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Palm oil and likely futures

Assessing the potential impacts of zero deforestation commitments and a moratorium on large-scale oil palm plantations in Indonesia

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Key messages

- This brief examines two contrasting policy options: the implementation of zero deforestation commitments by the private sector and a complete moratorium on the expansion of large-scale oil palm plantations, and compares them to a situation without policy action.
- The zero deforestation commitments and the moratorium on large-scale oil palm plantations expansion could reduce cumulative deforestation by 25% and 28%, respectively, compared to a situation without policy action. They could also cut greenhouse gas emissions from land use and land-use change by 13% and 16%, respectively, over the period 2010–2030.
- Even under the zero-deforestation and moratorium scenarios, Indonesia is projected to increase palm oil production between 124%–97% over 2010–2030, which is partly due to higher production originating from smallholders.
- Both measures – the zero deforestation commitments and a moratorium of future large-scale oil palm plantations expansion – would be especially beneficial to limit future deforestation in Indonesia in a context in which global demand for palm oil is expected to keep increasing.
- Foresight tools can equip stakeholders and policy makers with data and information to allow for evidence-based policy making. This will permit planning for reducing deforestation and greenhouse gas emissions, and finding options acceptable to all stakeholders involved.

Background

Oil palm has expanded significantly over the past few years in Indonesia. As a result, the country has become the major producer of palm oil in the global market. This expansion, however, has ignited an important controversy due to its contradictory impacts. On the one hand, oil palm expansion has delivered important economic development, including indirect benefits for local infrastructure development and rural poverty reduction. On the other, the palm oil sector's development has often come at the expense of local communities that have been evicted from their lands. It has also been to the detriment of biodiverse, carbon-rich tropical forests, and led to loss of precious primary forest and peatland ecosystems due to fire (see Sheil et al. 2009; Sayer et al. 2012). In this context, it is often argued that oil palm is a very efficient crop with high productivity per hectare compared to other oil crops (Rival and Levang 2014).

A number of studies have revealed oil palm expansion as a key driver of deforestation in the past. Previous studies have estimated a staggering 6 million ha of forest loss between 2000 and 2012 in Indonesia, with an increasing rate of primary forest loss in recent years (Margono et al. 2014). The contribution of oil palm to total deforestation is still controversial, and it varies across provinces. For example, in Kalimantan, Gunarso et al. (2013) estimated that 43% (1.2Mha) of industrial oil-palm plantations were developed at the expense of forests (old-growth and selectively logged natural forests). Carlson et al. (2012) estimated the palm oil industry caused 27% of the total deforestation by 2008, of which 40% took place in wetland areas. In turn, an analysis of forests cleared directly for oil palm between 1973 and 2015 estimates a higher proportion of oil palm was developed on already cleared degraded lands (a legacy of recurrent forest fires). Yet a rapid conversion of forests to industrial plantations, primarily oil palm plantations, was observed since 2005 (Gaveau et al. 2016).

While many studies focus on the *ex post* assessment of deforestation, little has been done to investigate deforestation *ex ante*. This is particularly true about the potential of policy decisions by the private sector with regards to zero deforestation. Similarly, little is known about the likely effect of state policies associated with a moratorium to prevent further development of large-scale oil palm plantations.

These knowledge gaps are important. Many agree that the future of the palm oil sector will be linked increasingly to a more complex policy regime that is emerging. This regime involves both state regulations and private sector standards, including zero deforestation commitments (Pacheco et al. 2017). The latter are related to pledges by the main palm oil corporate groups, including traders, to delink their supply from deforestation. In this context, land-use models that represent both the agricultural and forestry sectors can provide a holistic view of the implications of these initiatives. Such implications include impacts on deforestation and palm oil production, as well as possible effects on other sectors in the future.

We use the Global Biosphere Management Model (GLOBIOM, Havlík et al. 2014), developed at the International Institute for Applied Systems Analysis (IIASA), to understand the effects of policy decisions on palm oil expansion in Indonesia. For this study, we updated and refined the model using best available data. We analyze the impacts of zero deforestation commitments and a likely moratorium to prevent further large-scale oil palm plantations on deforestation, on agricultural production, trade and greenhouse gas (GHG) emissions under different world palm oil demands by 2030. This *ex ante* assessment would allow policy makers to base their considerations on past developments, and also provide a tool to compare future deforestation against alternative policy options.

Improving the land-use model

GLOBIOM is a global partial equilibrium model integrating the agricultural and forestry sectors into a bottom-up setting based on detailed spatially explicit information. Production is represented for 18 crops, 4 livestock types, sawn wood, and wood for pulp and paper. Demand is driven by population growth and economic growth, as well as dietary preferences for food. Either local production or imports can satisfy demand in a region, according to the relative competitiveness of production in each of the 31 world regions, tariffs on imports and transportation costs. GLOBIOM is run recursively in 10-year time steps starting in 2000. For each time-step, land use is allocated to grid cells in order to maximize total consumers' utility and producers' profits under resource and market constraints.

