This is a PDF file of a fully citable but unedited manuscript that has been accepted for publication.

The manuscript is undergoing copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content.
Mitigation Strategy on Reduction Greenhouse Gas (GHG) Emission of Landuse Sector for the Province of Papua

Elvis Franklin Suebu*, Joni Hermana, Rachmat Boedisantoso
Department of Environmental Engineering, Faculty of Civil Engineering and Planning, Institut Teknologi Sepuluh Nopember (ITS) Surabaya, Indonesia

Abstract. Studying the right strategy in the implementation of the mitigation of GHG emission reduction in an effort to control climate change caused by deforestation and forest degradation (REDD +) in Papua Province is an important step that must be done. Emission levels in Papua Province in 2010 was dominated by forestry sub-sector and other land use in the amount of 639,818,463 Ton CO\textsubscript{2}eq or approximately 99.8% of total GHG emissions of 640,737,952.64 Ton CO\textsubscript{2}eq. To analyze the implementation strategy of mitigation (REDD +) then the calculation of the level of carbon emission must be done first. The calculation of carbon emissions for this sub-sector is done with reference to the method that has been developed by the IPCC GL-2006. Meanwhile, to sub-sectors of forestry and other land use the calculation use the historical and forward-looking approach. The level of carbon emissions from forestry sub-sector accounted for 921,779,031.23 Ton CO\textsubscript{2}eq (historical method) and 1,052,683,205.46 Ton CO\textsubscript{2}eq (forward looking method) mitigation program at the end of 2020. Strategy of mitigation action program is for carbon uptake and carbon storage stabilization. The mitigation scenario for forestry sub-sector capable of reducing emissions by 552,303,873 Ton CO\textsubscript{2}eq or by 52.47% of the total cumulative emissions at the end of 2020 (forward-looking method).

Keywords: strategy, mitigation, carbon emission, landuse.

1. Introduction

Papua Province with a forest area of 31,687,680 Ha (RTRW Papua, 2012), has a very high level of genetic diversity, species or forest ecosystem. Papua Province Forestry and Conservation Service Statistics Data of 2012 shows that during the period 2006-2009 there was degradation of forest area of 645,684 Ha (161,421 Ha / year). The extent of forest degradation for the 2006-2011 period is 908,854.60 Ha (181,770.92 Ha / year), indirectly contributing to the increase in greenhouse gas emissions that have a wide impact on global climate change. Forest Areas based on their functions consist of Conservation Forest (KSA-KPA), Protect Forest (HL), Limited Production Forest (HPT), Production Forest (HP), and Conversion Production Forest (HPK), and Other Use Areas (APL).

The province of Papua as part of Indonesia's tropical forest province has a forest area of 98.94% of its territory, which has been firmly incorporated into national plans to address the...
issue of GHG emissions reductions over the past few years through a low-carbon economic
development task force. The idea of forming this future low-carbon economic development is
expected to provide smart and wise consideration for policy makers in Papua in guarding and
running the wheel of low-carbon economic development.

2. Research method

calculation of the level and projection of forest carbon emissions is done until 2020 which
refers to the method developed by IPCC GL-2006 with historical-based and forward looking
approach. The basic equations of carbon emissions or sequestration are:

\[ \text{Carbon emissions or sequestration} = \text{Activity Data} \times \text{Emission Factor} \]  \hspace{1cm} (1)

Historical Approach = Regression Equation/Trend Base Year Y (current year)

\[ = A \text{ (initial year emission)} \times \text{projection year} + B \text{ (coefficient)} \] \hspace{1cm} (2)

Forward Looking Approach = Equation Average land cover change (period) to plan overlay
pattern

(3)

The carbon emission and sequestration method uses the basic equation of the default
emission factor of the National Development Planning Agency 2010 and data Activities used are
sourced from digital data (spatial analysis of changes in land cover) or based on data of research
conducted in Indonesia, especially Papua Province.

3. Result and discussion

3.1. Emission level/status

The Papua Provincial Government should immediately make an effort to change the
paradigm that the rate of forest degradation will cause environmental degradation is not a mere
crisis, but it can be an opportunity to recover and improve the environment while overcoming
the economic crisis. The analysis of forest area based on its function is Conservation Forest
(KSA) with an area of 6,662,766.50 Ha, Protect Forest (HL) of 7,847,798.20 Ha, Limited
Production Forest (HPT) of 5,958,883.50 Ha, Production Forest (HP) of 4,726,330.40 Ha,
Conversion Production Forest (HPK) of 4,044,554.10 Ha and Other Use Areas (APL) covering an
area of 1,693,260.20, as shown in the figure below:

![Figure 1. Area Based on the function of forest area in Papua Province.](image)
The calculation of forest carbon emission and uptake is activity data (DA), while emission factor (FE) is obtained with average approach of carbon stock for each class of land cover presented in Table 1 below:

| NO | Land Cover                  | Land Cover Code | Carbon Stock (Ton/Ha) |
|----|----------------------------|-----------------|----------------------|
| 1. | Primary Dryland Forest     | 2001            | 195.40               |
| 2. | Secondary Dryland Forests  | 2002            | 169.70               |
| 3. | Primary Mangrove Forest    | 2004            | 170.00               |
| 4. | Primary Swamp Forest       | 2005            | 196.00               |
| 5. | Planted Forest             | 2006            | 140.00               |
| 6. | Shrubs                     | 2007            | 15.00                |
| 7. | Plantation                 | 2010            | 63.00                |
| 8. | Settlement                 | 2012            | 1.00                 |
| 9. | Open Land                  | 2014            | 0.00                 |
| 10.| Grass Land                 | 3000            | 4.50                 |
| 11.| Water                      | 5001            | 0.00                 |
| 12.| Secondary Mangrove Forest | 20041           | 120.00               |
| 13.| Secondary Swamp Forest    | 20051           | 155.00               |
| 14.| Swamp                      | 20071           | 15.00                |
| 15.| Dryland Farming            | 20091           | 8.00                 |
| 16.| Dryland Farming Mix        | 20092           | 10.00                |
| 17.| Rice                       | 20093           | 5.00                 |
| 18.| Tambak                     | 20094           | 0.00                 |
| 19.| Airport / Port             | 20121           | 5.00                 |
| 20.| Transmigration             | 20122           | 10.00                |
| 21.| Mining                     | 20141           | 0.00                 |
| 22.| Swamp                      | 50011           | 0.00                 |
| 23.| Cloud                      | 2500            | 0.00                 |

Source: Bappenas, 2010.

The condition of land cover change is activity data (DA), while the emission factor (FE) is obtained by the average approach of carbon stock for each class of land cover presented in Table 1. In calculating emissions, Formula (1) is modified as follows:

\[
\text{GHG Emissions} = \text{Land Cover Changes} \times (\text{Previous Carbon Cover Backgrounds} - \text{Current Carbon Reserve Coverage})
\]

The result of base year emission calculation is shown in the Table 2.

**Emission calculation based on Historical approach**

The projection of emissions with the Historical approach is linear projection by looking at the trend based on the base year period by analyzing the gradual changes of land cover based on the period of 2000-2003, 2003-2006, 2006-2009 and 2009-2011 so as to obtain a linear regression equation Approaching the existing condition, as shown in Figure 2.
y = 5E+07x - 5E+07
R² = 0.976

Table 2. Carbon Emissions level base year from 2000 to 2011

| Year | Carbon Emission (Ton CO₂eq) |
|------|-----------------------------|
| 2000 | 26.452.224,33               |
| 2001 | 52.904.448,67               |
| 2002 | 79.356.673,00               |
| 2003 | 105.808.897,33              |
| 2004 | 176.005.845,89              |
| 2005 | 246.202.794,40              |
| 2006 | 316.399.743,00              |
| 2007 | 367.016.095,11              |
| 2008 | 417.632.447,22              |
| 2009 | 468.248.799,33              |
| 2010 | 478.426.712,50              |
| 2011 | 488.604.625,67              |

Figure 2. Trend of base year emissions of land cover sector

From the picture above, we can see the regression equation and R² value of the base year emission. The emission value of 2012 - 2021 is obtained by substituting the value of x in the regression equation y = 48,384,500.42 × -45,910,977.17 so that the emission figures for 2012 - 2021 are as presented in the Table 3.

In the table above we can see the results of carbon emissions projection based on historical approach at the end of the year 2021 of 970.163.531,65 Ton CO₂eq. This indicates that the increase in carbon emissions from the year 2012 - 2021 following base year trend or linear projection. GHG emissions growth figures from 2012 to 2021 based on the historical approach can be seen in the following emission projection chart in Figure 3.
Table 3. Carbon Emission Sector Comparison of Land Cover Change (Historical Approach)

| Year | Carbon Emission (Ton CO2eq) |
|------|-----------------------------|
| 2012 | 534,703,027.87              |
| 2013 | 583,087,528.29              |
| 2014 | 631,472,028.71              |
| 2015 | 679,856,529.13              |
| 2016 | 728,241,029.55              |
| 2017 | 776,625,529.97              |
| 2018 | 825,010,030.39              |
| 2019 | 873,394,530.81              |
| 2020 | 921,779,031.23              |
| 2021 | 970,163,531.65              |

Emission calculation based on Forward Looking approach

The projection of emission levels in this approach is calculated based on land cover in 2011 which is overlaid with the spatial plan of Papua Province RTRW 2011-2021. The emission calculation based on this approach is the same as in the base year emissions calculation, i.e. the area of land cover change multiplied by the carbon stock of each type of land cover that changes.

