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REMOTE SENSING ANALYSIS OF CARBON DIOXIDE GHG EMISSIONS SUPPORTS REGIONAL ACTION PLANS FOR MITIGATION TO THE IMPACTS OF CLIMATE CHANGE IN SITUBONDO REGENCY

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Abstract

The study aims to inventory and analyze GHG Carbon Dioxide (CO_2) emissions to support RAD in the mitigation and adaptation of PI Situbondo Regency. It is hoped that the research output can become input for Regional Governments in implementative designing mitigation and adaptation actions. The scope of the research in the Situbondo Regency area was six months. The analysis method uses a remote sensing system through exploration of Sentinel-5P satellite data for GHG Carbon Dioxide (CO_2) gas numerical spatial data on cloud-based digital platform Java script Google Earth Engine (GEE) and Google Colaboratory Research (GColab) 2023, image digitization and outlasting in QGIS software. Research data is remote sensing data access to the Carbon Dioxide gas datasets Sentinel_5P OFFL_CO Offline, and MOD 11A1.061_Terra LST, and EDG 1km. The results show that the highest CO density variable in 2017 was 116 – 239 g/m2, then decreased to 109 – 227 g/m2 in 2019, and to 66 – 180 g/m2 in 2021. The highest range of LST variables in 2017al was 19 – 39 ^{0}C, then increased to 21 – 40 ^{0}C in 2019, and in 2021 decreased again to 18 – 38 ^{0}C. Regional variables The highest LST distribution in 2017 and 2019 was relatively the same in each sub-district, namely Situbondo, Panarukan, Panji, Kapongan and Jangkar. CO and LST density variables in 2021 are not correlated, r = 0.1 - 0.3.
Keywords : carbon ioxide, land surface temperature, regional action plans, mitigation

INTRODUCTION

According to Panwar et al, (2011), global warming is the phenomenon of increasing global temperatures due to the greenhouse effect (ERK) from rising emissions of CO_2, CH_4, NO_2, also freon CFC. Some gases classified as GHGs (Mackay, 2008); CO_2, CH_4, N_2O, and other gases fluorinated (F-gas) such as perfluorocarbons (PFCs), group of hydrofluorocarbons (HFCs) like as SF6 (Sulfure hexafluorida), and compounds will be destroyed the ozone layer. Damayanti dan Lestari (2013), releasing solar thermal energy trapped by greenhouse gases (GHG) will increase temperatures. The average increase in global surface temperature of the earth is 0.74 ± 0.18 ^oC in the last 100 years. Numberi (2009), there are two factors that cause global warming; 1) burning fossil energy for industry, motor vehicles, and power plan; and 2) emissions of various gases from industrial activities such as the use and manufacture of CFCs. Humans contribute to global warming as the largest contributor of greenhouse gases.

ERK, in the laws of physics (Wahyono, 2008), occurs because the wavelength of light emitted to an object will depends on the temperature object. The higher of the temperature object, make the shorter wavelength. The high temperature of the sun's heat emits short-wave rays. The low temperature of the earth's surface will emit long-wave infrared rays. Infrared rays in the atmosphere will be absorbed by certain gases so they are not released into space. Heat is trapped in the lower layer of the atmosphere (troposphere) due to the rise of the earth's surface, causing the air temperature to rise in the troposphere. If the trend of phenomena like this continues, the earth's surface air temperature (land surface temperature) in the future will rise by ± 2.3°C.

Climate change has encouraged the Republik Indonesia Government to commit to an active role in efforts to reduce the emission of GHGs through a RAN (National Action Program). Based on PP No. 61/2011, concerned with the RAN for Reducing GRK emissions, and PP No. 71/2011, concerning the Implementation of the National Greenhouse Gas Inventory, provincial and district/city governments facilitate mitigation of GHG emission reduction through RAN for Reducing GHG Emissions (RAN-GRK), then provinces and cities/districts throughout Indonesia (RAD-GRK). French (1998), mitigation is an effort to prevent, restrain the release of carbon, increase carbon absorption into forests or other carbon sinks, and slow down the effects of GHGs that cause global warming. Setiawan (2010), adaptation is an important response strategy approach in efforts to minimize the dangers caused by climate change. Adaptation has a role in reducing the impacts that immediately arise due to climate change that cannot be done by mitigation. The Indonesian government is trying to adapt through the RAN for Adaptation to climate change (PI). Slamet (2015), PI adaptation strategy; reducing socio-economic and environmental vulnerability originating from climate change; increasing community and ecosystem resilience; and improving the welfare of local communities through poverty alleviation. Mitigation and Adaptation to the PI impacts have been carried out both nationally through NAP and regionally through RAD. The methane GHG emissions analysis study was carried out to provide a baseline description of Carbon Dioxide GHG producers and potential in mitigate and adapt to the climate change impacts as a reference for RAD. It is hoped that the research results will become input for the Regional Government in designing implementing PI mitigation and adaptation actions. The research aims to inventory and analyze GHG emissions of Carbon Dioxide (CO_2) gas to support RAD for mitigating and adapting to the impacts of PI in Situbondo Regency.

