which is the availability of carbon stocks that will change in the soil and atmosphere. Globally, soil carbon stocks are estimated to be almost three times the carbon stock in biomass and twice the carbon stock in the air. If not properly conserved, this large soil carbon stock has the potential to become a source of greenhouse gas emissions (GHG) which in turn has an impact on the rate of climate change. The use of remote sensing method is one of the non-destructive methods to estimate the value of the vegetation index of the IKN buffer area so that it can estimate the value of the vegetation index and estimate the value of above-ground carbon (AGC) content through a model. The equation model AGC=23.669+3.741(NDVI)+6.448(NIR) with a value of $R^2 = 0.71$ and RMSE = 0.09 ($t.h^{-1}$) can estimate the AGC value properly using the vegetation index so that the value of the remote sensing method can be used as an approach in the calculation as one of the considerations in the land conversion program.

Keywords: *IKN, Above Ground Carbon (AGC), Remote Sensing, Vegetation Index, Food*

1. INTRODUCTION

Greenhouse gas (GHG) is one of the main causes of global warming originating from activities in urban areas, especially related to energy consumption which globally accounts for 70% of GHG. Meanwhile, transportation (energy) is the largest contributor to global GHG emissions, amounting to 62%, which comes from the use of liquid fuels for motorized vehicles, especially in urban areas [1]. Cities are the main contributor to GHG, it turns out that climate change also makes urban areas will receive a much more severe impact. So that homework in urban areas does not only reduce GHG emissions but also must focus more on adapting to climate change. In simple

A. D. Saputro et al. (Eds.): ICOSEAT 2022, ABSR 26, pp. 904–910, 2023.
https://doi.org/10.2991/978-94-6463-086-2_120

terms, addressing GHG and climate change should pay more attention to urban areas. Meanwhile, urban activities are very diverse and complex which require various GHG handling efforts [2].

1.1. The Nation's Capital

The move of the capital city from Jakarta to Nusantara, East Kalimantan as a program from the government for transformation towards Indonesia based on innovation, technology, and a green economy and developed with 100% clean energy [3] reaped many pros and cons [4]. One of them is food security, this is because in 2024 the estimated population that will move to the Nusantara (IKN) is 300,000 people, then it will increase to 500,000, while 75% of the IKN area will be planned to be a green open space of which 65% is a protected area. and 10% for food production [5].

1.2. IKN Buffer Area

The existence of Paser Regency as one of the buffer areas for food security IKN is determined to increase development for the next five years by compiling programs to advance and improve in the fields of agriculture and food. Increasing food production by making maximum use of paddy fields and opening new paddy fields [6].

1.3. Land-Use Change

Land conversion is one way to increase the amount of food production, from green open fields to agricultural fields. However, land use change which is one of the solutions for food security can cause other problems, such as sustainable management of water resources [7] and increasing the amount of sediment in river bodies [8]. In addition, land use change also has an influence on the soil structure system and has a direct impact on food and the availability of nutrients, changes in natural habitats, loss of biodiversity, and carbon stock ecosystems [9].

1.4. Carbon Content

As a result of the conversion of open land use into agricultural fields, it will also have an impact on the availability of carbon stocks that will change in the soil [10]. Globally, soil carbon stocks are estimated to be almost three times as much as carbon stocks in biomass and twice as carbon stocks in air [11], [12]. If not converted properly, this large soil carbon stock has the potential to become a source of greenhouse gas (GHG) emissions which in turn have an impact on the rate of climate change [13], [14].

2. DATA AND METHODS

2.1. Research Site

This research was conducted in Paser Regency, East Kalimantan Province, which is one of the supporting areas for IKN food security. Geographically, Paser Regency is located as far as 0o 45'18.37" - 2o 27'20.82" South Latitude and 115o 36'14.5" - 166o 57'35.03" East Longitude or ± 200 km south of Sepaku District, Penajam Paser Utara Regency which is the zero point of IKN. In 2020, the agricultural fields area of Paser Regency is 1.160.314 hectares, which consists of 13.729 hectares of rice fields and 1.076.667 hectares of non-rice fields. While the area of non-agricultural fields in Paser Regency is 69.918 hectares.

Five soil orders were identified in the East Kalimantan: Oxisols, Ultisols, Alfisols, Inceptisols, and Entisols. These are distributed differently among territories. Variation in physical and chemical characteristics was found among and within the soil types in the research region. These variations relate to parent materials and local management activities. Some important general characteristics were low nutrient availability, acidic pH, and poor capacity of adsorbing and supplying nutrients for plants (CEC). Nutrient availability has been depleted by natural leaching processes, sometimes augmented by human activities, and are reflected by low pH values and low availability of soluble nutrients. Poor CEC conditions are probably most affected by the clay type that formed in the area and by limited organic material. CEC is determined largely by the mineral structure of clay reflecting surface available for nutrient adsorption and release, and buffering. The CEC was found to be low despite the facts that clay dominates particle size distribution within the research area [15].

