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Research Article

Impact of Land Use and Land Use Change on Greenhouse Gas Emissions in Palembang City

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Abstract

Climate change is mainly anthropogenic mostly caused by urbanization, human activities in economics, industry, and transportation. The expansion of built-up land, deforestation and the loss of farmland are closely linked to land use and land use change. Greenhouse gas emissions produced by the land use sector can significantly affect global carbon budgets by changing the carbon storage level in terrestrial ecosystem vegetation and soil. In 2005, Indonesia was responsible for approximately 85% of carbon emissions. The Indonesian government is combating environmental issues by mandating local governments, including Palembang City, to conduct greenhouse gas inventories. Changes in land use and the amount of carbon stock in Palembang City can be taken into consideration by the Palembang City Government in dealing with climate change. Data analysis was carried out by interpreting satellite imagery SPOT-7 and classification of land use data into six classes based on AFOLU guidelines. The area derived from land use transition matrix of the period 2012-2018 is used as a basis to calculate greenhouse gas emissions. The greenhouse gas emissions were then calculated using the Gain-Loss method based on the IPCC journal as a reference. Due to land use and land use change from 2012 to 2018, Palembang City emits greenhouse gas as much as -149098.5827 Tonnes C/Year in total. Forest Land Category -26557.22425 Tonnes C/Year, Crop Land Category -112739.8894 Tonnes C/Year, Grass Land Category -32257.56413 Tonnes C/Year, Wetland Category -20721.68315 Tonnes C/Year, Settlement Category 43273.249 Tonnes C/Year and Other Land Category -95.4708 Tonnes C/Year. Inventories on greenhouse gas (GHG) emissions and absorption trends are crucial for climate change mitigation strategies in Palembang. One important strategy towards achieving net zero emissions by 2060, as initiated by the Government of Indonesia, is to curb carbon release associated with land use changes.

Keywords: *carbon stock, greenhouse gas, land use change, spatial analysis*

1. INTRODUCTION

Climate change mitigation has become urgent due to increased global warming [1]. Climate change that occurs in Indonesia is a phenomenon caused by human activities in economics, industry, transportation, and several things that occur naturally [2]. These activities directly or indirectly have an impact on climate change. The Intergovernmental Panel on Climate Change (IPCC) says that warming caused by human activities will reach 1°c with a possible estimate of between 0.8 °C-1.2°c in 2017. This figure increases by 0.2°C every decade. This report is based on the average surface air and sea temperature increase over 30 years [3].

Urbanization directly impacts land use, and various types of land experience unique spatiotemporal changes to varying degrees and directions [4]. The expansion of built-up land, deforestation, and the loss of farmland are closely linked to land use and land cover change (LUCC) [5]. In the last 300 years, the impact of land use change has increasingly increased from significant to threatening proportions [6]. *Agriculture, Forestry, and Other Land Use* (AFOLU) is a new term used to replace *Land use, Land used change, and forestry* (LULUCF) and agriculture. The categories and types of greenhouse gas sources included in the AFOLU sector are livestock, agriculture, forestry, and other land uses that currently contribute 25% of the global anthropogenic carbon emissions [7]. Greenhouse gas emissions produced by the land use sector are calculated based on carbon dioxide (CO_2) resulting from changes in biomass or emission storage for land

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that remains in the same land use category or land that changes to another land use [8]. Land use changes can significantly affect global carbon budgets by changing the carbon storage level in terrestrial ecosystems' vegetation and soil [9].

The dynamics of land use changes in Indonesia have the potential to significantly increase carbon emissions [10]. In 2005, Indonesia was responsible for approximately 85% of carbon emissions. The forestry sector in Indramayu Regency emitted 72,034 tonnes of carbon, reducing carbon reserves [2]. According to the research, there was a 0.97% change in land use between 2000 and 2020 in Surabaya. Additionally, the carbon stock value increased by 4.35% during that period, which equals 283,433.5 tons. As of 2020, the carbon stock value was 296,323.5 tons [4]. The Indonesian government, through Presidential Regulation Number 71, 2011 concerning an Action Plan for Reducing Greenhouse Gas Emissions, instructs every regional government, including the Palembang City government, to be involved in conducting an inventory of greenhouse gas emissions [11].

