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Synchronising Ministry of Agriculture Target with Emission Mitigation Action Target: Case Study of Indonesia Towards 2030

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The Indonesian government has constructed some emission mitigation schemes, one of which is the Nationally Determined Contributions (NDC) scheme for the post-2020 emission reduction scheme. This research has tried to examine the impact of those emission reduction schemes on Indonesian economics and how they can synchronise with the Indonesian Ministry of Agriculture target to boost agricultural production towards 2030. Using the Computer General Equilibrium (CGE), we tried to construct a mathematical model with which to calculate the impact of emission mitigation actions from agricultural land management. The result shows that every investment in emission mitigation actions can help to reduce the Gross Domestic Product (GDP) loss on some level in comparison to if Indonesia carried out emission reduction without implementing any mitigation actions. It is assessed that Indonesia will experience approximately a 6.92 % (260.8 billion USD) GDP loss in 2030 through cutting emissions by 29 %. The introduction of mitigation technology will reduce this. Comparing all scenarios in the model, the GDP loss under INDC2 (implementing comprehensive mitigation technology in agricultural sectors) in 2030 is 2.98 % (260.7 billion USD). One of the most interesting results is that we found no significant impact of climate policies on the economy until 2020. This is probably because even though Indonesia has already published the regulation on emission reduction, the implementation of the policies effectively started in 2015. Climate-related policy and investment are usually big and timely projects, so the simulation predicted that the impact could be seen after 2020. This finding can be a signal for Indonesia in boosting investment in emission mitigation technologies. It will otherwise lead to two probabilities: the emission reduction target cannot be met or the investment that should be made will be very costly and pose a big burden on Indonesian economics due to the very limited period.

1. Introduction

Indonesia has become one of the most vulnerable countries affected by climate change and it may cause critical damage to the agricultural production trend (Quincieu, 2015). At the same time, Indonesia has also become one of the biggest GHG emitters worldwide (Arga, 2007) and the most significant emission in Indonesia stems from the Agriculture, Forestry, and Land Use Change (AFOLU) sector, which contributes approximately 60 % of total emissions in Indonesia (Pribadi & Kurata, 2017). The Government of Indonesia (GOI) has established a policy on Agriculture and Climate Change Mitigation. With regard to climate change, all ministries should follow the Presidential Regulation for a National Action Plan for Reducing Greenhouse Gas Emissions (commonly called RAN-GRK). This Presidential Regulation is based on the GOI's international commitment to a 26 % reduction in GHG emissions below the "Business-as-Usual (BaU)" level by 2020, based on unilateral actions. A further reduction of up to 41 % below BaU will be made if adequate international support is made available to the Government of Indonesia. After 2020, all ministries and industries will follow the target based on Indonesian Intended Nationally Determined Contributions (INDCs), which targeted reducing emissions by 29 % from BaU unconditionally or 41 % with international support by 2030. At the same time, Indonesia has already targeted being a developed country and one of the economic powers in Asia by 2030. One official document which stated this target is the Master Strategy of Agricultural Development 2013 -

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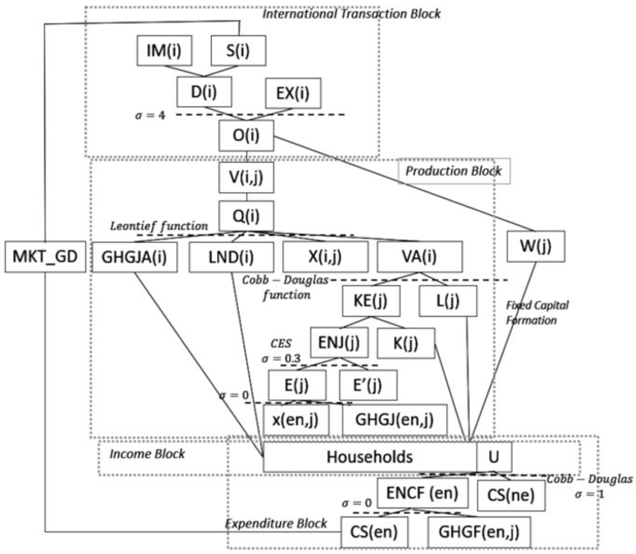
2045 issued by the Ministry of Agriculture. In general, these policies aim to reach sustainable self-sufficiency of some primary products. Indonesia should achieve all of these targets in the future in relation to both economics and emission reduction. Focusing on mitigation actions in agricultural land management, this study will try to achieve some objectives – To examine the impact of mitigation technologies in the agricultural sector on the Indonesian economy, examine whether the target regarding both economics and emission reduction can be achieved under the INDC scheme, and to examine the cost of taking such mitigation actions.
There is still very limited study related to the emission mitigation impact in the land-based sector, including the agricultural sector. The latest research related to Indonesian conditions only captures the impact of GHG mitigation actions until 2020 and has shown that the 2020 target is not economically rational for Indonesia (Hasegawa et al., 2016). In another South East Asian country, land-based-related research was conducted by Miphokasap (2017) to assess CO_2 removals from land sectors in Thailand. Although this research did not mention any economic impact of mitigation actions and the introduction of mitigation action itself, it shows the importance of land-based mitigation measurements, including those in the agricultural sector. This research will focus on the economic impact of emission mitigation actions in the agricultural sector after 2020 under the INDC scheme.

