Potential of Land-Based GHG Mitigation Policy to the Indonesian Economy

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Abstract. Indonesia GHG emission mostly originated from the Land-Use Change and Forestry (LUCF) sectors. The complexity of land conversion pattern and different carbon stocks for each land type makes have made the mitigation and emission calculations for the LUCF more challenging. However, the Indonesian government has already introduced some policy package to reduce the deforestation and increase the reforestation. Here we, simulate the policy to reduce deforestation by increasing the yield of the crops, and increase reforestation. The simulation was done by using the Computer General Equilibrium (CGE) combined with Land Conversion Matrix. The focus of this study was to observe how mitigation, especially from the land-use sector, would affect the economy under the low and high economic growth. The results indicated that the mitigation policy would hit the Indonesian economy harder under the low economic growth, since under the low growth, Indonesia might experienced around 2.7% of GDP loss in 2030 compared to the BAU level. However, if Indonesia is able to achieve high economic growth, the introduction of mitigation, especially through the improvement of crop productivity, might produce better implications to the economy. However, this result also might be overestimated, especially for the GDP due to the consideration of high economic growth and several study limitations in this paper.

1. Introduction
Along with other countries, Indonesia has committed to reducine GHG emission. Indonesia Nationally Determined Contribution (NDCs) states that Indonesia would reduce its emission by 29% from its projected 2030 BAU emission. This NDCs has been submitted to the United Nations Framework Convention on Climate Change (UNFCCC). However, this commitment was criticised by some parties because it was considered too high and too tough for Indonesia. This is because the Indonesian emission is mostly from the Land Use Change (LUC) sector and peatland (both peat decomposition and peat fire). Emission from land sectors and peat are not easily reduced because it should considered the land demands and other additional factors (e.g., emission from peat decomposition cannotbe reduced instantly).

In the other side, Indonesia has the ambition to be a high-income country by 2030, as stated in the Master Plan for Acceleration and Expansion of Indonesia's Economic Development. Indonesia has targeted to have an annual economic growth of 6% [1]. However, that assumption is regarded as too high, considering the uncertainty in the global economy and there is more infrastructure that needs to be prepared and improved. For instance, the energy efficiency would need to be improved to maintain
economic growth. Hence, the government has lowered the economic growth assumption to around 5% per annum.

Those two economic growth assumptions will result in different implications to the emissions while higher economic activity will lead to higher emissions [2]. In this study, we assess the impact of mitigation policy introduction to the economy under those two economic growth scenarios. Considering that the most significant emission comes from the land sector, more focus is given to the mitigation of land sector, mainly by increasing land productivity.

2. Data and Method

2.1. Method

2.1.1. CGE Model. This study was constructed by using a CGE Model using the Indonesia’s IO table 2010 was used. One additional feature of the CGE Model is that land was treated as an input along with capital and labour. The structure of the model is summarised in Figure 1. The center of the nested function is production function that assumed to use the Leontief production function. In this part, the total input costs were equal to the total sales. The Leontief function was chosen for this part to assure that there was no any substitution among inputs.

As for the land, infinity was set as the elasticity of substitution; meaning that land conversion was more flexible. The decision of which land conversion to be selected would be decided inside the model, based on the calculation of which land would use more efficient resources. However, there is a lack of information with regards to cost for each land conversion. Moreover, the emission from the land use was calculated by using carbon stock method. Carbon stock describes how much carbon that can be kept by a land type. The higher the tree cover, the bigger the carbon stock. When a land is converted from a higher density to a lower density, the land would emit emission, whereas, with land conversion from lower to higher density, it would absorb more
emission (negative emission). The carbon stock in this study was adjusted with the aggregation of land type.

The value added consisted of capital, labour, and energy. In this nesting part, the capital-energy composite (KE1(j)) and labour (L1(j)) were aggregated into the value added (VA1(j)) using the Cobb-Douglas function. The Cobb-Douglas function was used, meaning that the inputs (in this case capital-energy composite (KE) and labour) could be substitutes between one another but only to a certain extent. Moreover, a 5% annual capital depreciation was assumed in this study.

There is also household sector that receive income by providing some endowment. Moreover, share between the governments and the households, trade surplus and valuable waste generation were also assessed in the income level. In this model, the fixed capital formation was calculated from the future GDP growth in advance. In the same time, the government also received additional incomes from tax revenues, and uses these incomes for their consumptions.

