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RESEARCH PAPER

Mitigation strategy on reducing greenhouse gas emission of land use sector for the Papua Province

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Abstract. Studying the right strategy in the implementation of the mitigation of reducing GHG emission 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_2 eq or approximately 99.8% from the total of GHG emissions of 640,737,952.64 ton CO_2 eq. To analyze the implementation strategy of mitigation (REDD +), the calculation of the level of carbon emission must be done first. The calculation of carbon emissions for this sub-sector is done by referring to the method that has been developed by the IPCC GL-2006. Meanwhile, to sub-sectors of forestry and other land use, the calculation used the historical and forward-looking approach. The level of carbon emissions from forestry sub-sector accounted for 921,779,031.23 ton CO_2 eq (historical method) and 1,052,683,205.46 ton CO_2 eq (forward-looking method) of mitigation program at the end of 2020. Strategy of mitigation action program was for carbon uptake and carbon storage stabilization. The mitigation scenario for forestry sub-sector capable of reducing emissions was by 552,303,873 ton CO_2 eq or by 52.47% of the total cumulative emissions at the end of 2020 (forward-looking method).

Keywords: strategy; mitigation; carbon emission; land use

1. Introduction

Papua Province, with a forest area of 31,687,680 ha (BAPPEDA Papua, 2012) has a very high level of genetic diversity, species or forest ecosystem. The Forestry and Conservation Service Statistics data in 2012 of Papua Province recorded that during the period 2006-2009 the degradation of forest area in Papua was about 645,684 ha or 161,421 ha/year (Papua Provincial Forestry and Conservation Office, 2013). The extent of forest degradation for the 2006-2011 periode was 908,854.60 ha (181,770.92 ha/year). It contributed indirectly to increase greenhouse gas emissions that affect global climate change.

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The Papua province as part of Indonesia's tropical forest province has a forest area of 98.94% of its territory. It has been firmly incorporated into national plans to address the issue of greenhouse gas (GHGs) 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 methods

Calculation of the level and projection of forest carbon emissions was carried out since 2000 until 2020 by referring to the method developed by IPCC GL-2006 (IPCC, 2006) with historical-based and forward looking approach. The basic equations of carbon emissions or sequestration are:

$$\textit{Carbon emissions} \text{ or } \textit{sequestration} = AD \times EF \quad (1)$$

where, *AD* is activity data and *EF* is emission factor.

$$\textit{Historical approach} = \textit{Regression equation}/\textit{Trend Base Year } Y \text{ (current year)}$$

$$= A \text{ (initial year emission)} \times x \text{ projection year} +$$

$$B \text{ (coefficient)} \quad (2)$$

$$\textit{Forward Looking Approach} = \textit{Equation Average land cover change (period) to plan overlay pattern} \quad (3)$$

The carbon emission and sequestration method applied the basic equation of the default emission factor of the National Development Planning Agency 2010 (BAPENAS, 2014) and data activities used were sourced from digital data (spatial analysis of changes in land cover) or based on data of research conducted in Indonesia, especially Papua Province.

3. Results and discussions

3.1. Emission level/status

The Papua Provincial Government should immediately make an effort to change the paradigm that the rate of forest degradation causing 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 seen at Figure 1. There are six types of forest: conservation forest (KSA), protected forest (HL), limited production forest (HPT), production forest (HP), conversion production forest HPK) and other use areas (APL). It is apparent from Figure 1 that most of forests in Papua are protected forest and conservation forest.

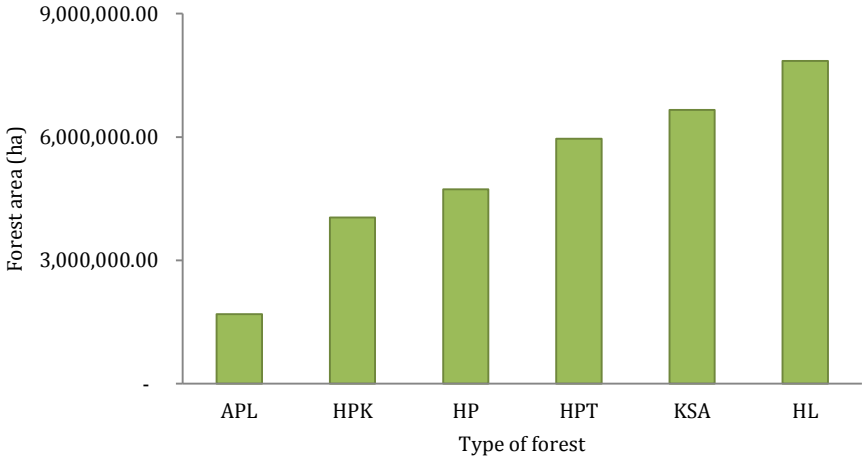

Figure 1. Area based on the function of forest area in Papua Province.