This study uses remote sensing imagery and a land use map to monitor changes in greenhouse gas emissions from land use. Spatial analysis is conducted using satellite image analysis techniques [12]. All of the satellite image processing and analysis was conducted using ArcGIS. Land use data obtained from the satellite image classification process will be processed by referring to IPCC guidelines and classified according to 6 categories of AFOLU. Sub-districts in Palembang City were divided to simplify land use verification and ensure data accuracy. The calculation of greenhouse gas emissions is calculated using Gain-Loss Method refers to 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

The Indonesian government is taking action to combat environmental issues by mandating that local governments, including Palembang City, conduct greenhouse gas inventories. The transformation of green space into developed areas is a significant contributor to global environmental change, with the potential to release CO_2 gas and carbon stocks. It is essential to monitor these changes in Palembang City and evaluate the scale of CO_2 gas deposits and carbon stocks. With this information, Palembang City Government can create efficient mitigation and adaptation strategies to combat the effects of climate change.

2. METHOD

This research was carried out in all sub-districts in Palembang City, South Sumatra. Palembang City is the Provincial Capital of South Sumatra Province. The area of Palembang City is 400,61 km^2 with the largest sub-district area being Gandus which has an area of 68,78 km^2 and the smallest area is Ilir Barat II which has an area of 6,22 km^2. Palembang City has an area that stretches between 104°37' – 104°52' East Longitude and 2°52' – 3°5' South Latitude. The research location in shown in Figure 1 and the sub-district classification of Palembang City is detailed in Table 1.

Table 1. Name and area of sub-district in Palembang

No	Sub-district	Area (km^2)
1	Ilir Barat I	56.21
2	Ilir Barat II	2.95
3	Ilir Timur I	5.26
4	Ilir Timur II	11.85
5	Ilir Timur Tiga	7.49
6	Seberang Ulu I	3.93
7	Seberang Ulu II	9.58
8	Gandus	48.91
9	Kertapati	42.85
10	Jakabaring	12.86
11	Plaju	13.86
12	Bukit Kecil	2.36
13	Kemuning	6.88
14	Kalidoni	29.82
15	Sako	16.59
16	Sematang Borang	26.32
17	Sukarami	45.85
18	Alang-Alang Lebar	22.97

Source: Palembang Statistics Agency (2022)

The data collected for this research was obtained from multiple sources, including:

1) Palembang Land use data for year 2012 from the Regional Development Planning, Research, and Development Agency of Palembang City.
2) Palembang forest distribution data, from the South Sumatra Province Environmental Agency and Forestry Service.
3) Palembang administrative boundaries and Sub-District, from Public Works and Spatial Planning Department of Palembang City.
4) SPOT-7 Satellite Image Data for Palembang City year 2012 and 2018, from LAPAN (National Institute of Aeronautics and Space) Remote Sensing Technology and Data Center

The research methods are descriptive methods using satellite image analysis techniques. All of the satellite image processing and analysis was conducted using ArcGIS. For the land use classification process in Palembang City, sub-districts were divided to make the verification of land use data easier. This verification process was implemented to ensure that the data collected matches the actual field data.

Remotely sensed imagery and remote sensing-based land use and land use change maps have emerged as crucial information sources for

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facilitating the statistically rigorous estimation of activity data [13]. Updating a map is an essential process for a country to monitor the social, environmental, and economic aspects of a region [14].

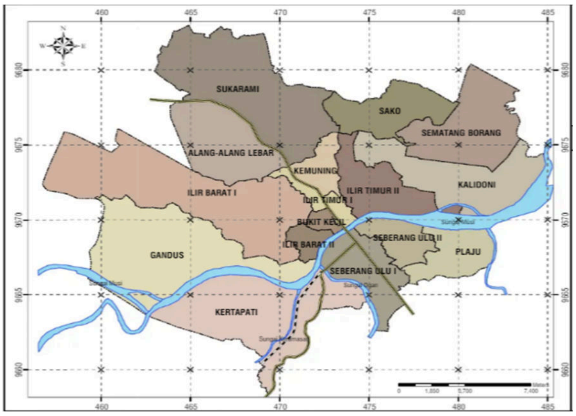

Figure 1. Palembang city map (Palembang Statistics Agency, 2022)

The goal of this process is to keep the objects on the map up-to-date for a specific period within an internal region. Manual image interpretation is the interpretation of remote sensing data that is based on recognizing the spatial characteristics of objects. The characteristics of objects depicted in images can be recognized based on interpretive elements such as hue or color, shape, size pattern, location and association of the object's appearance. The manual interpretation was chosen due to the difficulty of obtaining land cover data from local institution within a certain time period. Then, based on research conducted by Noraini and Handayani [15], it was stated that the accuracy of manual interpretation reached 97.73%, while digital interpretation has an accuracy of 85.58% [15].

