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Scenario for West Papua contribution for NDC from forestry sector

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Abstract. West Papua's tropical forests are one of the mega biodiversity in the Sahul Shelf ecoregion. The increasing economic growth has a deterrent impact on deforestation and forest degradation with the rate increased by 1.29% per year (2010-2018). Meanwhile, economic growth in Gross Regional Domestic Product (GRDP) reached 4.87% per year. This study aims to simulate carbon management from the forestry sector in West Papua into the long-term low-carbon sustainable development. This research uses a dynamic system method through Stock Flow Diagram (SDF) stage and model validation. The results showed that the forestry GRDP and emission based on the CM1 and CM2 scenarios calculated using emission reduction of 69.61% and 91.04% were determined by 0.28 and 0.09 times from BAU. The total GRDP and forestry GRDP decreased by 5.19% (CM1) and 6.59% (CM2) and 71.57% (CM1) and 90.93% (CM2). Under this scenario, West Papua could maintain a forest cover of more than 85%. The study concludes that the results of the BAU scenario predict forest cover of 70% in 2030. Simulations carried out with CM1 and CM2 reduction in emissions show that the achievement of forestry GRDP, total GRDP, and emissions is lower than BAU.

1. Introduction

Forest holds an essential role in climate mitigation efforts by preserving and adding its carbon sinks and curbing the deforestation rate that drives GHG gas emissions. Following the Paris Agreement, countries submitted their national commitments that reaffirmed the roles of forest and land-use change (LUCF) in climate mitigation. If NDC is fully implemented, it is expected, by 2030, the world will reach a net carbon sink (up to $-1.1 \pm 0.5 \text{ GtCO}_2^{\text{e-1}}$ per year) and provide a quarter of the country's planned emission reductions [1]. If countries fail to protect their remaining forest, it will be more difficult to limit the temperature increase to below 1.5°C. Achieve such commitments; many tropical countries opt for reforestation and other forest management options to ensure CO₂ sequestration. Reforestation and other forest management options to sequester CO₂. Nevertheless, such attempts could face failure should problems related to poverty, social, environmental, and politics are not properly recognized [2].

In Indonesia, the LUCF sector is the main foundation of the NDC emission reduction target, accounted for 63% of the target [3]. Of 189 million ha land in Indonesia, the potential to utilize unproductive land to increase carbon sequestration exists. The current national



afforestation/reforestation program remained under the total unproductive land available for mitigation. Indonesia also has provinces with intact forests such as Papua and West Papua that offer NDC opportunities by keeping the forest standing [4].

The islands of Papua and New Guinea are home to the third-largest tropical rainforest globally with a diversity of bird and plant species as in Australia, which is only one-tenth of its land area (Sahul Shelf). Some of the fauna include tree kangaroos and birds of Paradise with various species, while flora consisting of Merbau (*Intsia palembanica*), akway (*Drymis sp.*), Matoi (*Pometia pinnata*), etc. [5]. In the 2018 Manokwari Declaration, West Papua has declared 70% of its territory as a conservation area. Despite such ambitious commitments, it is not easy to achieve, given the need to achieve economic growth. On March 20, 2019, the Regional Representative Council ratified the Sustainable Development Special Regional Regulation (Perdatus) Policy, which formalized the provincial development paradigm. This provides a legal basis for local governments to study and implement development programs in the province. West Papua Province has entered Nationally Determined Contributions (NDCs) to oversee the issue of reducing emissions. The West Papua government has signed an MoU with Bappenas for low-carbon development planning, in which gas emissions are targeted to decrease by 15 percent by 2020. Emission reduction is expected to support the central government's program to reduce GHG emissions by up to 29% with its efforts and 45% with external assistance from 2030 [3].