LITERATURE REVIEW

Carbon GHGs Emission

The increasing use of energy from fossil fuels for various human activities, especially in transportation and industrial and household processes, the generation of solid and liquid waste, forest clearing activities for development purposes, as well as the intensification of plant cultivation and various processes related to development. Livestock activities cause greenhouse gas (GHG) emissions to increase. The emissions released are partially reabsorbed by the oceans and land. However, the ability of the oceans and land to reabsorb CO_2 has not changed much. Thus, an increase in the emission rate causes the concentration of CO_2 in the atmosphere to increase over time.

Furthermore, according to the US-EPA (2021), carbon dioxide is the main GHG resulting from human activities and is found in the atmosphere as part of the earth's carbon cycle (such as carbon cycle in the atmosphere, in the oceans, soil, plants, and animals). CO_2 enters the atmosphere through the burning of fossil fuels (coal, natural gas, and petroleum), solid waste, trees, and other biological materials processes as the result of certain chemical reactions (cement industrial process). From the atmosphere, carbon dioxide will be reduced or removed if its absorbed by plants as raw material for photosynthesis in the biological carbon cycle. According to Bassham et al. (2024), the photosynthesis reaction is:

$$\underset{\text{carbon dioxide}}{6CO_2} + \underset{\text{water}}{12H_2O} \xrightarrow[\text{green plants}]{\text{light}} \underset{\text{glucose}}{C_6H_{12}O_6} + \underset{\text{oxygen}}{6O_2} + \underset{\text{water}}{6H_2O.}$$

Chlorophyl enzym

Human activities change the carbon cycle, by adding more CO_2 to the atmosphere, and by affecting to ability of natural sinks (forests and soil), to remove and store CO_2 from the atmosphere. Although CO_2 emissions come from various natural sources, emissions caused by human being activities are responsible for the increases that have occurred in the atmosphere. Human being activities as main contribute to CO_2 emissions through the burning of fossil fuels (coal, natural gas, and petroleum) for energy and transportation, then specific industrial processes, and changes in land use (US-EPA, 2021).

Carbon Dioxide (CO_2) is a chemical compound consisting of 1 A carbon atom (C) is covalently bonded to 2 oxygen atoms (O_2). In the atmosphere, it is a gas at standard temperature and pressure. CO_2 does not It is liquid at pressures below 5.1 atm but becomes solid below temperature -78°C (Zid and Hardi, 2019). The process of anaerobic decomposition of solid waste and urban liquid waste, industrial liquid waste piles and composting of organic materials will emit methane gas and CO_2.

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Carbon Dioxide is a greenhouse gas that causes global warming and is trapped in the atmosphere due to human activities. Fossil fuels used in human activities like petroleum, gas, coal, and diesel will emit CO_2 gas (Mukono, 2020). In household activities, CO_2 gas emissions are classified into primary and secondary carbon footprints. The primary carbon footprint is CO_2 emissions originating by the burning fossil fuels process of transportation and cooking activities. Meanwhile, the secondary carbon footprint is CO_2 gas emissions originating from the use of household electronic devices that use electricity (Nursetiyani, 2021). The abundance of Carbon Dioxide gas in the atmosphere causes cooling in the stratosphere, triggering the acceleration of holes in the ozone layer (Rusbiantoro, 2008). 80% of CO_2 gas pollution comes from burning fossil fuels, and the remaining 20% comes from deforestation and forest fires. CO_2 gas is also produced from motor vehicle fuel and electricity generation. Human activity (anthropogenic) can cause an increase in the amount of CO_2 gas by 30%, and then this gas is trapped in the atmosphere for 500 years (Mukono, 2018).

Carbon Mitigation and Carbon Reduction Strategies

The increase in population is directly proportional to the rise in energy consumption, thus making the energy supply sector increasingly a major contributor to world GHG emissions. The large GHG emissions in this sector occur due to the large level of fossil energy used to provide power plans. Recorded 75% of Energy needs come from energy conversion non-renewables such as oil, coal, and natural gas (Ministry ESDM, 2010), where GHG emissions CO_2 from energy supply activities increased significantly by 83.7% from 1999-2009.

For industrial sectors that use fossil energy, both for energy and non-energy purposes, the largest contribution from the CO2 greenhouse gas emissions sector is 1) industries that consume large amounts of energy such as the metal, fertilizer, chemical, oil refinery, cement industries, and paper; 2) the process of burning agricultural waste and the aerobic decomposition process of organic material (Smith & Olesen, 2010); 3) waste/garbage management by traditional waste burning or by incinerators; 4) forestry, calculated based on the loss of the forest's ability to absorb and bind CO2 (carbon stock).