In this model, the elasticity of transformation of produced goods between export and domestic was assumed to be constant. From the function, the values of export and domestic goods were calculated from the total produced goods and their prices. On the other hand, it was assumed that the elasticity of substitution between imported goods and domestic goods was also constant.

2.1.2. Scenario. There were three scenarios: BAU, NDC_1, and NDC_2. BAU was business as usual scenario while the NDC_1 and NDC_2 were the conditions where Indonesia tried to achieve 29% of emission reduction from the projected 2030 BAU emission. The difference between these two scenarios was the land productivity improvement. In the NDC scenario, the land productivity was based on the Indonesia Deep Decarbonisation Pathway Project (DDPP) [3]. The NDC_1 using the land productivity improvement based on Development (DEV) scenario of DDPP and NDC_2 was using the DDPP assumption. In short, NDC_2 had higher productivity compared to NDC_1. Furthermore, the scenarios were simulated under the two conditions, i.e., low economic growth and high economic growth. The low and high economic growths were based on the General Plan for National Electricity based on the assumptions published by the National Development Bureau (Bappenas)[4] (Table 1).

| Economic Growth         | Scenario | Details                          | Emission reduction                      |
|-------------------------|----------|----------------------------------|----------------------------------------|
| Low economic growth     | Business as Usual (BAU) | None                             |                                        |
|                         | NDC_1    | Productivity based on “DEV” term in DDPP scenario | 29% emission reduction from the 2030 BAU emission |
|                         | NDC_2    | Productivity based on “DDPP” term in DDPP scenario |                                        |
| High economic growth    | Business as Usual (BAU) | None                             |                                        |
|                         | NDC_1    | Productivity based on “DEV” term in DDPP scenario | 29% emission reduction from the 2030 BAU emission |
|                         | NDC_2    | Productivity based on “DDPP” term in DDPP scenario |                                        |

The productivity was calculated by combining yield and crop rotation. Generally, the productivity under the NDC_2 was higher than other scenarios (Table 2).
Table 2. Productivity comparisons for several crops in 2030 (tonne/ha).

| Commodity             | BAU  | NDC_1 | NDC_2 |
|-----------------------|------|-------|-------|
| Paddy*               | 6.8  | 8.5   | 9.4   |
| Corn                  | 0.8  | 0.8   | 3.7   |
| Cassava               | 4.1  | 4.1   | 17.2  |
| Other annual crops    | 6.5  | 6.5   | 15.4  |
| Palm Oil              | 13.9 | 17.2  | 17.2  |
| Rubber                | 1    | 1.1   | 1.1   |
| Other Plantation      | 1.9  | 2     | 2     |

*) Including rice in Java and outside Java, and upland rice.

2.2. Data

The primary data used for this study were Input-Output Table (IOT) and Land Allocation Matrix. Moreover, since this study compared the low and high economic growth conditions, data on the GDP projection were used.

2.2.1. Input-Output Table (IOT). In this study, we use Indonesia Input-Output Table (IOT) 2010. IOT is a matrix presenting an overview of interrelationships between unit activities (sectors) in the Indonesian economy as a whole. Each row showed how the output of a sector was allocated to meet the intermediate demand and final demand, while each column showed the use of intermediate inputs and primary inputs by sector in the production process[5]. The total output was calculated by adding its use of goods and services and primary inputs such as capital and labour. By this scheme, the values of total outputs from row and column are the same [6]. In Indonesia, the IO table is usually compiled every 5 years. However, it is assumed that over a long period, the economic structure did not change significantly even though the current price of the economic sector of production process of goods and services are changed significantly [7].

2.2.2. Land Conversion Matrix. We combine the IOT with land allocation matrices published by the National Development Planning Agency. This matrix shows the pattern of land use changes in Indonesia, originated from several geographical information including spatial data of forest cover for the period of 2006-2011, by the Directorate General of Forestry Planning, Ministry of Forestry and data of appointment area in each province based on the Minister of Forestry Decree, which was issued in stages from 1999-2012 [8]. The matrix was then summarised in the 22 x 22 matrix form to inform the land use changes.