West Papua Province has 138,385 km² with a predominantly forest area of 97,239 km² [6]. On the environmental aspect, development in West Papua Province has the impact of degradation and deforestation. Statistical data shows a significant increase in forest cover from 2007 to 2018. In 2007, nearly 97% (9,480,338 ha) of West Papua's land area was covered by forest. In 2018, this figure decreased to 8,600,000 ha or around 88% of the province's area [12]. Although the current state of West Papua's forest cover remains above the national minimum threshold of 30%, these changes cannot be ignored. Based on data [7], it is estimated that the primary forest area will reach 6,226,200 ha in 2010 and will continue to be degraded to 5,758,700 ha in 2018 (degradation rate of 1.05% per year). The primary forest conversion has increased secondary forest between the 2010-2018 period from 2,992,200 ha from 2,464,000 ha in 2018. Meanwhile, the secondary forest conversion into shrubs or non-forest areas reached 2.41% per year. This has increased the non-forest areas to 1,059,347 million hectares.

Forest conversion into secondary and non-forest land is often inevitable with the accelerating economic development efforts at the provincial level. As of January 2020, West Papua is the second poorest province in Indonesia, with 21.51% of its population lives below poverty lines [8]. To improve economic conditions, the West Papua government has developed reliable targets with the Gross Regional Domestic Product (GRDP) for the 2010-2018 period accounting for 4.87% per year at constant prices [9].

It is taking the potential contribution of West Papua province to NDC through LUCF and the region's need to achieve its potential growth into account. This research would like to simulate carbon management from the forestry sector in West Papua into long-term low-carbon sustainable development to increase economic growth. Maintain forest cover up to 70% based on the Manokwari Declaration and reduce GHG emissions by up to 29% by own efforts and 41% with foreign assistance by 2030. Forest management towards low carbon development is one of the concrete instrument solutions in assessing and planning social, economic, and environmental programs towards sustainable development. We hope this study can contribute to the sustainable development discussion in West Papua that allows the province to meet current needs without sacrificing future generations by focusing on the environment's carrying capacity, achieving social justice, economics, and environmental sustainability in West Papua Province.

2. Method

2.1. Concept development

The method used in this research is system dynamics modeling. The data used in West Papua data with the variables shown in Table 1.

Table 1. General variables for forest management modeling [9, 21].

No	Selected Variable	Baseline Value	Unit	Calculation Method
1	Total Goss Regional Domestic Product (GRDP)	41,362 (2010)	Billion	Total GRDP data (BPS Papua Barat 2010-2018)
2	GRDP of the forestry sector	1,361 (2010)	Billion	GRDP of forestry data (BPS Papua Barat 2010-2018)
3	Deforestation and degradation	58,200 (2010)	Ha	Recapitulation of forest and land cover (KLHK 2010-2018)
4	Emission	10,522,475.13 (2010)	tonCO ₂ e	Emission Data x Emission Factor [21]
5	Forest and Management	26.30 (CM1) and -18.43 (CM2) (2010)	Percentage	Estimation (1 – Forestry Emission/ Emission Target) x Investment Fraction

Noted: CM1 (reduce emission 69.61% from BAU 2030) and CM2 (reduce emission 91.04% from BAU 2030).

Although West Papua still maintains more than 80% of its primary forest, other economic development conditions significantly affect increasing GHG emissions in West Papua Province [14]. This can be used to declare West Papua's NDC contribution for the national level commitments. The modeling stage consists of drafting, modeling, simulating, and validating the simulation results.

2.2. Modeling

At this stage, Stock Flow Diagrams (SFD) are used in the Powersim 10 Software, which is depicted in a diagram consisting of 2 types of variables, namely stock (level) & flow (rate) inside dynamic systems modeling. The SFD is a more detailed description and paid attention to the effect of time on linkages between variables. Later, each variable showed the accumulated results for a variable level and the variable, which is the activity system rate.

2.3. Simulation and validation of the model

At this stage, Stock Flow Diagrams (SFD) are used in the Powersim 10 Software, which is depicted in a diagram consisting of 2 types of variables, namely stock (level) & flow (rate) inside dynamic systems modeling. The SFD is a more detailed description and paid attention to the effect of time on linkages between variables. Later, each variable showed the accumulated results for a variable level and the variable, which is the activity system rate.

$$AME = (S_i - A_i) / A_i \times 100\% \quad (1)$$

AME is an absolute mean error, A is the actual value, and S is the simulation value. The AME value-based limit to relate to uncontrollable variables in this study is 30% [13].