Meanwhile, potential climate change mitigation and adaptation actions are carried out through policy reviews and document studies. Action potential refers to Carbon Dioxide GHG emissions after mitigation actions, namely reducing base year emissions by the amount of emissions after mitigation actions for each sector. Implementation of potential mitigation actions in Situbondo Regency through document studies (Agricultural Research and Development and Ministry of Agriculture according to IPCC 2006 Guidelines (Damayanti dan Lestari, 2013). Farmers can determine the implementation of mitigation actions in the work area by considering costs, ease of work, and opportunities for facilitation by other parties.

GHG mitigation is a form targeted human intervention reduce or increase emissions ability to absorb and change GHGs, so they are useful in environmental, social, and economic aspects. Simpson et al. (2008), four main implementation strategies mitigation of GHG emissions, 1) Elimination, avoidance of activities and the use of available tools produces GHG emissions, for example (Levermore, 1985), turning off lights when they are not in use; 2) Subtraction, done with carry out energy efficiency in each activity, for example (Ma et al., 2011), in purchasing equipment electronics, electricity savings indicators are not considered, but brand and price are the main ones, as is the result of research in China; 3) Substitution, strategy for replacing technology or change causes behavior large GHG emissions with technology or change to lower behavior emission, For example, the use of biogas to replace fossil energy or biomass energy. Laramee and Davis (2013), the use of firewood, charcoal, kerosene, and LPG for biogas in Tanzania is able to prevent GHG emissions of 5,825 kg CO2-eq/year/family; 4) compensation, absorb strategy GHG concentration thereby reducing GHG emissions that arise, for example, Putri and Wulandari (2015), that reforestation with resin plants cat's eye (*Shorea javanica* L) is capable absorbs CO_2 emissions of 124.86 tons/hectare.

METHOD

The research was conducted in the Situbondo Regency area at the astronomical line 7°35'–7°44' LS, and 113°30'–114°42' BT. The research period was six months, from May to October 2023. The scope of the research is a remote sensing system through exploration of Sentinel-5P satellite data. The research method uses remote sensing analysis of Carbon Dioxide GHG projections through access to the Sentinel-5P OFFL CO: Carbon Dioxide Offline satellite dataset, and MOD 11A1.061 Terra LST_and EDG 1km, then analyzed using G_Colaboratory Research (Google Colab). Numerical spatial analysis via remote sensing and five-year projections were carried out on the cloud-based digital platform Java script Google Earth Engine (GEE), Google Colab, and distributed on Quantum Geografic Information System (QGIS) software. According to Voogt and Oke (2003), the application of remote sensing methods based on satellite thermal spectral sensors on natural and agricultural surfaces provides insight into engineering methods and representative urban spatial and climate mapping capabilities. This method is a low-cost, high-resolution, more detailed, and inexpensive portable thermal scanning method for now and in the future. The following is an overview of the conceptual framework for the flow of stages in implementing remote sensing research.

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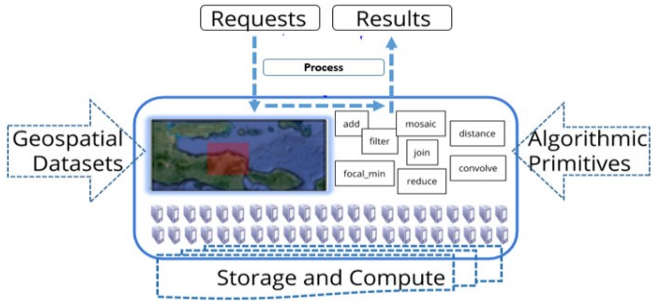

Figure 1

Flow charts of Implementation Stages of Remote Sensing Analysis of Carbon Dioxide (CO_2) Emissions on the GEE and Google Colaboratory Platforms.

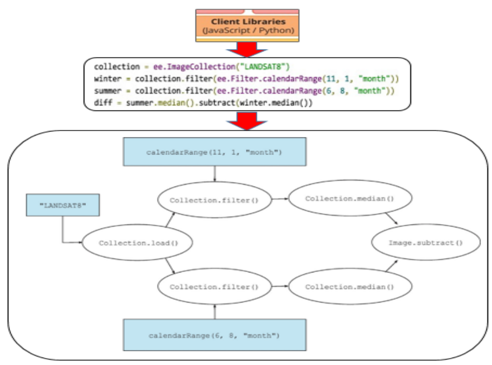

Figure 2. Accessing The Carbon Dioxide (CO_2) Emissions Data Set

(*Source : Noel, G.; Matt, H. et al. 2017)*

Furthermore, used regression and correlation analysis to determine relationship and closeness the model between carbon dioxide density variables and land sanalysurface temperature (LST), and multivariate PCA biplot to determine the relative position of the variables using SAS v.jmp 16, and Genstat v.18 software.

RESULTS AND DISCUSSION

Carbon Dioxide Density (Total Density, Distribution Area, Monthly Density).