The stages of this research were carried out in several stages:

1) Overlaying land use of Palembang City of year 2012 with administrative boundaries of Palembang City.
2) Land use classification into six classes based on AFOLU guidelines.
3) Satellite image SPOT-7 from year 2018 was used as a base map and analyzed through manual interpretation.
4) Data verification to ensure that the data from satellite image interpretation matches the actual field data.
5) Construct the land use transition matrix of period 2012-2018 from satellite imagery interpretation.
6) Calculate the greenhouse gas emissions produced using the 2008 IPCC journal as a reference.

Based on the National Greenhouse Gas Inventory Guidelines (Book III) and following IPCC directions, land use classification will be implemented into 6 categories:

1) Forest Land

This category encompasses all land that has woody vegetation, as defined by the threshold used for the National Greenhouse Gas Inventory's Forest Land category. It also includes systems with external vegetation structures that meet a country's definition of forest or have the potential to reach threshold values for forest classification.

2) Grassland

This category includes fields and pastures that are not used for agriculture, as well as systems of woody vegetation and non-grass vegetation like herbs and shrubs. It also covers all types of grassy areas, from unmanaged land to recreational and agricultural systems that combine both livestock and forestry.

3) Cropland

This category encompasses food crops such as rice fields and agroforestry systems, which have vegetation below the threshold for it to be classified as forest land.

4) Wetland

This category includes land that is either developed for peat or covered or saturated by water for all or part of the year, such as peatlands. It also includes natural rivers, lakes, and reservoirs.

5) Settlement

This category includes developed land, transportation, and residential infrastructure of various sizes, except those covered by other categories.

6) Other Land

This category includes open land, fields, rocky lands, snowy lands, and all other lands not covered by the five other categories.

The Greenhouse Gas Emissions Inventory was conducted by referencing the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. This publication outlines the steps for calculating greenhouse gas emissions in accordance with established guidelines, and includes worksheets to aid in the process. The inventory will categorize land use data into two distinct types, namely Converted Land and Remaining Land.

Gain-Loss Method

The Gain-Loss Method is a calculation using a process-based approach. Gain will be described with positive (+) signs, while losses will be described with negative (-) signs.

$$\Delta CB = \Delta CG - \Delta CL \quad (1)$$

where:

ΔCB = Annual carbon stock change

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ΔCG = Gain of carbon
ΔCL = Loss of carbon

Greenhouse Gas Emissions Calculations

Based on the directions published by the IPCC in a journal published in 2006, the calculation of greenhouse gas emissions is calculated using the following equation:

$$\Delta CAFOLU = \Delta CFL + \Delta CCL + \Delta CGL + \Delta CWL + \Delta CSL + \Delta COL \quad (2)$$

where:
$\Delta CAFOLU$ = Carbon stock change
ΔCFL = Forest Land
ΔCCL = Crop Land
ΔCGL = Grass Land
ΔCWL = Wetland
ΔCSL = Settlement
ΔCOL = Other Land

Remaining Land

This calculation can be done with the Gain-Loss Method. This method is a method that calculates the difference between carbon gain and carbon loss using the equation:

$$\Delta CB = \Delta CG - \Delta CL \quad (3)$$

where:
ΔCB = Annual carbon stock change
ΔCG = Gain of carbon
ΔCL = Loss of carbon

Annual gain of carbon stocks (ΔCG) can be calculated by multiplying the remaining land area with annual average biomass growth for each land use category, as in the equation:

$$\Delta CG = A \, x \, GTOTAL \, x \, CF \quad (4)$$

where:
ΔCG = Gain of carbon
A = Area
$GTOTAL$ = Average annual biomass growth
CF = Carbon fraction of dry matter

The amount of $GTOTAL$ is obtained from the total growth of biomass above the surface (GW), growth of biomass below the surface, and biomass above the surface (R) so that $GTOTAL$ can be calculated using the following equation:

$$GTOTAL = GW \, x \, (1 + R) \quad (5)$$

where:
$GTOTAL$ = Average annual biomass growth
GW = Average annual above-ground biomass for a specific woody vegetation type
R = Ratio of below-ground biomass to above-ground biomass for specific vegetation type