3. Results and discussion

3.1. Baseline data of forest management (2010-2018) in West Papua

The compilation of a baseline under Business as Usual scenario (BAU) for the preparation of the West Papua Province RAD-GRK for the forestry sector is carried out using the historical-based time-series data (2010-2018) on forest conversion and land use and land-use change (LULUCF) as well as the identified drivers of deforestation and forest degradation in West Papua Province, namely illegal logging; forest fires; and conversion of forest land for other activities such as plantation and agricultural areas, expansion of areas (regencies), mining and settlements. The total value of deforestation and degradation (2010-2018) has almost reached 2 million ha with an annual rate of 200.000 ha (Table 2).

Using the deforestation and degradation data extracted from Regional Action Plan for Greenhouse Gas Reduction in West Papua Province 2013-2020 period [14], the analysis found cumulative emissions from forest conversion, land use, and land-use change (LULUCF) in the 2010-2018 Period of 62,507,052 tonCO_{2e} as shown in Table 2. A year to year cumulative emissions of West Papua until 2018 continued to increase as calculated using deforestation and degradation data based on historical scenarios based on stock change and gain-loss, a 4x increase from the base year, 2010.

To achieve the emission levels in Table 2, the growth rate of GRDP of West Papua in the period 2010-2018 must reach 4.87% per year. While the growth rate for the GRDP of the forestry sector also increased by 4.95% per year.

Table 2. Forest area, non-forest area, Total GRDP, GRDP of Forestry, Emission (2010-2018) [9].

Year	Primary Forest (Ha)	Secondary Forest (Ha)	Non-forest area (Ha)	Total GRDP (billion Rp)	GRDP of forestry (billion Rp)	Total Emission (tCO _{2e})
2010	6,226,200	2,464,000	837,700	41,361.7	1,362.1	24,650,073
2011	6,026,800	2,430,600	837,700	42,867.2	1,423.7	29,580,087
2012	6,024,100	2,413,100	1,219,000	44,423.3	1,541.5	34,311,958
2013	6,127,200	2,660,300	830,900	47,694.2	1,420.2	39,083,828
2014	5,605,300	3,259,200	760,300	50,259.9	1,563.3	43,835,699
2015	5,890,500	2,899,300	834,800	52,346.5	1,663.1	48,587,569
2016	5,806,400	3,015,200	803,700	54,711.3	1,641.8	53,339,440
2017	5,761,400	2,989,400	873,900	56,906.8	1,700.9	57,923,246
2018	5,758,700	2,992,200	873,900	60,453.6	1,971.9	62,507,052

3.2. Stock flow diagram

At this Stock Flow Diagram (SFD) stage, the modeler can add variables to the explicit models such as capital, investment, and Incremental Capital Output Ratio (ICOR) from forestry and non-forestry sector (Figure 1) and the other variables for reduction emission for 29% (CM1) and 41% (CM2) (Figure 2).