Indonesia has the third largest tropical rainforest in the world (after Brazil and Congo) and ranks third in countries with the highest greenhouse gas emissions. In 2005, land use, land-use change, and forestry (LULUCF) contributed 75% of its total emissions. In 2015, Indonesia experienced its worst forest fires since 1999, which were exacerbated by land conversion. These emitted approximately 15.59 Mt CO_2/day, exceeding the average daily emissions from all economic activities in the United States. East Kalimantan, the fourth largest province in Indonesia, was among the six provinces with the highest number of fires that year. Like other Indonesian provinces, East Kalimantan's economy relies on local and foreign investment in natural resource extraction, including timber, oil gas, coal, and gold. This poses a threat to the environment through forest and land conversion for mining and for timber and oil palm plantations. Overlapping land tenure rights between mining, plantation and forest areas has also had prominent effects on deforestation, and increases the possibility of conflicts between communities and companies, or between companies [16].

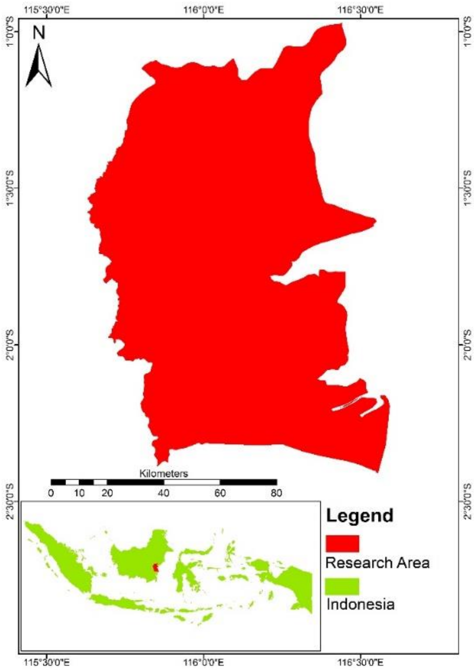

Figure 1 Study AreaImage Dataset

This study uses Sentinel-2A satellite imagery from January 1, 2019, to December 31, 2020. This image was downloaded via Google Earth Engine and has gone through the atmospheric and radiometric correction process and cloud cover is less than 10%. Sentinel-2A satellite imagery has a resolution of 10 m x 10 m, so it has a higher accuracy than other commercial satellite images and has a revisit time of every 5 days [17].

2.2. *AGC Estimation*

Carbon stock estimation has been practiced in many ways. One of the most frequently used applications is field data collection and survey methods. However, this method is time consuming, costly, and difficult to implement in mountain ecosystems due to its physiographic and climatic conditions. Recent technological advances such as the use of Geographic Information Systems (GIS) and remote sensing have unique characteristics, such as integrated imagery, high accuracy, timesaving, cost-effective, easy to access regularly [18].

This study refers to the modelling equation published in the journal [18] to be able to estimate the carbon stock available in Paser Regency by comparing the values between two variables, namely, the Vegetation Index and the calculation of the carbon stock field [14].

3. RESULT AND DISCUSSION

The high value of the vegetation index illustrates the plants with a high level of greenery in the observed area. On the other hand, a low vegetation index value indicates that the observed location has a low level of greenery [19]. Vegetation index produces different value ranges to explain the reality of conditions in the field [20], [21] with a range of values as follows:

Table 1 NDVI Classification

No.	Dense Class	NDVI
1	Non-Vegetation	<0
2	Lowest dense	0 – 0.15
3	Lower dense	0.15 – 0.3
4	Dense	0.3 – 0.45
5	Higher dense	0.45 – 0.6
6	Highest dense	> 0.6

Table 2 Percent NDVI

No.	Dense Class	% NDVI
1	Non-Vegetation	0,00%
2	Lowest dense	0,01%
3	Lower dense	0,15%
4	Dense	0,81%
5	Higher dense	4,60%
6	Highest dense	94,43%

Based on the

Figure **2** NDVI Processing, the NDVI value is (-0,992674) – 1. Based on the classification class according to the Table 1, the density class is spread between the lowest dense to the highest dense. This is because the Paser Regency area is still dominated by green open fields. As for some errors that we can find, such as settlements or even urban areas that are still detected as the Lowest dense class, which means that at every pixel with a resolution of 10 m x 10 m there is vegetation that can affect the Digital Number value of a pixel [22]. The comparison between density classes can be seen in the Table 2 which shows the highest percentage is in the Highest dense density class, which is 93.43%.