2. Methodology and Scenario

2.1 Model Structure

2.1.1 Production block

There are 32 sectors in this model, five of which are AFOLU sectors. These 32 sectors are aggregated from the more detailed Indonesian input–output table, which has 185 sectors. In production blocks, each producer maximises its own profit subject to the production function in each sector. The relations between every sector are described as Figure 1 below.



Code	Definition
O(i)	Total domestic production goods i
V(j,i)	Produced goods i in sector j
D(i)	Domestic supply of produced goods i
S(i)	Total supply of goods i
EX(i)	Export goods i
IM(i)	Import goods i
Q(i)	Production of goods i
K(i)	Capital input of goods i
X(en,j)	Energy goods from energy use in sector j
VA(j)	Value added, including energy in sector j
L(j)	Labour input in sector j
KE (j)	Energy capital composite in sector j
LND (j)	Land in sector j
GHGJA(j)	GHG emissions from activity in sector j
ENJ(j)	Aggregated energy input in sector j
E(j)	Energy from energy sector j
GHGJ(en,j)	GHG from industry
X (ne,j)	Intermediate input of non-energy goods (ne) in sector j
ENCF(en)	Composite of energy in household sector
GHGF	GHG in household
CS(ne)	Final consumption of non-energy goods
CS(en)	Final consumption of energy goods
MH	Household income

Figure 1: The relations and structure between each sector in the CGE model

The production block is disaggregated into sub-sectors using the existing capital stock and the new capital stock. Each sub-sector has a nested production function. The top of the nested function assumes the Leontief production function. In this part, the total input costs are equal to total sales. The second nested integration is the value added. In this model, value added consists of capital, labour and energy. The third nested part is the connection between the capital and energy composite in each sub-sector. In the existing sub-sector, the capital cannot move to the sector, the capital in each sector is differentiated. The energy composite is aggregated into individual energy inputs using the Constant Elasticity of Substitution (CES) function. The energy input consists of intermediate energy input and CO_2 emissions.
The production in the new investment sub-sector also has a similar structure. In this sub-sector, the capital to be inputted is moveable among the sectors. It is also assumed that efficiency and other parameters for new investment are improved compared to those of the existing capital. The top of the nested function has assumed the Leontief production function.

2.1.2 Household block

The household sector receives income from endowment such as capital, labour, land, and GHG emissions. Trade surplus and valuable waste generation are also assessed in relation to the income level. In this model, fixed capital formation is calculated from the future GDP growth in advance. The utility of the household sector is defined by the non-energy final consumption of the non-energy commodity. In this study, the utility function has assumed the Cobb–Douglas function, the elasticity of substitution among the non-energy final consumption is set to be 1. From this assumption, each final consumption is calculated from the income level of households and commodity goods.

2.1.3 Relationship between output, export, and the domestic market

In this model, the elasticity of transformation of produced goods between export and domestic markets is assumed to be constant. From this function, the values of exports and domestic goods are calculated from the total produced goods and their prices.

2.1.4 Relationship between the domestic market, import, and total supply to the domestic market

In this model, it is assumed that the elasticity of substitution between imported goods and domestic goods is also constant.

2.1.5 Trade balance

In this model, international commodity prices (prices of export and import) and trade surplus are assumed to be exogenous parameters.

2.1.6 Market equilibrium

The last part is the market equilibrium. There are five equilibria available in this model: production market, market goods, market of capital, market of labour, and market of GHG.

2.2 Data

2.2.1 Input–output table

The input–output table (I–O table) provides data for intermediate demands, final demands, and value added. In Indonesia, the I–O table is published every five years, and the latest available example is the 2010 table. The table consists of 185 sectors; these sectors are aggregated to 32.