The analysis results shows, the highest CO_2 density variable in 2017 was 116 – 239 g/m2, then decreased to 109 – 227 g/m2 in 2019, and to 66 – 180 g/m2 in 2021, as in Figure 4, 5, and 6 below.

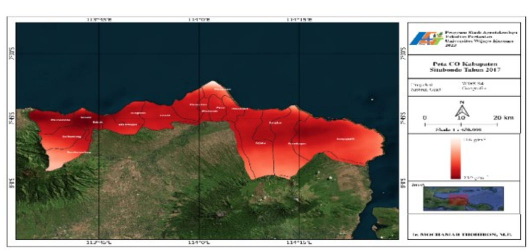

Figure 4 GHG CO_2 Distribution Map (g/m^2) Based on District in Situbondo Regency in 2017.

(source: Results of Remote Sensing Analysis)

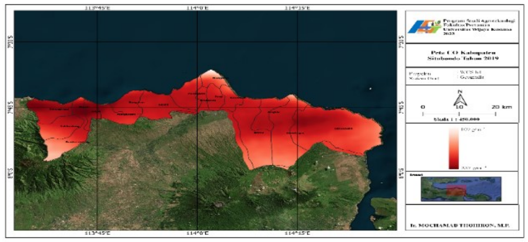

Figure 5. GHG CO_2 Distribution Map (g/ m^2) Based on District in Situbondo Regency in 2019.

(source: Results of Remote Sensing Analysis)

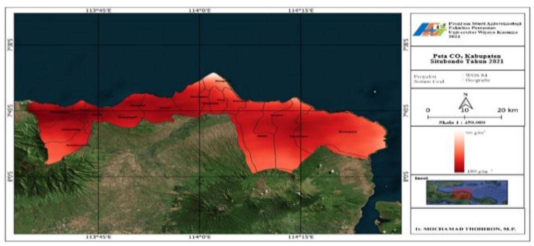

Figure 6. GHG CO_2 Distribution Map (g/ m^2) Based on District in Situbondo Regency in 2021. *(source: Results of Remote Sensing Analysis)*

For regional distribution variables, the highest CO_2 density in 2017, and 2019 in each sub-district was Besuki, Suboh, Banyuglugur, Panarukan, and Situbondo, then in 2021 it would be Banyuglugur, Besuki, Suboh, and Kendit. Meanwhile, for the monthly distribution variable, the highest CO_2 density in 2017, and 2019 occurred at the beginning of October to the end of November, while in 2021 it fluctuated highly from March to June with the highest peak in November, as in Figure 7 below.

Figure 7

Yearly and Monthly Distribution Pattern of GHG CO_2 Density in Situbondo Regency in 2017, 2019 and 2021

(Source: Results of Remote Sensing Analysis)

The CO_2 distribution map for 2017, 2019 and 2021 shows a decrease in density or change in density due to the dynamic nature of CO_2 in the atmosphere. As US-EPA (2021), in the atmosphere, carbon dioxide will be reduced or removed if its absorbed by plants as raw material for photosynthesis in the biological carbon cycle. According to Bassham et al. (2021), that increasing carbon dioxide levels in

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the atmosphere will be affects climate elements, increasing temperatures, changing rainfall patterns, and these changes affected rate of photosynthesis.

Furthermore, as US-EPA (2021), the impact of gases on climate change depends on three main factors: 1) Gas density in the atmosphere (how much), density, or abundance, is the amount of a particular gas in the air. Greater GHG emissions lead to higher concentrations in the atmosphere; 2) Survival time (how long), each type of GHG can survive in the atmosphere for different periods, from several to thousands years. Whatever the source of emissions, all gases the atmosphere long enough to be well mixed, meaning the amounts measured in the atmosphere are nearly the same throughout the world; 3) Strength of Influence (how strong), some gases are more effective than others in having an impact on the earth. Each greenhouse gas has a GWP, which is calculated as a measure of the average time the gas stays in the atmosphere and how strongly it absorbs energy. Gases with higher GWPs will absorb more energy and contribute more to warming than gases with lower GWPs.

Meanwhile, annual and monthly density shows the same pattern in 2017, and 2019, and is different in 2021 which tends to fluctuate. Changes in the distribution area of CO_2 density levels, as well as monthly and annual distribution patterns, are thought to be related to the dynamic nature of CO_2 in the atmosphere so that it can be reduced or sequestered due to uptake by plants (US-EPA, 2021; Bassham et al., 2021).

Land Surface Temperature (LST, Distribution Area, Monthly Distribution Pattern)

Referring to the results of previous research (Thohiron et al., 2023), show that the highest range of LST variables in 2017 was 19 – 39 ^oC, then increased to 21 – 40 ^oC in 2019, and decreased again to 18 – 38 ^oC in 2021. Regional variables The highest LST distribution in 2017 and 2019 was relatively the same in each sub-district, namely Situbondo, Panarukan, Panji, Kapongan, and Jangkar. Meanwhile, in 2021, the distribution area will be wider, namely Situbondo, Panarukan, Panji, Kapongan, Jangkar, Mangaran, Arjasa, and Asembagus as seen in figures 8, 9, and 10 below.