Table 1. Stock Carbon (emission factor) based on land cover classification

Land cover	Land cover code	Carbon stock (ton/ha)
Primary dryland forest	2001	195.40
Secondary dryland forests	2002	169.70
Primary mangrove forest	2004	170.00
Primary swamp forest	2005	196.00
Planted forest	2006	140.00
Shrubs	2007	15.00
Plantation	2010	63.00
Settlement	2012	1.00
Open land	2014	0.00
Grass land	3000	4.50
Water	5001	0.00
Secondary mangrove forest	20041	120.00
Secondary swamp forest	20051	155.00
Swam plan	20071	15.00
Dryland farming	20091	8.00
Dryland farming mix	20092	10.00
Rice	20093	5.00
Tambak	20094	0.00
Airport/port	20121	5.00
Transmigration	20122	10.00
Mining	20141	0.00
Swamp	50011	0.00
Cloud	2500	0.00

Source : Bappenas (2010)

The calculation of forest carbon emission and uptake i.e. land cover change was activity data (*DA*), while emission factor (*FE*) was obtained with average approach of carbon stock for each class of land cover presented in Table 1.

The condition of land cover change was activity data (*DA*), while the emission factor (FE) was 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.

$$\text{GHG Emissions} = LCC \times \{PCCB - CCRC\} \quad (4)$$

where, LCC is land cover changes, PCCB is previous carbon cover background and CCRC is current carbon reserve coverage. The result of base year emission calculation is shown in the Table 2.

Table 2. Carbon emissions on base year level from 2000 to 2011

Year	Carbon Emission (ton CO_2 eq)
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

3.2. Emission calculation based on historical approach

The projection of emissions with the Historical approach is linear projection by looking at the trend on the base year period by analyzing the gradual changes of land cover in the period of 2000-2003, 2003-2006, 2006-2009 and 2009-2011 so as to obtain the equation of linear regression approaching the existing condition, as shown in Figure 2.

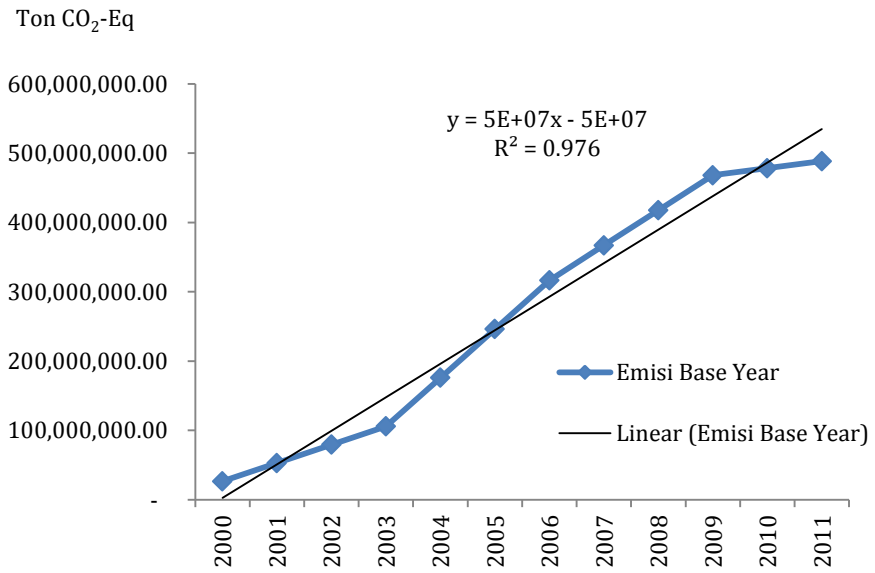

Figure 2. Trend of base year emissions of land cover sector

From the picture above, we can see the regression equation and R^2 value of the base year emission. The emission value of 2012 - 2021 was obtained by substituting the value of x in the regression equation y = 48,384,500.42x – 45,910,977.17 so that the emission figures for 2012 - 2021 are as presented in the Table 3.