To combine land allocation matrix with IOT, number and type of land uses should be the same so that it can run simultaneously during the simulation. For this study, the land types were classified into ten types assuming the grassland land was used for livestock sector. The original land types and the aggregation are given in Appendix A2.

The necessary information for land use change and allocation used in this study were summarised in the land allocation matrix (Table 3). From the matrix, it was found that the croplands (paddy, corn, and cassava), and oil palm plantations were more likely to be converted into “other-agriculture” land. It means, those land areas were usually converted for horticulture purposes including vegetables and fruits. Conversely, other-agriculture land (OAG), plantations, and forest lands (excluding the commercial wood plantation) were usually converted into oil palm plantations.
Table 3. Modified Land Allocation Matrix in 2010 (ha).

|       | PAD     | COR     | CAS     | OAG     | RUB     | PAL     | OPL     | LIV     | WOO     | OFO     |
|-------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| PAD   | 6,881,200 | 4,855  | 2,662   | 23,142  | 739     | 1,491   | 985     | 0       | 420     | 105     |
| COR   | 13,432  | 2,603,034 | 35,224  | 305,663 | 35,448  | 71,534  | 47,261  | 45      | 26,540  | 6,555   |
| CAS   | 7,365   | 35,238  | 1,424,478 | 168,133 | 19,627  | 39,608  | 26,168  | 25      | 14,695  | 3,630   |
| OAG   | 64,018  | 305,711 | 168,090 | 13,568,596 | 169,587 | 342,227 | 226,102 | 213     | 126,969 | 31,363  |
| RUB   | 1,933   | 39,141  | 22,115  | 186,087 | 3,845,311 | 269,302 | 177,745 | 22      | 44,859  | 11,109  |
| PAL   | 2,576   | 52,187  | 29,485  | 248,114 | 1,043   | 689     | 3,247,000 | 252     | 59,809  | 14,812  |
| OPL   | 2,443   | 512     | 282     | 2,443   | 517     | 1,043   | 689     | 3,247,000 | 252     | 59,809  | 14,812  |
| LIV   | 400     | 512     | 282     | 2,443   | 517     | 1,043   | 689     | 3,247,000 | 252     | 59,809  | 14,812  |
| WOO   | 3,741   | 30,678  | 16,965  | 146,697 | 45,239  | 91,292  | 60,316  | 17      | 5,583,731 | 10,899  |
| OFO   | 1,035   | 13,275  | 7,339   | 64,370  | 35,854  | 72,343  | 47,756  | 204     | 23,377  | 87,777,641 |

Note: Own sector: highest converted land

The emission factor of each land type were re-calculated by aggregating the emission factor based on the technical guidelines as stated in reference [8]. For this study, forest referred to all permanent forest, convertible forest, and forest land in APL (Area Penggunaan Lain/ Other Use Area).

2.2.3. Economic Growth and Population. As a small open economy, Indonesian economic condition is unpredictable because it depends on the global economic constellation. The 2018-2037 General Plan for National Electricity (Rencana Umum Ketenagalistrikan Nasional/ RUKN) followed the two economic growth assumptions based on the National Development Agency (Badan Pembangunan Nasional/ Bappenas) i.e. low and high economic growths. The economic growth assumption would affect the total emission, with better economy creating more emission. Based on that consideration, this study used both economic growth scenarios, as shown in Table 4 below. While for the economic growth from 2011-2015 (Table 5), the values of both scenarios were the same because actual data gathered from the Central Bank of Indonesia were used.

Table 4. Annual Economic Growth Projection for 2018-2030 (%)[4].

| Economic Growth Scenario | 2018 | 2019-2024 | 2025-2026 | 2027-2030 |
|--------------------------|------|------------|------------|------------|
| Low                      | 5.4  | 5.1        | 5.2        | 5.2        |
| High                     | 5.4  | 5.5        | 6.5        | 7.0        |

Table 5. Actual Annual Economic Growth for 2011-2017 (%)[9, 10].

| Year Growth (% yoy) | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---------------------|------|------|------|------|------|------|------|
|                     | 6.5  | 6.3  | 5.56 | 5.01 | 4.88 | 5.01 | 5.07 |

The high economic growth was an optimistic target that was in line with the economic target as stated in the Master Plan for Acceleration and Expansion of Indonesia's Economic Development (abbreviated MP3EI) that targeted Indonesia to become a high-income country post-2020. Unfortunately, looking at the recent global economic trend, the government has corrected the economic growth target. To project the population, projections from Statistics Indonesia were used (Table 6).
Table 6. Population Projection in 2010-2030 (Million People) [11].