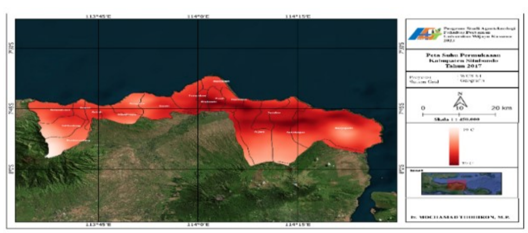

Figure 8

Land Surface Temperatur (LST) Distribution Map (^oC) Based on District in Situbondo Regency in 2017

(Source: Analysis Results 2023)

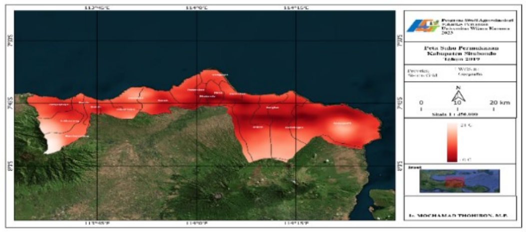

Figure 9

Land Surface Temperatur (LST) Distribution Map (°C) Based on District in Situbondo Regency in 2019

(Source: Analysis Results 2023)

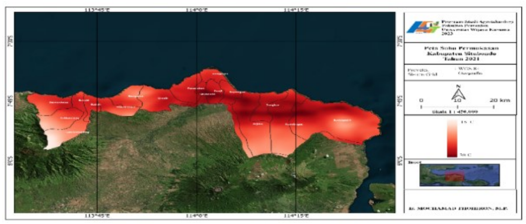

Figure 10

Land Surface Temperatur (LST) Distribution Map (°C) Based on District in Situbondo Regency in 2021

(Source: Analysis Results 2023)

Furthermore, from the analysis of monthly LST distribution pattern variables, the highest LST in 2017 occurred in November and early December, and in 2019 it happened in November, then in 2021 in May and November, as in Figure 11 below.

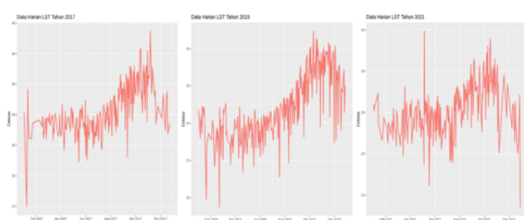

Figure 11

Monthly Distribution Pattern of Land Surface Temperature (LST) in Situbondo Regency in 2017, 2019 and 2021

(Source: Analysis Results 2023)

LST is a measure of "how hot" the soil land if to the touch. This temperature is different from air temperature because land heats and cools faster than air. This image depicts monthly average land surface temperatures (Celcius degrees) as measured by the MODIS (*Moderate Resolution of Imaging Spectroradiometer*) on NASA's Terra satellite (NEO, 2024a).

In 2017 and 2019, the LST distribution map shows the same distribution pattern, which increases but decreases in 2021, even though the distribution area was wider. This has an impact on the extent of

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land exposed to maximum LST distribution because the land or land will heat up more quickly (NEO, 2024a). The large distribution of land areas exposed to maximum LST causes land temperatures to increase rapidly, thus having an impact on the ecological aspects of the land and the life on it (plants, livestock, and humans). Meanwhile, the maximum monthly and annual LST distribution pattern occurs until October-November, then decreases as we enter December. The occurrence of changes in land surface temperature will affect land temperature, which has a broad impact on the regional warming of local land.

Analysis of the CO_2 density distribution pattern with land surface temperature (LST) in 2017, 2019, and 2021 shows variations in the pattern of increase with the highest peak in 2019, then decreasing in 2021, as presented in Figure 12 below.

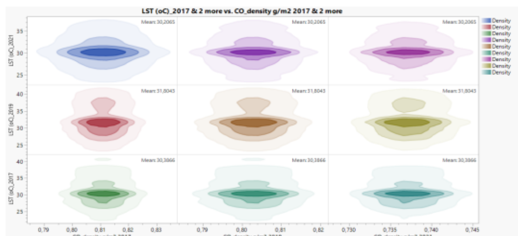

Figure 12

Description of the Distribution Pattern of GHG CO_2 Density on Land Surface Temperature (LST) in Situbondo Regency in 2017, 2019 and 2021

(source: analysis results, 2023).

Furthermore, as NEO (2024b), the LST map shows the temperature of the earth's land during the day as a measure of how warm or cold an object is which will influence weather and climate patterns and impact plant life. The implication for plants, as research results by Suryaningsih (2023), is that temperature is closely correlated with the variable quantity and quality of potato yields (Solanum tuberosum) at $R2 > 0.8$. Eventually, worldwide land surface temperature (LST) measurements can be made from space via satellite instruments (NEO, 2024b).