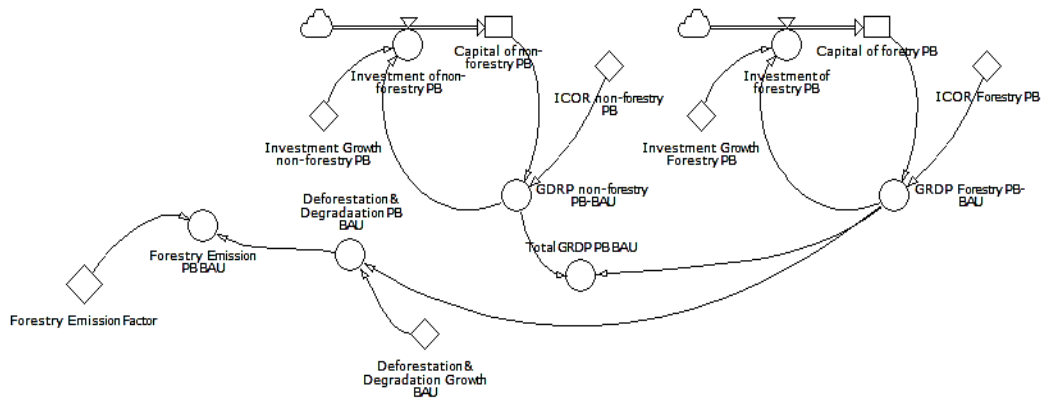


Figure 1. SFD Forest Management in West Papua.

Figure 1 shows that BAU’s SFD variables consist of economic factors by considering the GRDP value of forestry originating from ICOR, capital, and investment. Meanwhile, the forestry factor comes from the value of deforestation and degradation data and the GRDP of the forestry sector. Then, emission will be calculated from deforestation and degradation data using Emission Factor.

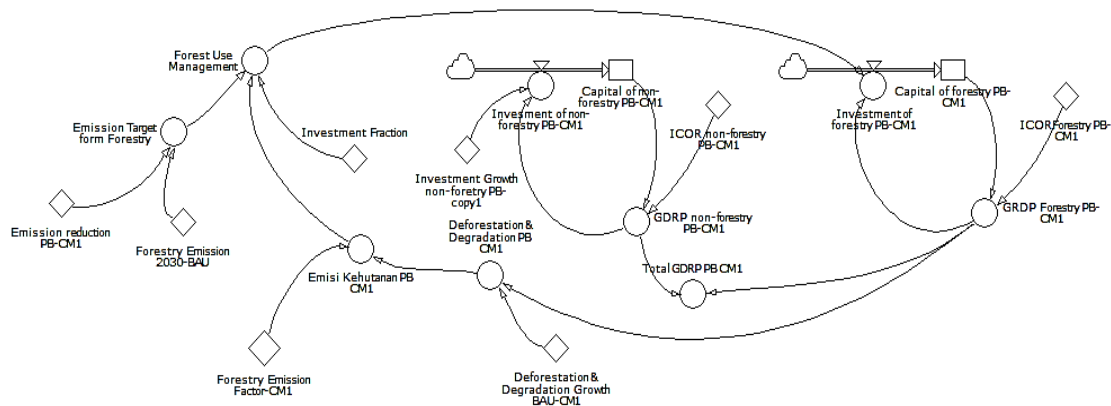


Figure 2. SFD Forest Management Emission Target in West Papua.

Figure 2 represents that the SFD of CMI and CM2 scenario variables require forest use management treatment obtained from the BAU (2030) emission target value, 69.61% (CM1), and 91.04% (CM2) emission reduction from deforestation and degradation and investment fraction.

3.3. Process of simulation

The forest management model is a simplification of the real condition in the field. The following are the assumptions and limitations in the model that can be identified in Table 3.

Table 3. The initial value of simulation and estimation methods [9, 21].

No	Selected Variable	Baseline Value	Unit	Calculation Method
1	Capital of the forestry sector	3,459.78	billion	GRDP of forestry data (BPS 2008-2018) x ICOR forestry sector (Bappeda, 2017)
2	Capital of non-forestry sector	199,626.03	billion	GRDP of non-forestry data (BPS 2008-2018) x ICOR non-

				forestry sector (Bappeda, 2017)
2	Waste density	169.44	kg/m ³	Secondary data, IPCC (2007)
3	Investment growth from the forestry sector	33.68	%	Investment from forestry data (BPS 2008-2018)
4	Investment growth from the non-forestry sector	26.58	%	Investment from non-forestry data (BPS 2008-2018)
5	Deforestation & degradation growth	129.93	ha/billion	Deforestation & Degradation Data (BPS 2008-2018) / GDRP from forestry sector
6	Forestry Emission Factor	72.33	tonCO ₂ e/ha	Differential stock carbon from the primary and secondary forest (IPCC, 2007)
7	Emission Reduction CM1	69.61	%	Target/BAU (KLHK, 2018) 497 MtonCO ₂ e/714 Mt CO ₂ e
8	Emission Reduction CM2	91.04	%	Target/BAU (KLHK, 2018) 650 MtonCO ₂ e/714 Mt CO ₂ e
9	Emission 2030 BAU	83,315,054.74	tCO ₂ e	Data Emission x Emission Factor (IPCC, 2006)