Table 3 Equation

Equestion	Equestion Number	Applicantion	Reference
$NDVI = \frac{NIR - RED}{NIR + RED}$	1	Land Cover	[23], [24]
$AGC = 23.669 + 3.741(NDVI) + 6.488(NIR)$	2	Soil Carbon Calculation	[18]

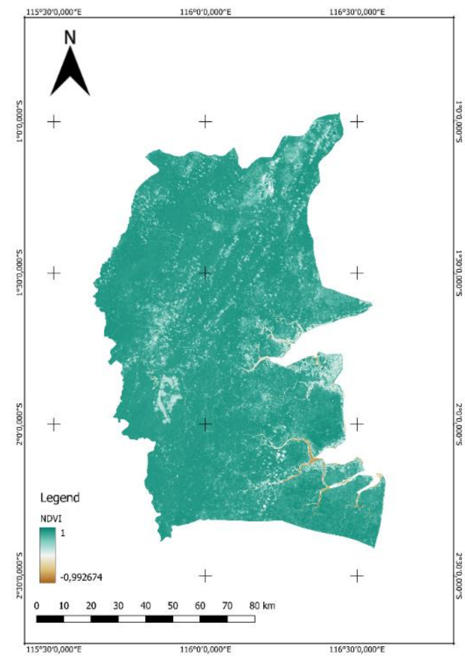

Figure 2 NDVI Processing

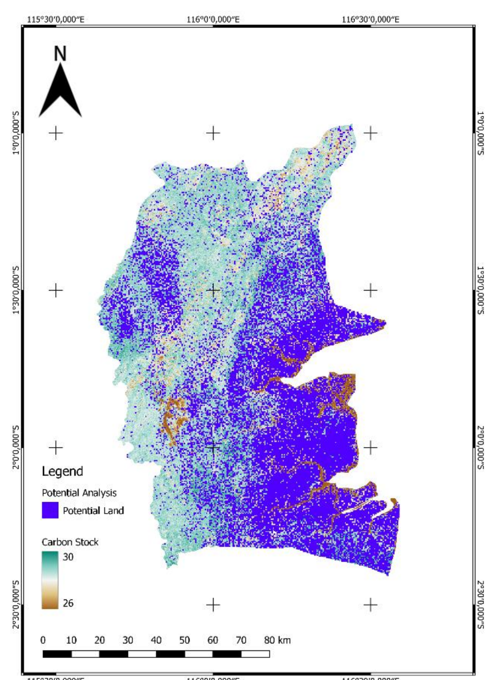

Figure 3 Potential Land Map

Table 4 Carbon Stocks Estimation

Carbon Stocks	GT
Kabupaten Paser	29.842.550
Potential Land	2.508.192

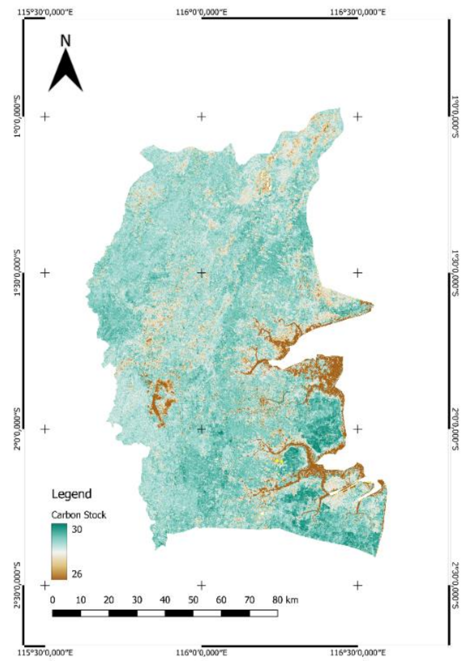

Figure 4 Carbon Stocks Estimation

The available carbon stock in Paser Regency by calculation using the modelling in

Table 3 is 29 GT. The following carbon stock value approach is based on the NDVI and NIR values [14] that have been downloaded and processed through the Google Earth Engine (GEE). GEE is a cloud computing platform designed to store and process huge data sets for analysis and ultimate decision making. The easily accessible and user-friendly front-end provides a convenient environment for interactive data and algorithm development. Users are also able to add and curate their own data and collections, while using Google's cloud resources to undertake all the processing. The result is that this now allows scientists, independent researchers, hobbyists, and nations to mine this massive warehouse of data for change detection, map trends, and quantify resources on the Earth's surface like never before [25]. Processing of the NDVI vegetation index using the open source QGIS application, besides processing to obtain land suitability analysis for rice crops is also carried out using the QGIS application. Land potential analysis is carried out to obtain land area that can be converted from green open land into agricultural fields. This land conversion activity will cause differences in the value of available carbon stocks due to deforestation activities. The loss of carbon stocks can be done by calculating the value of available carbon stocks on the potential land.