2.2.2 GHG inventories and Land Area

GHG inventory data are used to provide GHG emissions by activities per sector. For the Indonesian case, data for GHG inventories are taken from an official document of the UNFCCC Submitted Biennial Update Reports (BURs). The data consist not only of CO_2 gas but also of other GHG gases, such as CH_4 and NO_2. The GHG inventory data themselves provide details of emissions for the energy, industry and transportation, agriculture, forestry and waste sectors. For this study, the data are aggregated similarly to the sectors in the aggregated input–output table. Moreover, in this model, the land is assumed to be one of the inputs provided by households, and households also gain income by providing this factor. Data on land area in this research comprise data on land areas for the specific sectors gained from the FAOSTAT database and the Indonesia Statistic Bureau (BPS).

2.3 Indonesian Economic Target Based on Master Strategy of Agriculture 2013 - 2045

In this study we use the long-term economic goal as stated in the Master Strategy of Agriculture 2014 – 2045 (Table 1). The reason for choosing this document as the policy benchmark is that it has a specific long-term target which also passes the INDC target year. In this document it is mentioned that Indonesia wants to expand its economic achievement and become a higher middle-income country by 2030. It is also stated that Indonesia is expected to achieve food and energy sufficiency as well as sustainable economic development. In the Master Strategy of Agriculture, it is mentioned that by 2030 Indonesia should have achieved 3,654.5 billion USD in GDP, with the total population comprising 309.1 million people.

Table 1: Summary of Indonesian economic target in Master Strategy of Agriculture

Indicator	Unit	2010	2020	2030	2040
Population	million people	237.5	273.5	309.1	344.4
GDP	billion USD	712.8	1,569.1	3,654.5	6,889.0
GDP/capita	10^3 USD	3.0	5.7	11.8	20.0

Source: Ministry of Agriculture (2014)

2.4 Scenario and Study Limitations

In this study, Indonesia has implemented the INDC policy. The INDC policy itself is a post-2020 emission reduction policy aiming towards 2030. By this consideration, it is assumed that there are six scenarios in this study:

BaU : Without any emission reduction policy
INDC : Emissions begin to be limited to achieve the 29 % reduction target (INDC scheme)
INDC1-01 : INDC + partial mitigation technology in the paddy sector
INDC1-02 : INDC + partial mitigation technology in the soil management sector
INDC1-03 : INDC + partial mitigation technology in the livestock sector
INDC2 : INDC + all mitigation technologies introduced

The BaU scenario is describing a condition in which Indonesia does not perform any mitigation actions until 2030. In the INDC scenario, the Indonesian government is implementing the policy so as to reduce emissions by 29 % by 2030. In INDC1 scenarios, either INDC1-01, INDC1-02 or INDC1-03, partial mitigation technology is implemented in either the paddy, soil or livestock sector. In the INDC2 scenario, all of the mitigation technologies in the agricultural sectors are implemented. There are several mitigation technologies, depending on the emission sources. All of them also have emission reduction, which is described by its adjustment emission coefficient. Due to the temporal and data limitations, only a few selected mitigation technologies have been chosen:

Paddy : Replacing urea with ammonium sulphate and midseason drainage
Soil Management : High-efficiency fertiliser application
Livestock : Dome digester to make biogas

There are also some research limitations. In this study we only assume that the mitigation technology implemented is from the agricultural sector; the mitigation technology began to be implemented and work in 2015.

3. Results and Discussion

By introducing a GHG emission reduction constraint, a country usually experiences the GDP loss due to the reduction in output production. It is assessed that Indonesia will experience approximately a 6.92 % GDP loss in 2030 (from 3,769 billion USD to 3,508 billion USD) after implementing the INDC scheme. The introduction of mitigation actions will reduce the GDP loss. Comparing all scenarios in the model, the GDP loss under INDC2 in 2030 is 2.98 %, which is the lowest compared to other scenarios, and it will cause the GDP to be approximately 3.66 trillion IDR. This is followed by INDC1-02 (4.60 %), INDC1-01 (5.57 %) and INDC1-03 (6.60 %). The details can be seen in Table 2.

Table 2: Summary of simulation results of all scenarios in 2030

Scenario	Carbon Price (hundred USD)	GDP (Billion USD)	GDP Loss (Billion USD / Percentage)	Consumption Level (Billion USD)	GHG Emission (10^3 t CO_2-eq)		
					CH_4	N_2O	CO_2
BAU	-	3,769.2	-	3,095.3	247.8	260.8	2349.1
INDC	2.39	3,508.4	260.8 / 6.92 %	2,844.1	250.2	198.6	1567.5
INDC1-01	2.03	3,559.2	210.0 / 4.60 %	2,890.6	201.9	212.4	1601.9
INDC1-02	1.97	3,595.9	173.3 / 4.60 %	2,926.5	269.3	134.3	1612.6
INDC1-03	2.30	3,520.4	248.8 / 6.60 %	2,856.1	240.9	201.4	1573.9
INDC2	1.48	3,656.8	112.4 / 2.98 %	2,987.6	196.8	136.7	1682.8