Meanwhile, for calculating the decrease in annual carbon stocks in ΔCL biomass, it is estimated that biomass loss is due to wood harvesting, firewood collection, and disturbances such as pests/diseases, fires, and storms. This calculation can be expressed with the equation:

$$\Delta CL = L \, wood-removal + L \, fuelwood + L \, disturbances \quad (6)$$

where:
ΔCL = Annual decrease in carbon stocks due to biomass loss
L wood-removal = Annual carbon loss due to wood removals
L fuelwood = Annual biomass carbon loss due to fuelwood removals
Ldisturbances = Annual biomass carbon losses due to disturbances

L wood-removal is the carbon loss caused by wood harvesting. This value is obtained from the following equation:

$$L \, wood-removal = \{H \, X \, BCEFR \, (1 + R) \, X \, CF\} \quad (7)$$

where:
H = Annual wood removals
$BCEFR$ = Biomass conversion and expansion factor for conversion of removals in merchantable volume to total biomass removals (including bark)
R = Ratio of below-ground biomass to above-ground biomass for specific vegetation type
CF = Carbon fraction of dry matter

Then, for L Fuelwood, it is the carbon loss caused by taking firewood from trees. This value is obtained from the equation:

$$L \, fuelwood = [\{FGtreesx \, BCEFR \, (1 + R)\} + FGpartx \, D] x \, CF \quad (8)$$

Where:
Lfuelwood = Annual carbon loss due to fuelwood removals
FGtrees = Annual volume of fuelwood removal of whole trees
FGpart = Annual volume of fuelwood removal as tree parts
R = Ratio of below-ground biomass to above-ground biomass

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D = Basic wood density
$BCEFR$ = Biomass conversion and expansion factor for conversion of removals in merchantable volume to biomass removals (including bark)
CF = Carbon fraction of dry matter

Next for L Disturbances is carbon loss caused by pests/diseases, fires, and storms. This value is obtained from Equation:

$$L\ disturbances = \{A\ disturbances\ x\ BW\ (1 + R)\ x\ \ CF\ x\ fd\} \quad (9)$$

Where:
Ldisturbances = Annual other losses of carbon
Adisturbances = Area affected by disturbances
BW = Average above-ground biomass of land areas affected by disturbances
R = Ratio of below-ground biomass to above-ground biomass
fd = Fraction of biomass lost in disturbances
CF = Carbon fraction of dry matter

Converted Land

The methods for estimation of emissions and removals of carbon resulting from land-use conversion from one land-use category to another are presented in this section. Possible conversions include conversion from non-forest to Forest Land, Cropland and Forest Land to Grassland, and Grassland and Forest Land to Cropland.

The CO_2 emissions and removals on land converted to a new land-use category include annual changes in carbon stocks in above-ground and below-ground biomass. Annual carbon stock changes for each of these pools can be estimated by using the Equation:

$$\Delta CB = \Delta CG - \Delta CL \quad (10)$$

Where:
ΔCB = Annual change in carbon stocks
ΔCG = Annual increase in carbon stocks
ΔCL = Annual decrease in carbon stocks

ΔCB was estimated separately for each land use category (e.g., Forest Land, Agricultural Land, Grassland). Estimating changes in carbon stocks (ΔCB) on land converted to forest land *(L-FL)* can use the calculation method as described previously, while on land converted to agricultural land (*L-CL*), to grassland (*L-GL*), to settlements (*L-SL*), and to other land uses (*LOL*) are calculated as the sum of the addition of carbon stocks due to biomass growth (ΔCG), changes in carbon stocks due to conversion (the difference between biomass stocks before and after conversion), and decreases in carbon stocks due to loss of biomass ΔCL. This relationship can be expressed with the equation below:

$$\Delta CB = (\Delta CG + \Delta CCONVERSION - \Delta CL) \quad (11)$$

Where:
ΔCB = Annual change in carbon stocks
ΔCG = Annual increase in carbon stocks
$\Delta CCONVERSION$ = Initial change in carbon stocks in biomass on land converted to other land-use category
ΔCL = Annual decrease in carbon stocks

Changes in carbon stocks on land conversion ($\Delta CCONVERSION$) can be calculated using the following equation:

$$\Delta\ CCONVERSION = \{(BAFTER - BBEFORE) x \Delta ATO\_OTHER\} x\ CF \quad (12)$$

Where:
$\Delta CCONVERSION$ = Initial change in carbon stocks in biomass on land converted to other land-use category
$BAFTER$ = Biomass stocks on land type i immediately after the conversion
$BBEFORE$ = Biomass stocks on land type i before conversion
ΔATO_OTHER = Area of land use i converted to another land-use category in certain year
CF = Carbon fraction of dry matter

3. RESULTS AND DISCUSSION

Once the areas have been divided into sub-districts, the next step is to classify the land use categories in each one of Palembang City's sub-districts into the six IPCC categories. These include Forest Land, Crop Land, Grass Land, Settlement, Wetland, and Other Land. Figure 2 displays the land use classification of Alang-Alang Lebar Sub-District in 2012.