From the calculation based on the two approaches we can see that the value of emissions with forward looking approach in 2021 is 1,104,747,151.77 Ton CO2eq higher than the historical approach of 970,163,531.65 Ton CO2eq. In the picture below, presented the results of emission projection with forward looking approach.
Table 4. Carbon Emission Sector Comparison of Land Cover Change (Forward Looking Approach)

| Tahun | Total Emisi (Ton CO2eq) |
|-------|-------------------------|
| 2012  | 559,769,184.58          |
| 2013  | 630,933,743.49          |
| 2014  | 702,098,302.40          |
| 2015  | 773,262,861.31          |
| 2016  | 844,427,420.22          |
| 2017  | 896,491,366.53          |
| 2018  | 948,555,312.84          |
| 2019  | 1,000,619,259.15        |
| 2020  | 1,052,683,205.46        |
| 2021  | 1,104,747,151.77        |

Ton CO2-Eq

\[ y = 5E+07x - 7E+07 \]
\[ R^2 = 0.993 \]

Figure 4. Land use sector emissions with the Forward Looking (FL) approach
Figure 5. Comparison of Emission Base Year, Historical and Forward Looking (Reference Emission Level / REL Province of Papua)

Figure 5 is a comparison graph of the base-year carbon emission values and emissions based on historical and forward looking approaches. Carbon emission rates calculated through historical and forward looking approach are referred to as BaU (Business as Usual) emissions or estimates of GHG emission and projection rates with scenarios without local government policy interventions and mitigation efforts.

3.2. Emission reduction scenario

Efforts to be taken in reducing carbon emissions from deforestation and forest degradation are through several mitigation action mitigation scenarios for greenhouse gas emissions such as the Table 5 below:

| Scenario | Description                        |
|----------|------------------------------------|
| Scenario 1 | Increase forest carbon uptake.    |
| Scenario 2 | Stabilization of forest carbon stocks |

Based on the mitigation action group described above, the calculation of cumulative emissions up to 2020 can be known that in Papua Province can implement mitigation actions of forest carbon storage stability and increased forest carbon uptake was able to contribute to the reduction of emissions as shown in the following figure:

The contribution of all mitigation actions in Papua Province as a whole will reduce the cumulative emissions by 552,303,873 tons CO2-eq or 52.47% at the end of the 2020 mitigation period. Papua Province through mitigation action planning period assumes that the implementation of all mitigation actions goes according to optimistic scenario, meaning that all planned mitigation actions can be implemented with maximum results during the mitigation period.
4. Conclusion

The level of carbon emissions in Papua Province by 2020 is 1,052,683,205.46 Ton CO2eq (forward looking method) and 921,779,031.23 Ton CO2eq (historical method). Mitigation action of GHG emission reduction is as follows: Emission reduction activities for this sector are: Increase forest carbon uptake through activities and Stabilization of forest carbon stocks. If these two scenarios can be implemented, the GHG emissions that can be derived from this sector are 52.47% or 552,303,873 Ton CO2eq at the end of the 2020 mitigation period.

Acknowledgement

Thanks to all those who have helped to collect research data both primary and secondary data, can be a scientific article that can be useful for further research.

Reference

FWI, GFW (Fores Watch Indonesia / Global Forest Watch). 2001. Portrait of Forest Condition Indonesia.FWI and GFW Bogor;

Inter-governmental Panel On Climate Change (IPCC), 2006. IPCC Guidelines for National Greenhouse Gas Inventories. Prepared by The National Greenhouse Gas Inventories Programme, Eggleton HS, Buendia L, Miwa K, Ngara T, and Tanabe K. (eds.). IGES Japan.

Director General of Forestry Planning. Jakarta 2012 Policy on Accelerating Forest Area Conservation. Semiloka "Toward a Legally and Equitable Forest Area"

Law of the Republic of Indonesia, No. 41 of 1999 on Forestry;

National Development Planning Agency. 2014. Technical Guidelines for the Calculation of Greenhouse-Based Sector and Land-Based Greenhouse Gas Absorption.

Regional Development Planning Agency (BAPPEDA) of Papua Province 2012, 'RTRW Province of Papua 2011-2031';

Papua Provincial Forestry and Conservation Office 2013, "Papua Province Forestry Statistics 2012".

Environmental Management Agency of Papua Province, Strategy and Action Plan of Papua Province in Implementation of REDD + 2015;

Hariyadi. August 2015, 'Climate Change Mitigation Policy of the Forestry Sector Ahead of the 2015-2019 RPJMN in Papua Province and Aceh Province'.

112