Table 3. Carbon emission sector comparison of land cover change (historical approach)

Year	Carbon emission (ton CO_2eq)
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

In the table above we can see that the results of carbon emissions projection based on historical approach at the end of the year 2021 is 970.163.531,65 ton CO_2 eq. This indicates that the increase in carbon emissions from 2012 – 2021 follows 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.

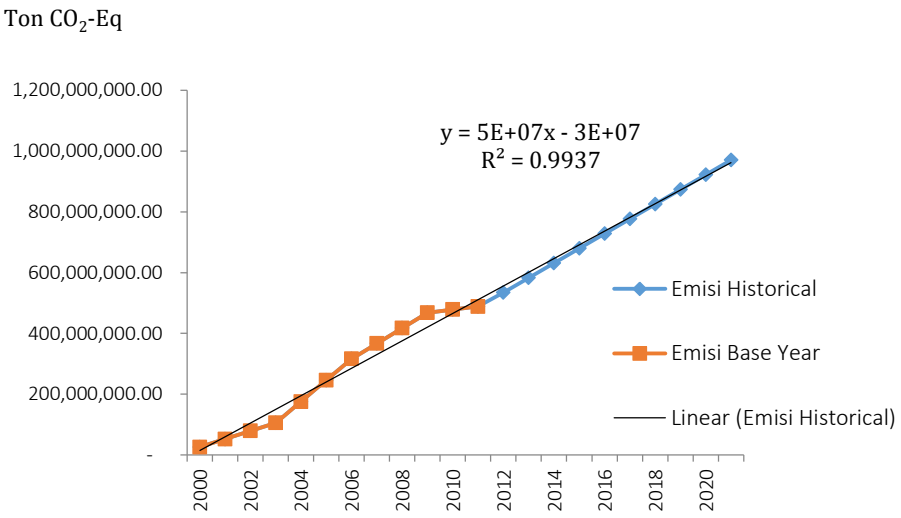

Figure 3. Land use sector emissions with the historical approach

3.3. Emission calculation based on Forward Looking approach

The projection of emission levels in this approach was calculated based on land cover in 2011 overlaid with the spatial plan of Papua Province *RTRW* in 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.

Table 4. Carbon emission sector comparison of land cover change (forward looking approach)

Year	Total of emission (ton CO_2 eq)
2012	559.769.184,58
2013	630.933.743,49
2014	702.098.302,40
2015	773.262.861,31
2016	844.427420,22
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

From the calculation based on both approaches we can see that the value of emissions with forward looking approach in 2021 is 1.104.747.151.77 ton CO_2 eq higher than the historical approach with 970.163.531,65 Ton CO_2eq. In the picture belowpresented the results of emission projection with forward looking approach.

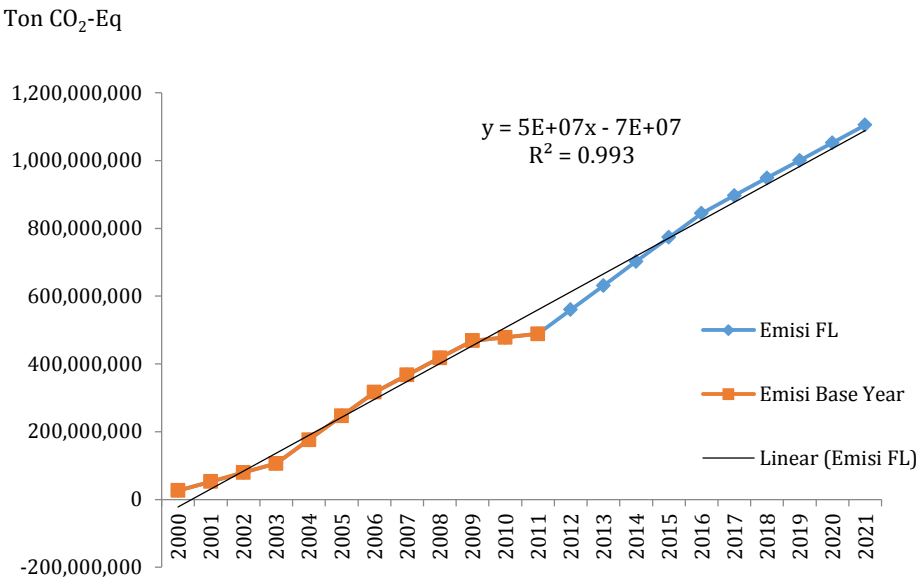

Figure 4. Land use sector emissions with the Forward Looking (FL) approach IPCC 2006
Elvis Franklin Suebu