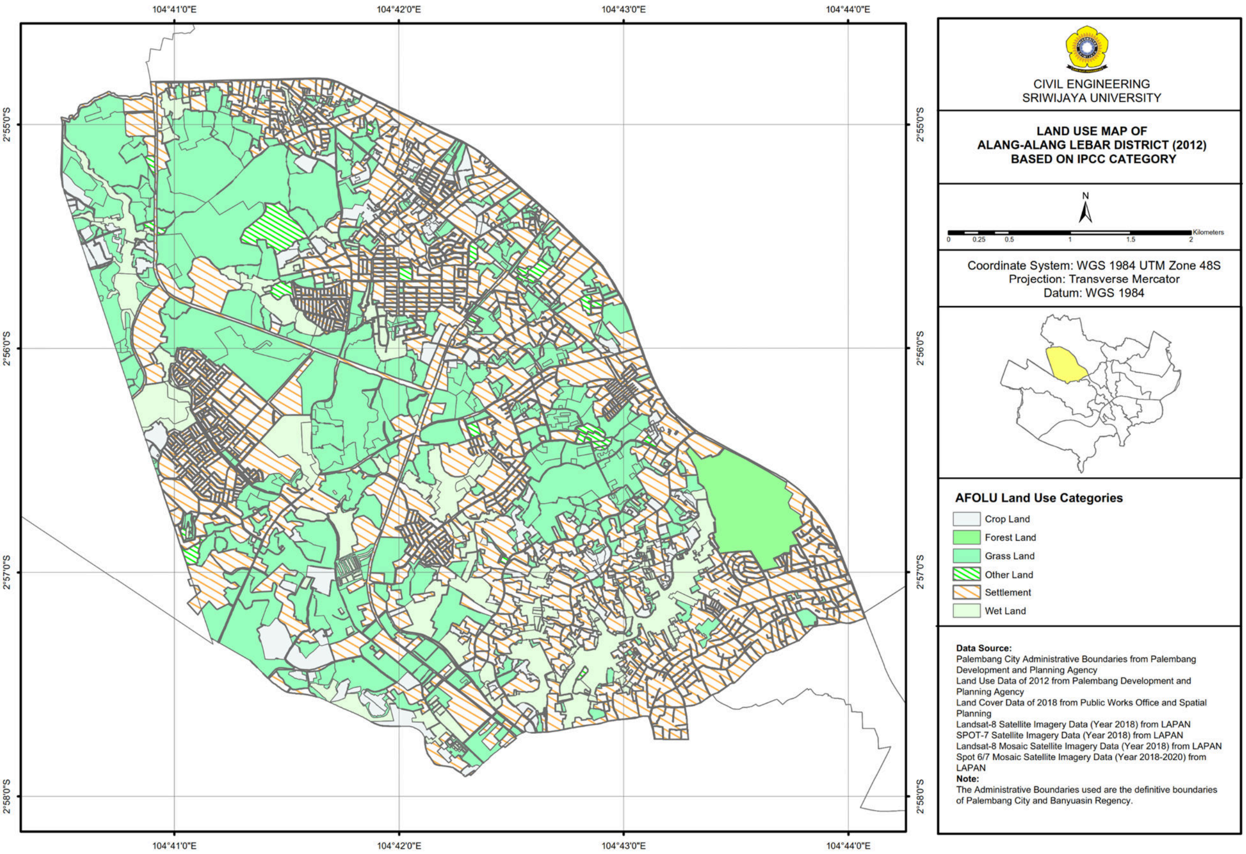

Figure 2. 2012 Land use classification based on IPCC

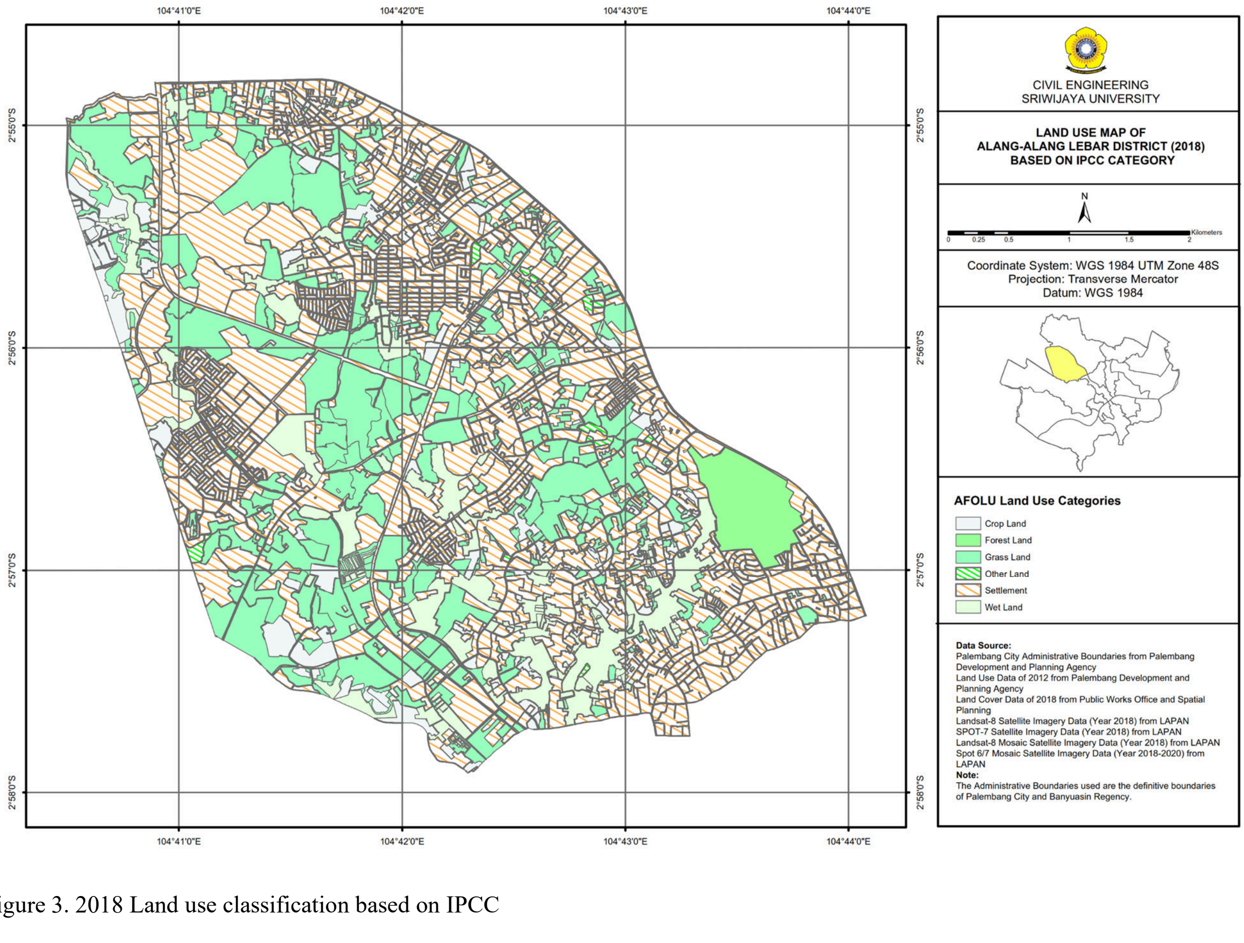

Figure 3. 2018 Land use classification based on IPCC

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Following the 2012 land use classification, the next step involved the manual interpretation of the High-Resolution Satellite Imagery of Palembang City in 2018. This was aimed at identifying any changes that occurred in the city's land use within the time period. The interpretation process relied on various elements such as color, shape, pattern, size, location, and the object's association to recognize the characteristics of objects depicted in the images. Figure 3 Displays the outcomes of this process.

The land use mapping results for Alang-Alang Lebar District in 2012 and 2018 are available in Table 2.

Table 1. Alang-Alang Lebar Land Use Changes (Ha)

Categories	2012	2018
Forest Land	382.8642688	226.6121
Crop Land	113.2306786	362.8646557
Grass Land	482.2875127	318.2572699
Settlement	259.8995103	215.3054102
Wetland	1062.453466	1177.696
Other Land	0	0
Total	2300.735436	2300.735436

Once the land use classification process in the Alang-Alang Lebar District is complete, the next step involves verifying the accuracy of the data. This is achieved by comparing the results of interpreting satellite images with data gathered during field surveys. The survey is conducted manually by cross-referencing the data obtained from the field with that obtained from satellite image interpretation. In order to verify the data, one regional sample is selected from each category and matched with the field data.