| Year | Population |
|------|------------|
| 2010 | 238.5      |
| 2015 | 255.5      |
| 2020 | 271.1      |
| 2025 | 284.8      |
| 2030 | 296.4      |

2.3. Study Limitation.

2.3.1. Treatment of peatland. Limited data were available on peatlands with regard to the cost differences between economic activities on peatland compared to those on mineral lands. This underlies the reason why the land area calculation only considered land use change on mineral land. However, because peatland emission was significant within the Indonesia emission calculation, emissions from peat were also calculated. Statistical data trend from 2010-2015 were used and gathered from the Biennial Update Reports (BURs), and for year 2015 onwards, the calculation was based on the average value from years 2010-2015 (Table 7) [12].

Table 7. Summary of Treatment between Mineral and Peat Land.

| Land Categories   | Total Area | Emission |
|-------------------|------------|----------|
| Mineral Land      | Considered | Considered|
| Peat Land         | Not considered | Considered, but with limitation* |

* Actual data from 2010-2015, the average value from 2015 afterward

Moreover, the CGE Model itself is a macroeconomic model. The land categorisation should be aggregated/disaggregated to fit the sector classification in the model that was referenced from the Indonesia Input-Output Table.

2.3.2. Treatment of Energy Efficiency. In the Third National Communication, for the 29% of emission reduction, the energy sector has been targeted to contribute around 37.93% ($\approx$ 38%) out of the total national emission reduction[13]. Since each technology was not introduced in detail, the parameter of energy efficiency was set until it has achieved at least 29% of the total emission. To do that, the 38% of the total emission reduction was calculated. The energy efficiency was set on the model to allow it to achieve this value in 2030. (Table 8).

Table 8. Adjustment of Emission for the Energy Sector (Mton CO2eq).

| Economic Growth Scenario | Total emission in 2030 | Total emission from the energy sector | 38% from 29% of emission reduction | Maximum emission from energy to achieve 29% of emission reduction |
|--------------------------|-----------------------|--------------------------------------|------------------------------------|---------------------------------------------------------------|
| Low                      | 2901.4                | 1720.9                               | 319.1                              | 1401.8                                                        |
| High                     | 3085.4                | 1887.6                               | 832.4                              | 1055.2                                                        |

2.3.3. Cost. Relative cost was used. Specifically for land use change, land conversion was mainly determined by the profit optimisation calculated from capitals, labours, and other inputs utilised in each sector, since some land conversions were not considered as an economic activity.
2.3.4. Reforestation and conservation. For this study, reforestation/afforestation policy was not introduced along with the conservation functions. By this, because the land is assumed as the input endowment, the calculation of the GDP may over-estimated because the land that conversed/ reforested will be used simultaneously for the economic activity.

3. Result and Discussion

3.1. Economic Impact

Under the low economic growth condition, the full implementation of mitigation action would caused around 2.7% of economic loss in 2030 compared to the BAU level. Under the NDC_2 scenario, the GDP loss could be reduced slightly to around 0.02% in 2030. The economic burden would not be high if Indonesia is experiencing high economic growth. The simulation showed that under the NDC_2, the mitigation scenario would increase GDP of around 0.01% (Table 9). This would be possible because, under the high economic condition, it was assumed that Indonesia has already achieved high energy efficiency. Furthermore, the NDC_2 scenario has set higher land productivity compared to other scenarios. Increasing yields, for example, would be followed by an increased in the production using the same or even smaller area.

Table 9. Summary of GDP Gain/Loss under Each Scenario (Trillion IDR).

| Year | BAU      | NDC_1       | NDC_2       | Year | BAU      | NDC_1       | NDC_2       |
|------|----------|-------------|-------------|------|----------|-------------|-------------|
| 2010 | 6402.78  | 6402.78     | 6402.78     | 2010 | 6402.78  | 6402.78     | 6402.78     |
| 2015 | 8952.56  | 8940.64     | 8938.97     | 2015 | 8952.56  | 8940.64     | 8938.97     |
| 2020 | 13114.39 | 12786.69    | 13137.82    | 2020 | 13263.50 | 12725.35    | 13314.66    |
| 2025 | 18585.61 | 17912.07    | 17907.74    | 2025 | 19634.07 | 19908.41    | 19468.66    |
| 2030 | 27510.91 | 26761.52    | 26774.04    | 2030 | 32710.33 | 32601.54    | 32714.3     |