4. CONCLUSION

Paser Regency is dominated by the NDVI Highest dense density class, this is because most of the land is still filled with rice fields, gardens, and forests or 93.80% of the land in Paser Regency is vegetation with high density. A high value of vegetation index density will also affect how much carbon stock is available which is 29 GT. Paser Regency as one of the food security buffer areas needs to increase rice production, this can be done by one of them is land conversion. Land conversion can be done by analysing land potential for rice plants, this aims to determine a suitable location for rice cultivation. Planning for potential land conversion from green open fields into agricultural fields will cause a loss of carbon stocks that need to be considered so that it can be minimized. This is in accordance with the purpose of moving the country's capital city. Based on the map from the analysis of potential land, the estimated carbon loss is 2,5 GT or 8,45% from total carbon stock in Paser Regency. For further research, an analysis of planting methods can be carried out that can reduce the loss of carbon stocks so that it does not lead to the acceleration of the rate of climate change.

5. AUTHOR'S CONTRIBUTION

Muhammad Arga Hita: Conceptualization, Methodology, Formal analysis, Writing – original draft. **Sahid Susanto:** Validation, Interpreting, Writing – review & editing. **Lely Fitriana:** Validation, Interpreting, Data collecting. **Muhamad Khoiru Zaki:** Validation, Interpreting, Writing – review & editing. **Chandra Setyawan:** Validation, Interpreting, Writing – review & editing. **Ngadisih:** Validation, Interpreting, Writing – review & editing.

ACKNOWLEDGMENT

Based on the Decree of the Chancellor of the Universitas Gadjah Mada Number 482/UN1.P.III/KPT/HUKOR/2022, the Chancellor of the Universitas Gadjah Mada assigns tasks to: Prof. Dr. Endang Semiarti, M.S., M.Sc. as attached in this Assignment Letter as Recipients of the Batch 1 Final Recognition Program at Universitas Gadjah Mada for the 2022 Fiscal Year. Researchers are required to choose one of the four mandatory research outputs, one of which is a minimum of 3 proceedings that are indexed at least by Scopus (or equivalent) with the status of Accepted (proven by a letter of eligibility published) or Published (as of November 30, 2022).

REFERENCES

[1] E.B. Jaski, Mitigation of Climate Change, Ocean/Corbis, Shanghai, 2015.

[2] Ministry of Land, Infrastructure T and TJ, Low Carbon City Development Guidance, 2014.

[3] Republik Indonesia, Undang-Undang Republik Indonesia Nomor 3 Tahun 2022 tentang Ibu Kota Negara, Jakarta, Indonesia, 2022.

[4] Prayudi, Aspek Politik Pemerintahan Dari Rencana Pemindahan Ibukota Negara Ri. J Kaji, 25, 2020, pp. 177–195.

[5] Rusono Direktorat Pangan dan Pertanian N, Sumber Daya Alam dan Lingkungan Hidup Kementerian Perencanaan Pembangunan Nasional K, Perencanaan Pembangunan Nasional Jl Taman Suropati No B, Pusat J Peningkatan Produksi Daging Sapi untuk Mewujudkan Kedaulatan Pangan Hewani (Increasing Beef Cattle Production to Achieve Animal Food Sovereignty).

[6] Hairuni, Bupati Bertekat Paser Sebagai Penyangga IKN Harus Menjadi Daerah Lumbung Padi & Pangan, In: Ber. Kaltim, 2021. http://humas.paserkab.go.id/berita/-bupati-bertekat-paser-sebagai-penyangga-ikn-harus-menjadi-daerah-lumbung-padi-pangan. Accessed 28 Jun 2022

[7] L. Zhang, L. Zhang, F. Chiew, B. Fu, Understanding the impacts of climate and landuse change on water yield, Curr Opin Environ Sustain, 33, 2018, pp. 167–174. DOI: https://doi.org/10.1016/j.cosust.2018.04.017

[8] J. Zhao, H. Xie, J. Ma, K. Wang, Integrated remote sensing and model approach for impact assessment of future climate change on the carbon budget of global forest ecosystems, Glob Planet Change, 203, 2021, 103542. DOI: https://doi.org/10.1016/j.gloplacha.2021.103542