City Forest Data Verification

The area derived from image interpretation results is also verified with city forest area from Forestry Service, South Sumatera Province Environmental Agency. From the data comparison, area derived from image interpretation complied with the tabular data and the difference shown because the area from the agency is mostly rounding off while from analysis the area was calculated spatially. Verification of City Forest Area from the South Sumatra Province Environmental Agency and Image Interpretation Results can be seen in Table 3.

Table 3. Verification of city forest area from the South Sumatra Province Environmental Agency and image interpretation results

No	Area	District	Forest area based on the Forestry Service, South Sumatra Province Environmental Agency (Ha)	The area from image interpretation results (Ha)
1	Punti Kayu City Forest	Alang-Alang Lebar	60	54.5
2	Sultan Mahmud Badaruddin II City Forest	Sukarami	30	37
3	Bumi Perkemahan Pramuka Gandus City Forest	Gandus	20	20
4	Recreation area around OPI retention basin.	Jakabaring	8	8
5	Jakabaring Sport Centre	Jakabaring	110	110
6	Bukit Siguntang City Forest	Ilir Barat I	10	13
7	Archaeological Park	Ilir Barat I	14	10
8	Tombs of the Kings	Sporadic	10	10
9	Pulau Kemaro	Ilir Timur II	30	45
10	Community Forest	Sporadic	1000	881.692
11	Abandoned Land owned by local government	Sporadic	1000	881
	Total		2292	2070.192

Table 4. Palembang city land use changes 2012 and 2018 (Ha)

2018 \ 2012	Forest Land	Crop Land	Grass Land	Wetland	Settlement	Other Land	Final Sum
Forest Land	1994.662	5.483	35.418	7.536	25.676	1.417	2070.192
Crop Land	463.058	5931.837	701.680	223.819	132.426	1.159	7453.979
Grass Land	291.259	256.394	6319.595	199.208	176.801	3.619	7246.877
Wetland	40.438	36.134	106.654	4438.392	36.925	0.025	4658.568
Settlement	201.716	731.509	621.224	214.654	13128.911	23.796	14921.811
Other Land	1.056	3.429	1.105	0.476	3.068	111.269	120.402
Initial Sum	2992.190	6964.786	7785.676	5084.086	13503.807	141.285	36471.829

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Land Use Transition Matrix year 2012 and 2018

This calculation compared land use classification data per sub-district in 2012 with land use classification data in 2018. The following is a land use transition matrix resulting from satellite imagery interpretation for the entire city of Palembang in 2012 and 2018 shown in Table 4. Based on the information in Table 4, it can be inferred that Palembang City underwent changes in each land use category between 2012 and 2018. Forest Land experienced a significant decrease of 30.81% in area, from 2992.190 Ha to 2070.192 Ha in 2018. On the other hand, Grass Land saw an increase of 7.02% in area, from 6964.786 Ha to 7453.979 Ha in 2018. Wetland Category and Other Land both declined in area, with Wetlands decreasing from 5084.086 Ha in 2012 to 4668.568 Ha in 2018, a decrease of 8.36%, while Other Land decreased from 141.285 Ha in 2012 to 120.402 Ha in 2018, a decrease of 14.78%. The Cropland and Settlement categories saw an increase in area, with Cropland increasing by 7.02%, from 6964.786 Ha in 2012 to 7453.979 Ha in 2018, and Settlement increasing by 10.5%, from 13.503.81 Ha in 2012 to 14.921.81 Ha in 2018.

Calculation of Greenhouse Gas Emissions for Palembang City

According to the journal published by the IPCC in 2006, greenhouse gas emissions can be calculated using land use changes through the absorption and loss method (Gain and Loss) of carbon in each land cover. Therefore area that has not undergone changes (remaining land) and area that changes (converted land) between the given time frame (Intergovernmental Panel on Climate Change, 2008). The results of calculating greenhouse gas emissions in land use that have not undergone changes (Remaining Land) in Palembang City between 2012 and 2018 can be seen in Table 5 below.