GDP gain/loss in 2030: -749.4, -736.9, GDP gain/loss in 2030, -108.8
Percentage (%): -2.72%, -2.68%, 0.33%, 0.01%

Under the higher economic growth, the rate of consumption, investment, and net export were higher than under the lower economic growth. This condition minimised the shock from the emission mitigation policy. Although the NDCs policy might caused a shock on macroeconomic variables, however the shock experienced under low economic growth would be higher than under high economic growth. However, such condition was difficult to achieved, since firstly, there was a very optimistic economic growth assumption that the economic growth would reached more than 6% after 2025; Secondly, for the energy sector to contribute to 38% of the total emission reduction in 2030, the energy efficiency would need to be elevated than when the economic growth was low; and thirdly, under the NDC_2, the yield improvement was higher than under other scenarios.

3.2. Area

Under all scenarios, the simulation predicted that the land area for paddy, oil palm, and timber would increase every year although under various growth rates depending on the scenario details. This was also an indication that land demands for these commodities would keep increasing, in line with the fact that those commodities were the most important commodities for Indonesia. The increase of area for rice assumed that rice would keep being the main staple food for the Indonesians. Demands for oil palm and timber products would lead to increased demands of these commodities.

The results also showed that land demands for commercial plantations (e.g., oil palm and rubber) were higher under the high economic growth. This is a sign that Indonesia economy still relied on commercial plantations to boost its economy even under higher energy efficiency and better economic condition. For forest area, although there was the tendency that deforestation would continue until 2030, but crops productivity improvement would have a positive impact on controlling the rate of
deforestation and maintaining the total forest area. We found that under the NDC_2 scenario, the total forest area was better maintained than under other scenarios (Appendix A2). From this result, it was considered crucial for the government to improve crop productivities, not only to maintain economic stability but also to help reduce emissions and maintain forest areas. The NDC scenario could maintain the forest area around 81 million ha by 2030 compared to only around 77.8 million ha under the BAU scenario (Table 10).

Table 10. Total forest area under all scenarios, 2010-2030 (Million ha).

|       | 2010   | 2015   | 2020   | 2025   | 2030   |
|-------|--------|--------|--------|--------|--------|
| Low   | BAU    | 87.88  | 86.73  | 84.83  | 81.97  | 77.84  |
|       | NDC_1  | 87.88  | 86.85  | 85.46  | 83.62  | 81.27  |
|       | NDC_2  | 87.88  | 86.87  | 85.48  | 83.63  | 81.26  |
| High  | BAU    | 87.88  | 86.73  | 84.83  | 81.97  | 77.81  |
|       | NDC_1  | 87.88  | 86.85  | 85.43  | 83.55  | 81.14  |
|       | NDC_2  | 87.88  | 86.87  | 85.48  | 83.63  | 81.27  |

4. Conclusion
The emission reduction was more difficult to achieve under the lower and slower economic growth. Although higher economic growth would lead to higher emission, the economic resources might also be adequately high to support the mitigation activities.

For land sector, the mitigation policy could not directly reduce the emission because it would depend on the land demands that would lead to land conversion. This signified the importance of considering land demands and land conversions as a step before calculating the emissions from the land use change. The simulation results also suggested there was a high dependency of Indonesian economy on some commercial crops, as with higher economic growth, land required for those commodities were also increased as compared when the economic growth was lower.

Furthermore, the simulation also showed that mitigation policy for land sector should be maintained to control further land exploitation. Moreover, land productivity improvement would also increase the output, and it would help to uphold economic growth. For future studies, it was suggested to introduce the detail of mitigation technology from each sector. It is also crucial to introduce the use of biofuel and biomass in energy that will highly relate to land sector, as well as consideration of emission from peatland; future studies need to find a better method for calculating emission and land use for peatlands.

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APPENDIX
Appendix A1. Macroeconomic Variables under all Scenarios (Trillion IDR)
Appendix A2. Total Area in Mineral Land under each Scenario (ha)
Appendix A2 (Cont.)