[9] T. Kastner, A. Chaudhary, S. Gingrich, et al, Global agricultural trade and land system sustainability: Implications for ecosystem carbon storage, biodiversity, and human nutrition, One Earth, 4, 2021, pp. 1425–1443. DOI: https://doi.org/10.1016/j.oneear.2021.09.006

[10] F. Adiyah, E. Micheli, A. Csorba, et al, Effects of landuse change and topography on the quantity and distribution of soil organic carbon stocks on Acrisol catenas in tropical small-scale shade cocoa systems of the Ashanti region of Ghana, CATENA, 216, 2022, 106366. DOI: https://doi.org/10.1016/j.catena.2022.106366

[11] D. Carless, B. Kulessa, A.D. Booth, et al, An integrated geophysical and GIS based approach improves estimation of peatland carbon stocks, Geoderma 402, 2021, 115176. DOI: https://doi.org/10.1016/j.geoderma.2021.115176

[12] L.M. Chabala, S. Angombe, W. Amelung, R.M. Lark, The effect of water deficit and livestock stocking density on soil organic carbon stocks in Namibia, Geoderma, 407, 2022, 115522. DOI: https://doi.org/10.1016/j.geoderma.2021.115522

[13] J. Zhao, D. Liu, Y. Cao, et al, An integrated

remote sensing and model approach for assessing forest carbon fluxes in China, Sci Total Environ, 811, 2022, 152480. DOI: https://doi.org/10.1016/j.scitotenv.2021.152480

[14] E. Purnamasari, M. Kamal, P. Wicaksono, Comparison of vegetation indices for estimating above-ground, Reg Stud Marione Sci, 44, 2021, 101730. DOI: https://doi.org/https://doi.org/10.1016/j.rsma.2021.101730

[15] I. Basuki, D. Sheil, Local Perspectives of Forest Landscapes: A Preliminary Evaluation of Land & Soils, & their Importance in Malinau, Center for International Forestry Research (CIFOR), Jakarta, 2005.

[16] Center for International Forestry Research (CIFOR), Provincial Council on Climate Change, 2011.

[17] N. Oktaviani, H.A. Kusuma, Pengenalan Citra Satelit Sentinel-2 Untuk Pemetaan Kelautan. Oseana, 42, 2017, pp. 40–55. DOI: https://doi.org/10.14203/oseana.2017.vol.42no.3.84

[18] M.G. Motlagh, S.B. Kafaky, A. Mataji, R. Akhavan, Calculation of the aboveground carbon stocks with satellite data and statistical models integrated into the climatic parameters in the Alborz Mountain forests (northern Iran), J For Sci, vol. 65, 2019, pp. 493–503. DOI: https://doi.org/10.17221/107/2019-JFS

[19] C.E. Reid, L.D. Kubzansky, J. Li, et al, It's not easy assessing greenness: A comparison of NDVI datasets and neighborhood types and their associations with self-rated health in New York City, Heal Place, vol. 54, 2018, pp. 92–101. DOI: https://doi.org/10.1016/j.healthplace.2018.09.005

[20] A. Zaitunah, S. Samsuri, A.G. Ahmad, R.A. Safitri, Normalized difference vegetation index (ndvi) analysis for land cover types using landsat 8 oli in besitang watershed, Indonesia, IOP Conf Ser Earth Environ Sci, 126, 2018. DOI: https://doi.org/10.1088/1755-1315/126/1/012112

[21] T.M. McFarland, C. Riper, Prepared in cooperation with the University of Arizona Use of Normalized Difference Vegetation Index (NDVI) Habitat Models to Predict Breeding Birds on the San Pedro River, Arizona Open-File Report 2013-1100, 2013.

[22] Pengolahan P, Penginderaan D, LAPAN Pedoman Pengolahan Data Penginderaan Jauh Landsat 8 untuk MPT. LAPAN, 2015.

[23] A. Gitelson, M.N. Merzlyak, Quantitative estimation of chlorophyll-a using reflectance spectra: Experiments with autumn chestnut and maple leaves, J Photochem Photobiol B Biol, vol. 22, 1994, pp. 247–252. DOI: https://doi.org/10.1016/1011-1344(93)06963-4

[24] A. Gitelson, A. Viña, A. Solovchenko, et al, Derivation of canopy light absorption coefficient from reflectance spectra, Remote Sens Environ, 231, 2019. DOI: https://doi.org/10.1016/j.rse.2019.111276

[25] L. Kumar, O. Mutanga, Google Earth Engine Applications, Remote Sens, 2019.