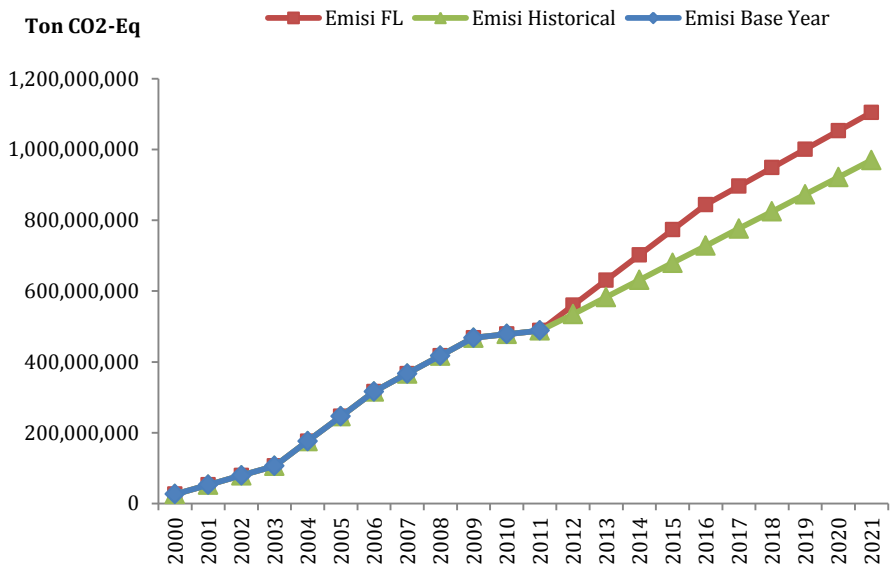

Figure 5. Comparison of emission based year, historical and forward looking. (Reference Emission Level in Papua Province)

Figure 5 is a comparison graph of the baseyear 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 the interventions of local government policy and mitigation efforts.

3.4. Emission reduction scenario

Efforts to be taken in reducing carbon emissions from deforestation and forest degradation were through several mitigation action of mitigation scenarios for greenhouse gas emissions is as follows:

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 is known that in Papua Province mitigation actions of forest carbon storage stability can be implemented and increased forest carbon uptake was able to contribute to the reduction of emissions as shown in Figure 6.

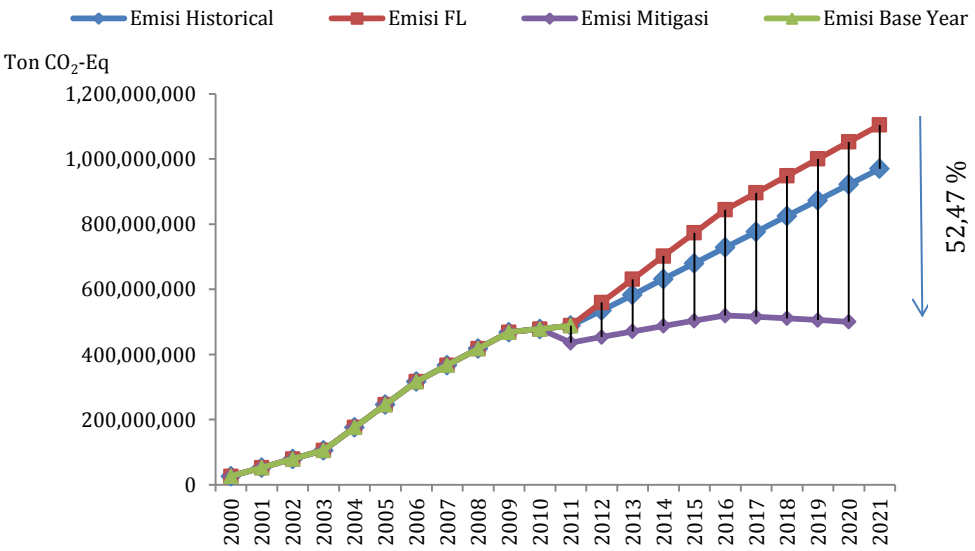

Figure 6. Emission reduction scenario

The contribution of all mitigation actions in Papua Province as a whole will reduce the emissions by 552,303,873 tons CO_2-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 CO_2eq (historical method). Mitigation action of GHG emission reduction is as follows: Emission reduction activities for this sector are: Increasing 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 CO_2eq in the end of 2020 mitigation period.

Acknowledgement

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