3.4. Validation model

Furthermore, the environmental model is validated using the Absolute Mean Error (AME) value with the following formula: $AME = |S - R| / R$, where S is the average value of the simulation results. R is the average value of the reference data. The model is valid if the AME value < 0.3. Based on this formula, the environmental sector validation can be seen in Table 4.

Table 4. Validation from carbon management.

Years	Deforestation & Degradation		Total GRDP		Forestry GRDP	
	Data	Simulation	Data	Simulation	Data	Simulation
2010	58,200	145,479	41,362	41,205	1,362	1,120
2011	58,200	161,335	42,867	43,467	1,424	1,242
2012	401,500	178,920	44,423	45,856	1,542	1,377
2013	738,400	198,422	47,694	48,380	1,420	1,527
2014	147,600	220,050	50,260	51,047	1,563	1,694
2015	149,200	244,034	52,346	53,866	1,663	1,878
2016	62,900	270,633	54,711	56,845	1,642	2,083
2017	141,000	300,141	56,907	59,995	1,701	2,310
2018	100	332,845	60,454	63,326	1,972	2,562
Average	195,233	227,948	50,114	51,554	1,588	1,755
	S	R	S	R	S	R
AME	0.1678		0.0287		0.1052	

The validation results in deforestation and degradation areas, Total GRDP and Forestry GRDP, show that the AME value is 0.1678; 0.0287, and 0.1052. This value indicates that the AME value is < 0.3, which means that the model is valid.

3.5. Simulation analysis

The forest management simulation model in West Papua is performed with functional intervention from BAU, CM1, and CM2 scenario. Changes in the leverage factor affecting the model were carried

out in the CM1 and CM2 scenarios. This aims to find the most effective policies in reducing GHG emissions in the CM1 and CM2 scenarios. (Table 5).

Table 5. Scenario reduce emission from the forestry sector.

No	Scenario	Emission Level	Unit	Estimation Method
1	CM1	25,319,445	tCO ₂ e	BAU 2030 x 69.61%
2	CM2	7,465,029	tCO ₂ e	BAU 2030 x 91.04%

Based on the forest management model, deforestation and degradation from the forestry sector of BAU scenario 2030 are still maintaining 70% forest cover. Furthermore, to implement LCD in West Papua, the CM1 scenario can save forest up to 71.57% until 2030 from the BAU scenario or maintaining forest to 84.64%. However, this will decrease the economic value of GRDP from the forestry sector from IDR 8,865.34 billion of BAU 2030 to IDR 2,520.14 billion of CM1 2030 (-71.57%) (Figure 3). Meanwhile, the Total GRDP has reduced by only 5.19% from IDR 122,271 billion (BAU) to IDR 115.926.02 billion (CM1) (Figure 4). We can see the decline of a 0.28 time of BAU scenario for the emission calculation when emissions are reduced to 71.57% from BAU (Figure 5).

The CM2 scenario is based on the emission level with reduced 91.04% emission from the BAU scenario. Calculate the CM2 scenario; forest cover can be maintained up to 86.93% until 2030 from the BAU scenario. This scenario will impact the decline of forestry GRDP of 0.09 times lower than the BAU scenario (Figure 3). At the same time, the Total GRDP has declined by 6.59% from a value of IDR 122,271 billion (BAU) to IDR114,209 billion (CM2) (Figure 4). The same condition for the emission of CM2 scenario is 0.09 times from the BAU scenario (Figure 5).