Relationship Between Variables

To find out the extent of the relationship pattern between CO_2 density in 2017, 2019, and 2021 as an independent variable with a fixed variable (response) of land surface temperature (LST) in 2021, a regression analysis was carried out. The analysis results show that the model is insignificant with a relatively low correlation coefficient (r). This indicates that the relationship between these two variables does not stop. Results of the 2021 Land Surface Temperature (LST) response variable regression model: $Y = 34.72 – 1.65*(CO_2\_density\ g/m2\_2017) – 0.00*(CO_2\_density\ g/m2\_2019) – 4.33*(CO_2\_density\ g/m2\_2021)$. The overall model estimation plot is presented in Figure 13 below.

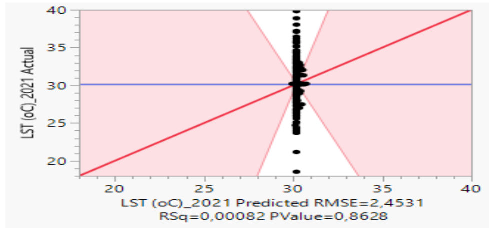

Figure 13. Actual Land Surface Temperature (LST) Model By Predicted Plot

(source: *Data Processing 2023*).

Periodically, the results of the analysis in 2017, 2019, and 2021 show a decrease in the CO_2 density variable, while the LST variable experiences fluctuations. In 2019, CO_2 density reached its highest density. The CO_2 density variable with land surface temperature (LST) is not correlated with r = 0.1 – 0.3, as presented in Figure 14 below.

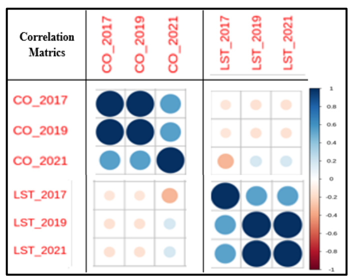

Figure 14

Correlation Matrix Map of the GHG CO_2 Density Variable with Land Surface Temperature (LST) in Situbondo Regency in 2017, 2019 and 2021

(source : analysis results, 2023).

Relative position of variables

Multivariate analysis was uses to determine the relative position of variables through principal component analysis (PCA) AMMI (Additive Main Effect of Multiplication Interaction) Biplot. An overview of the analysis results is presented in Figure 13 below.

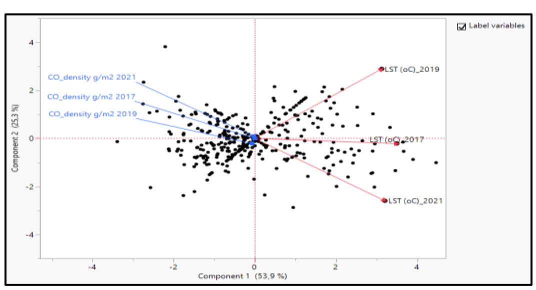

Figure 13

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Multivariate Analysis of the Main Components of the AMMI Biplot Graph for the GHG Carbon Dioxide (CO_2) Density Variable and Land Surface Temperature (LST) in Situbondo Regency in 2017, 2019 and 2021

(Source: analysis results, 2023).

The figure above explains that the value of the suitability measure for the two-dimensional biplot graph is 53.9% (not too high), however, the biplot results obtained are considered quite representative. The independent variable (CO_2 density) is not correlated with LST in 2017, 2019, and 2021, but the periodic CO_2 density variables in 2017, 2019, and 2021 are all correlated. The periodic Land Surface Temperature (LST) variables for 2017, 2019, and 2021 show the same variations, none of which are higher and uncorrelated.

Based on the regression analysis results, shows that regression analysis of CO_2 density (2017, 2019, and 2021) on LST in 2021 not significan, and it was seen that intercept (β0) was positive but the regression coefficients (β1), (β2), and (β3) of CO_2 density during 2017, 2019, and 2021 is negative so the LST prediction for 2021 will also decrease. There is a similar pattern in the regression results and remote sensing LST analysis results in 2021. According to NEO (2024a), land affected by the maximum LST distribution will experience warming more quickly. The large distribution of land areas exposed to maximum LST causes land temperatures to increase rapidly.

Potential Mitigation Actions

The carbon footprint can be reduced through improved energy efficiency, lifestyle changes, and purchasing habits. Diversion of energy use and transportation has an impact on the main carbon footprint, for example, the use of public transportation (buses, trains, use of energy-saving lighting, and building insulation). Carbon emissions can also be reduced by using renewable energy sources to produce the required electricity.