The results of the GDP loss itself can be explained by the increase in GHG prices through the introduction of GHG emission reduction. The GHG price indicates the abatement cost by introducing the emission reduction. Once the emission reduction constraint is introduced, the price of GHG will increase. To reduce the emission by 29 % by 2030 from the BaU level, the price of GHG in 2030 will increase to 2,400 USD/t CO_2-eq. The higher price of GHG will cause all sectors to reduce the production of GHG-intensive goods and services. This is the reason why under the high GHG price, the output will decrease. This will lead to a higher GDP loss.

By comparing all scenarios as shown in Figure 2, the lowest GHG price is found under the INDC2 scenario (1.5 hundred USD/t CO_2-eq), followed by INDC1-02 (1.9 hundred USD/t CO_2-eq), INDC1-01 (2 hundred USD/t CO_2-eq) and INDC1-03 (2.3 hundred USD/t CO_2-eq). It means that the implementation of mitigation action will introduce GHG reduction potential; as a result, a lower GHG price will be observed. Higher GHG prices will lead to output reduction because all sectors tend to be reducing their production of GHG-intensive products. The higher the carbon prices, the greater the output reduction, which will lead to a higher GDP loss. This is the reason why under the INDC2 scenario, the GDP loss is lower than in any other scenarios introduced.

Indonesia is also a country whose economy is supported by a high level of consumption. It is also considered important to see the consumption loss caused by the emission reduction policy (Supriatna, 2017). Emission reduction policies will reduce consumption to a certain extent. This is because the increase in GHG price will lead to the increase in the price of services and goods which produce high GHG emissions. The increase in price will reduce the demand from consumers and lead to a consumption loss. Scenario INDC2 has the lowest consumption loss compared to the other scenarios; it only reduces consumption by approximately 3.5 % from the BaU level in 2030. It is relatively low compared to the INDC scenario, whose consumption loss may reach 8.1 % from the BaU level in 2030 (from 3,095 trillion USD under BaU to 2,844 billion USD under INDC). The result is followed sequentially by lower consumption loss to high consumption loss scenarios: INDC1-02 (-5.5 %), INDC1-01 (-6.6 %) and INDC1-03 (-7.7 %). It can also be summarised that mitigation technologies will reduce the consumption loss of consumers.

Another benefit of introducing mitigation technologies in agricultural sectors is that it will maintain the output from AFOLU sectors. Compared to BAU sectors, the output in AFOLU sectors decreases from 779 billion USD from the BAU level to 711 billion USD under the INDC scenario in 2030. Introducing mitigation technologies in agricultural sectors will reduce the emissions of these sectors without reducing production and will bring about the output increase to 926 billion USD in 2030 under the INDC2 scenario.

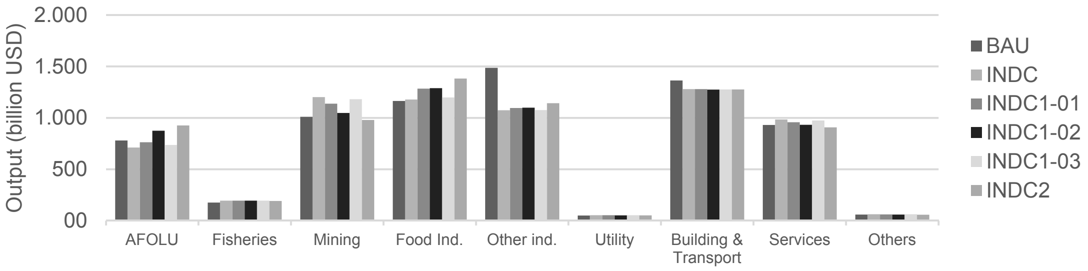


Figure 2: Sectorial output comparison in each scenario in 2030

Another sector that has a close relation with agriculture is the food industry. The main inputs from this industry come from agricultural sectors. In 2030, through the implementation of the INDC scheme, the food industry will still experience a slight increase in production (from 116.35 billion USD under the BAU scenario to 117.83 billion USD). In line with the increase in output in AFOLU sectors under the INDC2 scenario, the output from this industry also increases more under this scenario (to 138.25 billion USD). For Indonesia, especially for the Ministry of Agriculture, this result is satisfying because it is stated in their target to boost the production of agro-industries, which in Indonesia are dominated by the food industry, by 2030.