NDC forestry sector scenario shows that the forestry GRDP is estimated to an unrealistic target; it is necessary to strengthen mitigation action to perform the NDC target. Several studies have also shown difficulties in achieving the 2030 NDC target in the forestry sector. Therefore researchers have provided NDC mitigation input such as the implementation of REDD+, conservation practices, afforestation, reforestation, a moratorium on licensing of new companies and large plantations, and developing another mitigation sector such as green energy, green agriculture, and green transportation. [12,13,14,15].

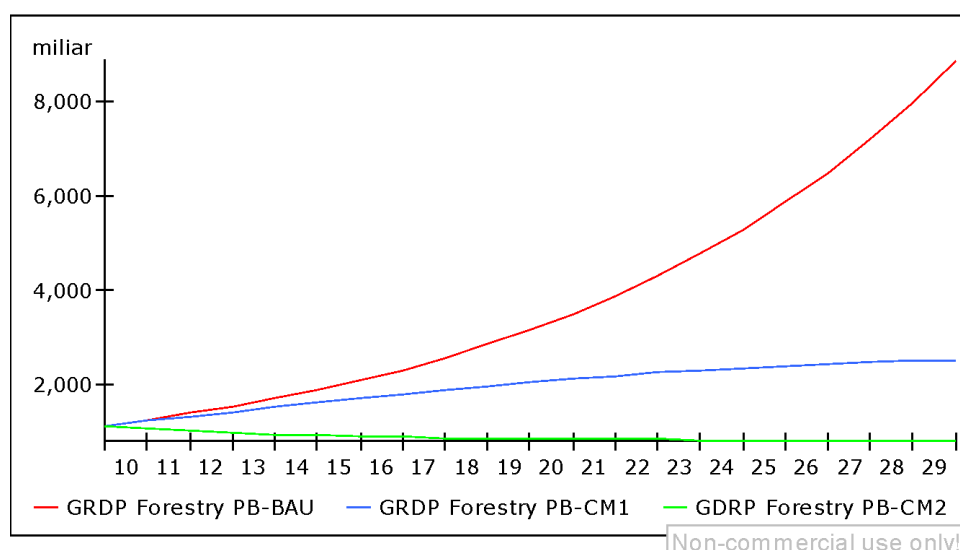


Figure 3. GDRP of forestry sector (BAU, CM1, CM2).

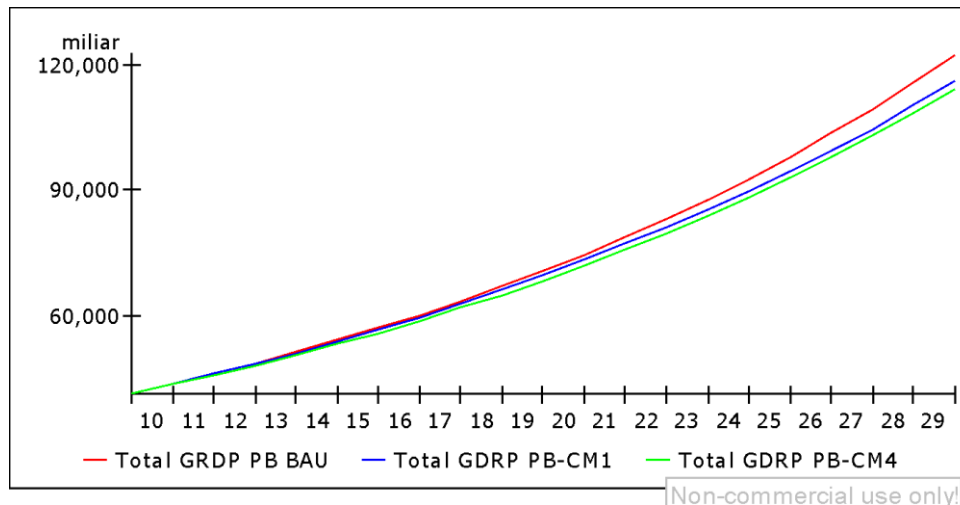


Figure 4. Total GRDP (BAU, CM1, CM2).