The choices of Carbon Dioxide GHG mitigation actions that can be developed for Carbon Dioxide Reduction Opportunities are 1) Energy Efficiency, through building insulating, use of more fuel-efficient vehicles, use of more economical electrical appliance to reduce of uses energy, and CO_2 emissions; 2) Energy Conservation, through reducing of uses personal of energy, and petroleum consumption; 3) Fuel Switching, through the use of more energy from renewable sources and the use of fuel conten lower carbon; 4) CCS, via CO_2 capture and sequestration to reduces CO_2 emissions from new or existing coal and gas-fired powerplants, industrial processes, and other stationary CO_2 sources. Capturing CO_2 from coal-fired powerplants stacks before its released into the atmosphere, transporting CO_2 through pipes, and injecting CO_2 deep underground into specific geological formations for storage; and 5) Changes in Land Use through increasing carbon storage through different land uses or maintaining carbon storages by avoiding land degradation, and Changes in Land Management Practices through practically improving management for types of existing land use.

CONCLUSION

Of all the variables analyzed, the research results concluded that 1) there were differences in CO_2 density in terms of quantity, distribution area, and monthly patterns throughout the year, where in 2017 - 2019 there was an increase, then a decrease in 2021; 2) there are differences in LST in terms of temperature, LST distribution area, and monthly patterns throughout the year, where there was an increase in 2017 and 2019, then a decrease in 2021; 3) The regression model is not significantly different and does not correlate between CO_2 density in 2017, 2019 and 2021 and LST in 2021, which shows a decrease in LST in 2021 because the results obtained are the same as the results of remote sensing analysis; 4) The LST variables are not correlated and the variations are the same, but the CO_2 density variables during 2017, 2019 and 2021 are correlated; 5) The chosen CO_2 GHG reduction mitigation strategy is by implementing; Energy efficiency and conservation, Fuel switching, CCS, Changes in Land Use, also Land Management Practices.

Further research is needed to calculate the potential for reducing kind of GHG emissions through several mitigation options that are most likely to be carried out so that mitigation actions can be obtained and implemented for consideration by several interested parties. Community understanding and institutional operational steps are very necessary for socializing the impact of PI.

REFERENCES

Bassham, James Alan and Lambers, Hans. (2021). "*photosynthesis*". Encyclopedia Britannica, 25 Jul. Source: https://www.britannica.com/science/photosynthesis. Accessed 4 August 2024

Damayanti, S., dan P. Lestari. (2013). Inventarisasi Emisi CO2 Dari Proses Kalsinasi Pada Industri Semen di Indonesia Berdasarkan IPCC Guidelines 2006.

French, D. (1998). Kyoto Protocol to the United Nations Framework Convention on Climate Change. *Journal of Environmental Law*. Vol. 10 (1), p: 215-224, ISSN: 0952-8873, DOI: 10.1093/jel/10.1.215. Germany

Hairiah, K., Ekadinata, A., Rika, R, S., dan Rahayu, S. (2011). *Petunjuk Praktis Pengukuran Stok Karbon dari Tingkat Lahan ke Bentang Lahan.* Edisi Ke 2 Bogor World Agroforestry Centre

IPCC. (2007). Climate Change 2007 Synthesis Report. Intergovernmental Panel on Climate Change Core Writing Team IPCC. Source: https://doi.org/10.1256/004316502320517344
NEO, 2024a. NASA Earth Observatory. Vegetation and Land Surface Temperature. Source: https://earthobservatory.nasa.gov/global-maps/MOD_NDVI_M/MOD_LSTD_M#:~:text=Land%20surface%20temperature%20is%20a,cools%20more%20quickly%20than%20air

IPCC. (2019). *Intergovermental Panel on Climate Change. IPCC Guidelines for National Greenhouse Gas Inventories Intergovernmental Panel on Climate Change* (2019)., In H.S. Eggleston., K. Miwa., N. Srivastava., & K. Tanabe (Ed), Prepared by the National Greenhouse Gas Inventories Programme. Japan: IGES.

Laramee, J and Davis, J. (2013). Economic and environmental impacts off domestic bio-digesters: Evidence from Arusha, Tanzania. *Energy for Sustainable Development*. Vol 17. 296–304

Levermore, G. J. (1985). Monitoring and targeting; motivation and training. *Proceeding in Energy Management Experience Conference*. Cambridge, UK. 21-30

Ma, G. Andrews-Speed, P. & Zhang, J. D. (2011). Study on Chinese consumer attitudes on energy-saving household appliances and government policies: based on a questionnaire survey of residents in Chongqing, China. *Energy Procedia*. Vol 5 : 445–451

Mackay, A. (2008). Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Journal of Environmental Quality. *Cambridge University Press*. Vol. 37 (6), 2008, p: 2407, DOI: 10.2134/jeq2008.0015br, ISSN: 0047-2425

Ministry ESDM. (2010). *Peraturan Menteri Energi dan Sumber Daya Mineral Nomor 1 Tahun 2010 tentang Pedoman Pengawasan Di Lingkungan Kementerian Energi Dan Sumber Daya Mineral.* Kementerian Energi dan Sumber Daya Mineral. Sumber: BN 2010/ NO 22; PERATURAN.GO.ID : 4 HLM

Mukono, J. (2020). *Kesehatan Lingkungan Akibat Pemanasan Global dan Perubahan Iklim*. Ailangga University Press. hal. 23-65, 119-130