Industry sectors are considered the sectors which produce GHG-intensive products. By introducing emission reduction policy under the INDC scenario, output from this sector is predicted to decrease significantly from 148.65 billion USD under the BAU level to 107.36 billion USD under the INDC scheme by 2030. Simulation results show that mitigation technologies in agricultural sectors can help industry sectors to reduce the output loss. Under the INDC2 scenario, other industry sectors' outputs will reach 114.23 billion USD by 2030. This is because the emission reduction burden faced by industry is decreased through the introduction of mitigation technologies in agricultural sectors. Once mitigation technologies are introduced, they will not only maintain the production of AFOLU sectors themselves, but also help other sectors, e.g. industry sectors, not to reduce their production at a very high level. Another important result gained from this study is the mitigation technologies in agricultural sectors treated in this study are noticeable in reducing the CH_4 and N_2O emissions.

3.1 CH_4 and N_2O emissions

The CH_4 emissions in the agricultural sector mainly stem from urea use in agricultural sectors. This is the reason why the CH_4 reduction under INDC1-01 in the paddy sector is bigger than those in INDC1-02 and INDC1-03. The other scenarios will produce a higher CH_4 emission increase than the BaU level. This is because the main emission of CH_4 in agricultural sectors is mainly found in the paddy sector, which is due to the high use of urea fertiliser to accelerate the growth of the paddy. Introducing mitigation technology in the paddy sector will, of course, cut the emissions of this sector. Another CH_4 emission from agricultural sectors stems from livestock because their manure can emit levels of CH_4 emission. Based on this simulation, mitigation technology in livestock under the INDC2-04 scenario cannot provide a CH_4 emission reduction which is as high as under the INDC2 and INDC1-01 scenarios.

N_2O emissions from agricultural sectors mainly come from soil cultivation by using nitrogen fertiliser. Based on the simulation, the biggest N_2O emission can be achieved through mitigation technology in the agricultural sector (INDC1-02). This is because the emission in technology involves soil management technology by replacing the single content fertiliser with multi-content fertiliser. By using multi-content fertiliser, the amount of fertiliser used for agriculture can be cut, which will lead to the high N_2O emission reduction in this field. The second-highest N_2O emission reduction scenario is under the INDC2 scenario. INDC, INDC1-01 and INDC1-03 scenarios can also reduce N_2O emissions from the BaU level, albeit not at as significant a level as under the INDC2 and INDC1-02 scenarios.

3.2 CO_2 emissions

CO_2 emission is the major GHG emission. It is important to reduce the CO_2 emission from the BaU level. From all scenarios, the INDC scenario and INDC1-03 are better for CO_2 emission. The INDC2 scenario is relatively ineffective in CO_2 emission reduction compared to other scenarios available. The reasons for this result are likely the following: 1) The main sources of emission in agriculture are CH_4 and N_2O, and 2) By introducing more mitigation technologies, it also means additional inputs from the other sectors involved, which means that another sector might produce more of their product in order to support the mitigation technology. Under the INDC2 scenario, chemical industries produce more ammonium sulphate fertilisers so as to support mitigation technology in the paddy sector and produce more multi-content fertilisers in order to support agricultural land management. Chemical industries will increase their total production, leading to an increase in CO_2 emission. In short, the INDC2 scenario will reduce the emissions of non-CO_2 emissions; as the replacement, it cannot reduce the high level of CO_2 emissions. From all scenarios, INDC1-03 can reduce more CO_2 emissions than can INDC1-01 and INDC1-02.

4. Conclusion

In this study, we tried to simulate the role of implementing the emission mitigation technology to Indonesia economics. We found that by introducing the mitigation technology in agricultural sectors, we can minimise the GDP loss inflicted by the establishment of INDC scheme by 3.94 %. Another interesting finding is we predict that the implementation of mitigation technology in agriculture will take around 3 - 5 years until it shows its effect on the economics. We believe that the government should start to implement the technology as soon as possible, because of the land-based projects, including projects in agriculture, are mostly time-consuming projects. We are noticing that another big problem for the developing countries like Indonesia is the matter of budget availability. From our simulation result, the alternative way for the GOI is to implement partial mitigation policy. The total GHG reduction amount will be the same, but in a different proportion of CO_2 and non-CO_2 emission, also the GDP lost will a little bit higher compared to fully implementing the mitigation technology. We recommend the INDC1-02 scenario (implementation of mitigation technology in soil management) as the next alternative when the GOI budget is not sufficient for executed the INDC2 scenario. It is only able to minimise the GDP loss by 2.32 %, 1.62 % lower than INDC2 scenario. We realise that assessing only agricultural sector is not enough, future research should assess AFOLU sectors in a whole.

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