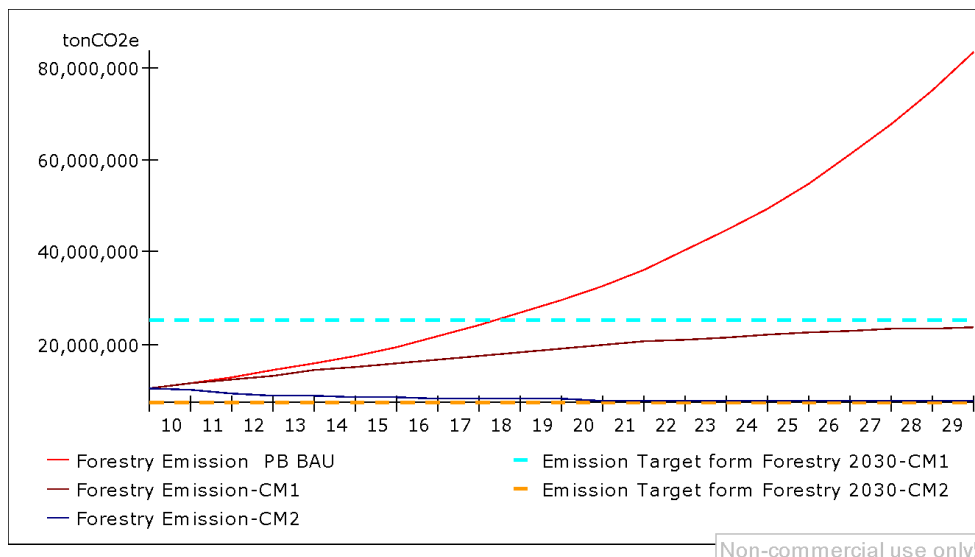


Figure 5. Emission from the forestry sector (BAU, CM1, CM2).

Maintain the economic sector from falling in the CM1 and CM2 scenario, mitigation, and green growth efforts need to be done by considering preserving forests and increasing the welfare of indigenous peoples, as reflected in the Manokwari Declaration increased. Researchers have provided many suggestions and suggestions regarding the green economy so that the economy continues to run well while still paying attention to forest sustainability [16,17,18,19,20]. Based on the experiences and researches, several efforts that have made in West Papua, as the following:

1. Identifying company permits located in forest areas (policy strategy).
2. We are collaborating with Bappenas in implementing the Low Carbon Development Indonesia program at the provincial level (policy strategy).
3. We are promoting downstream industry from non-timber forest products such as nutmeg oil, masohi oil, eucalyptus oil, cacao, coffee, and others (economic strategy).
4. We are developing the economy from environmental services such as the clean water industry and natural tourism (butterflies, primary forest, paradise bird, smart bird, coral reef, white sand and blue sea, and others) (economic strategy).

4. Conclusion

Reducing emission from the forestry sector is needed for the NDC target in West Papua Province. Dynamic system modeling clarifies that the NDC target from the forestry sector faces an extreme economic sector problem. This research modeling exercise showed how West Papua could maintain forest cover to 84,64% (CM1) from BAU by 2030. However, this will come at the expense of the province economic growth as GDRP from the forestry sector sharply decline by 71.57% lower in comparison to BAU. This makes the provincial contribution for NDC from the forestry sector becomes unrealistic. Unless the province is fairly compensated for their performance, such as REDD+ schemes, Until recently, the global carbon market is still relatively low, thus raises pessimism among forest-rich countries on market-based REDD+ financing. At the global level, the difficult negotiation process on Article 6 of the Paris Agreement arranges on carbon market mechanisms and how national-subnational benefit-sharing ring mechanism architecture will add to the complexities. West Papua province requires a unique development approach, given its carbon sequestration potential. Current low carbon development initiatives open up a window of opportunity that allows conservation and development comes hand in hand. The on-going COVID-19 pandemic put the process to halt, and the post recoveries open up bigger calls for building back better. Further research that simulates NDC's provincial contribution is needed by taking more diverse social and economic variables such as health, human development index, education level, and others.

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