NEO, 2024b. NASA Earth Observatory. Land Surface Temperature [Day] (1 Month - Terra/Modis). Source:https://neo.gsfc.nasa.gov/view.php?datasetId=MOD_LSTD_M

Noel, G.; Matt, H. et al. 2017. *Remote Sensing of Environment.GGE: Planetary-Scale Geospacial Analysis for Everyone.* Science Direct. Elsevier

Numberi F. 2009. *Perubahan Iklim: Implikasi terhadap Kehidupan di Laut, Pesisir dan Pulau-pulau Kecil.* Jakarta (ID): Citrakreasi Indonesia

Panwar, N.L., S.C. Kaushik, Surendra Kothari. (2011). Role of renewable energy sources in environmental protection: A review, Renewable and Sustainable Energy Reviews, Volume 15, Issue 3, 2011, Pages 1513-1524, ISSN 1364-0321, https://doi.org/10.1016/j.rser.2010.11.037. (https://www.sciencedirect.com/science/article/pii/S1364032110004065)

Putri, A. H. M & Wulandari, C. 2015. Potensi Penyerapan Karbon Pada Tegakan Damar Mata Kucing (Shorea Javanica) Di Pekon Gunung Kemala Krui Lampung Barat. *Jurnal Sylva Lestari*. Vol. 3 : 13-20

Rusbiantoro, D. (2008). *Global Warming For Beginner.* Penerbit O_2 Panembahan Yogyakarta. Cetakan 1 (April). hal. 1-39. ISBN: 979-17343-0-1. e-mail: redaksiO_2@gmail.com

Setiawan, B. (2010). Kajian Awal Adaptasi dan Mitigasi Perubahan Iklim di Indonesia: Peluang dan Tantangan. *Teknik Sipil.* Universitas Sriwijaya. Palembang

Simpson, M.C. Gössling, S. Scott, D. Hall, C.M. and Gladin, E. 2008. *Climate Change Adaptation and Mitigation in the Tourism Sector: Frameworks, Tools and Practices*. UNEP, Oxford University

Slamet, B. (2015). Analisis Kebijakan Land Use Land Use Change Forestry (LULUCF) dan Skenario Mitigasi dan adaptasi Perubahan Iklim. Research Gate, Juli 2015

Smith, P., J.E. Olesen, (2010). Synergies between the mitigation of, and adaptation to, climate change in agriculture. *The Journal of Agricultural Science*, Volume 148 , Issue 5 , October 2010 , pp. 543 – 552. DOI: https://doi.org/10.1017/S002185961000034. Source: https://www.cambridge.org/core/journals/journal-of-agricultural-science/article/synergies-between-the-mitigation-of-and-adaptation-to-climate-change-in-agriculture/20FFDF69A92646BBE7390A2B54B10B58. Acces, Juni19, 2023

Suryaningsih, D.R., Mochamad Thohiron, Faez M. Hassan, Tatuk Tojibatus Sa'adah, Ken William Ang, dan Moch. Alifi Akbar. (2023). Potato (Solanum tuberosum L) Quality Evaluation in Different Growing Environments. *International Journal of Multidisciplinary Research and Literature (IJOMRAL)* Vol. 3 (3), March 2024, E-ISSN: 2827-8062, P-ISSN: 2827-8585 website: http://ijomral.esc-id.org DOI: https://doi.org/10.53067/ijomral.v3i3.230

Thohiron, M., Faez M. Hassan, Achmadi Susilo, Dwi Retno Suryaningsih, dan Achmad Wicaksono. (2023). Methane GHG Emission Analysis Supports Regional Action Plans For Mitigation and

Adaptation to the Impacts of Climate Change in Situbondo Regency. *International Journal of Multidisciplinary Research and Literature (Ijomral).* Vol. 3 (2), March 2024, E-ISSN: 2827-8062, P-ISSN: 2827-8585 website: http://ijomral.esc-id.org DOI: https://doi.org/10.53067/ijomral.v3i2

US-EPA. (2021). U.S. Environmental Protection Agency (EPA). Overview of Greenhouse Gases: Carbon Dioxide. Source: https://19january2021snapshot.epa.gov/ghgemissions/overview-greenhouse-gases_.html#CO2-references

Voogt, J.A., and T.R Oke. (2003). Thermal remote sensing of urban climates, Remote Sensing of Environment, Volume 86, Issue 3, 2003 Pages 370-384, ISSN 0034-4257, https://doi.org/10.1016/S0034-4257(03)00079-8. (https://www.sciencedirect.com/science/article/pii/S0034425703000798)

Wahyono, S. (2008). Dinamika Perubahan Temperatur dan Reduksi Volume Limbah Dalam Proses Pengomposan. *Jurnal Penelitian Badan Pengkajian dan Penerapan Teknologi Lingkungan* Vol. 9. http://ejurnal.bppt.go.id/index.php/JTL/article/view/559/361.