Table 5. Greenhouse gas emissions from remaining land

No	Remaining Land	Area (Ha)	GHG Emission (Tonnes C/Year)
1	Forest Land	1994.662	-22403.90425
2	Crop Land	5391.837	-107959.4334
3	Grass Land	6319.595	-28110.06413
4	Wetland	4438.392	-19742.32269
5	Settlement	13128.911	38073.8419
6	Other Land	111.269	0
	Total	31411.627	-140141.8826

Meanwhile, the results of calculating greenhouse gas emissions in land use changes (Converted Land) in Palembang City which occurred between 2012 and 2018 can be seen in Table 6 below.

Tabel 6. Greenhouse gas emissions from converted land

No	Converted Land	Area (Ha)	GHG Emission (Tonnes C/Year)
1	Land Converted to Forest Land	75.53	-4153.32
2	Land Converted to Crop Land	1552.152	-4780.456
3	Land Converted to Grass Land	927.281	-4147.5
4	Land Converted to Wetland	220.176	-979.36046
5	Land Converted to Settlement	1792.898	5199.4071
6	Land Converted to Other Land	9.13	-95.4708
	Total	4577.167	-8956.7

From these two tables, the greenhouse gas emission values will be combined according to each category. This value can be seen in Table 7.

Table 7. Palembang city greenhouse gas emissions in 2018

No	Categories	Area (Ha)	GHG Emission (Tonnes C/Year)
1	Forest Land	2070.192	-26557.22425
2	Crop Land	7453.979	-112739.8894
3	Grass Land	7246.876	-32257.56413
4	Wetland	4658.568	-20721.68315
5	Settlement	14921.809	43273.249
6	Other Land	120.399	-95.4708
	Total	36471.823	-149098.5827

From table 7, the value of greenhouse gas emissions that occurred in Palembang City varies between converted land and remaining land from 2012 to 2018. The Forest Land category has an area of 2070,192 Ha with a greenhouse gas emission value of -26,557.22,425 Tonnes C/Year. Then the Crop Land Category has an area of 7453,979 Ha with a greenhouse gas emission value of -112739.8894 Tons C/Year. Then, the Grass Land Category has an area of 7246,876 Ha with a greenhouse gas emission value of -32257.56413 Tons C/Year. The Wetland category has an area of 4658,568 Ha with a greenhouse gas emission value of -20721.68315 Tonnes C/Year. Then, the Settlement Category has an area of 14921,809 Ha with a greenhouse gas emission value of 43273,249 Tonnes C/Year. Lastly is the Other Land Category which has an area of 120,399 Ha with a greenhouse gas emission value of -95,4708 Tonnes C/Year.

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For calculations of annual increases and decreases in biomass carbon stocks, the IPCC guidelines are referred to as an example for calculating increases in carbon stocks for forest land using the formula $\Delta CG : A \times GTotal \times CF$ and for carbon stock reduction uses the formula $\Delta CL : LDistrub + Lwr + Lwf$. Then the results of the calculations are accumulated with other categories and calculated annually, while the absorption is calculated based on converted land, for example, forest land remains forest land then the category experiences absorption with the assumption that the trees experience growth. Losses or emissions can occur from forest land undergoing disturbances such as being deforested or experiencing fires. A category will experience absorption if one category is converted from a category with a higher carbon stock such as grassland converted to forest land, while emissions occur if forest land is converted to settlements. The results can be emissions or absorption depending on what categories changed. Annual GHG emissions and removals can be generated based on forest type, forest function, soil type, subsequent land use and carbon sources.

4. CONCLUSION

Inventories on carbon emissions and absorption trends are crucial for developing mitigation measures to control the increase in greenhouse gas (GHG) emissions in Palembang. One important strategy towards achieving net zero emissions by 2060, as initiated by the Government of Indonesia, is to curb carbon release associated with land use changes. Greenhouse gas emissions produced by Palembang City between 2012 and 2018 were -149098.5827 Tonnes C/Year with the following details; the Forest Land category has a greenhouse gas emission value of -26557.22425 Tonnes C/Year. Then the Crop Land Category has a greenhouse gas emission value of -112739.8894 Tonnes C/Year. Then, the Grass Land Category has a greenhouse gas emission value of -32257.56413 Tonnes C/Year. The Wetland category has a greenhouse gas emission value of -20721.68315 Tonnes C/Year. Then, the Settlement Category has a greenhouse gas emissions value of 43273,249 Tonnes C/Year. Lastly is the Other Land Category which has a greenhouse gas emission value of -95.4708 Tonnes C/Year.

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