For the assessment of policy options and zero deforestation commitments, Indonesia is represented as a single economic region; GLOBIOM is updated with the best available data for this region. Specific information included corresponds to: (1) the land cover map of the Ministry of Forestry (KLHK), (2) information for large-scale oil palm plantations from Gunarso et al. (2013) for Sumatra and Papua and from Gaveau et al. (2016) for Kalimantan, and (3) statistics for area and production of crops[1] and number of heads and production of four animal types at Kabupaten level for the whole of Indonesia between 2000 and 2009 from the Ministry of Agriculture (Kementan).

GLOBIOM-Indonesia distinguishes the following land-use classes: cropland, grassland, plantation forests, large-scale oil palm plantations, managed forests, unmanaged forests, and other natural land that might also include degraded land. Large-scale plantations are above 100-ha blocks of oil palm trees planted in lines. They can be detected on satellite images due to their distinctive geometric shape and their grid-like patterns (Gaveau et al. 2016).

We harmonized data and included them in GLOBIOM at the simulation unit level. These are polygons between 5 and 30 arcmin (10^{-1} to 50^{-1} km), encompassing cells of similar soil, altitude and slope characteristics. The land cover map is harmonized with the statistics for each simulation unit. For example, in the context of agriculture, the sum of cultivated area by crop is equal to the total cropland. Cropland also includes smallholder oil palm plantations. Similarly, for livestock, the grazed area by ruminants should be proportionate to the total grassland area. Representation of oil palm in the model is further refined by differentiating oil palm yields and area between large-scale oil palm plantations and smallholder oil palm growers. Combining the different datasets available for the year 2001, we assume that large-scale plantations planted around 4 million ha of oil palm and that smallholders planted 1.2 million ha.

We calculated GHG emissions from three main sources: land conversion, peatland drainage and agriculture. Deforested areas are identified as the sum of all land-use changes from unmanaged forests to cropland, large-scale oil palm plantations, and grassland. GHG emissions from deforestation

1 The crops represented for Indonesia are corn, rice, sweet potato, dry beans, soybeans, groundnuts, cashew nuts, cassava, coffee, cotton, oil palm, sugar cane, cocoa, rubber, tea, tobacco, vanilla, pepper and candle nut.

are computed using the carbon map of Baccini et al. (2012) for above ground biomass (with 25% of it for below ground living biomass). Other emissions are related to conversion of other land uses (e.g. natural land) to cropland and grassland. A peatland map is used to calculate the share of each land-use class in peatland in each simulation unit. Then the hectares of forest or other natural land conversion towards oil palm are multiplied by the share of peatland in that location. We consider a steady emission factor of 60.8 tCO_2 eq per ha and year for emissions related to oil palm expansion on peatland (Valin et al. 2014). Since peatland continues to emit GHG even decades after conversion, the area of peatland-related emissions cumulates over the years. We account for biomass in tree crops such as oil palm, cocoa and rubber. Emissions from the agricultural sector account for livestock enteric fermentation and manure, rice cultivation and fertilizer use. We also use a factor of 48 tCO_2 eq per ha per 10 year-time step for carbon sequestration in tree crops.

The comparison of GLOBIOM projections against historical development gives us confidence in the ability of the model to reproduce past trends. We see that model estimates of past deforestation over 2000–2010 are in line with numbers reported by Margono et al. (2014) at the national level (Figure 1, left). For the final use of palm oil, the model tends to underestimate exports growth and overestimate local consumption growth. However, the evolution of production fits quite well with past trends reported by the Food and Agriculture Organization of the United Nations (FAO) (Figure 1, right).

Moreover, from the model results, large-scale oil palm plantations increased by 4.6 million ha (Mha) between 2000 and 2010. This included increases of 2.2 Mha in Kalimantan, 1.5 Mha in Sumatra and 0.7 Mha in Papua. For Kalimantan this is consistent with observations based on satellite images from Carlson et al. (2012) (2.3 Mha) and Gaveau et al. (2016) (2.2 Mha). For Sumatra, it is close to observations from Gunarso et al. (2013). They estimate that industrial oil palm plantations expanded by 1.8 Mha in Sumatra between 2000 and 2010. The model does overestimate industrial oil palm plantations expansion in Papua.

We underestimate peatland conversion. Margono et al. (2014) estimate that 2.6 million ha of forest in wetland have been converted over 2000–2012 i.e. 43% of total deforestation. We project a conversion of only 1.5 million ha over the entire 2000–2030 period. This leads to an underestimation of GHG emissions from peatland conversion in our results.

In the assessment of no-deforestation commitments of large-scale oil palm plantations, we use the population and gross domestic product (GDP) projections from the SSP2 scenario developed for the 6th Assessment Report of the IPCC (AR6).[2] In this middle-of-the-road scenario, the population of Indonesia is expected to rise by 30% in 2030 compared to 2000 and GDP per capita is expected to multiply by four.

Assessing different constraints on expansion of large-scale oil palm plantations

Different constraints are set to depict varying scenarios of large-scale oil palm plantation expansion (Table 1). However, no

2 See https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=about

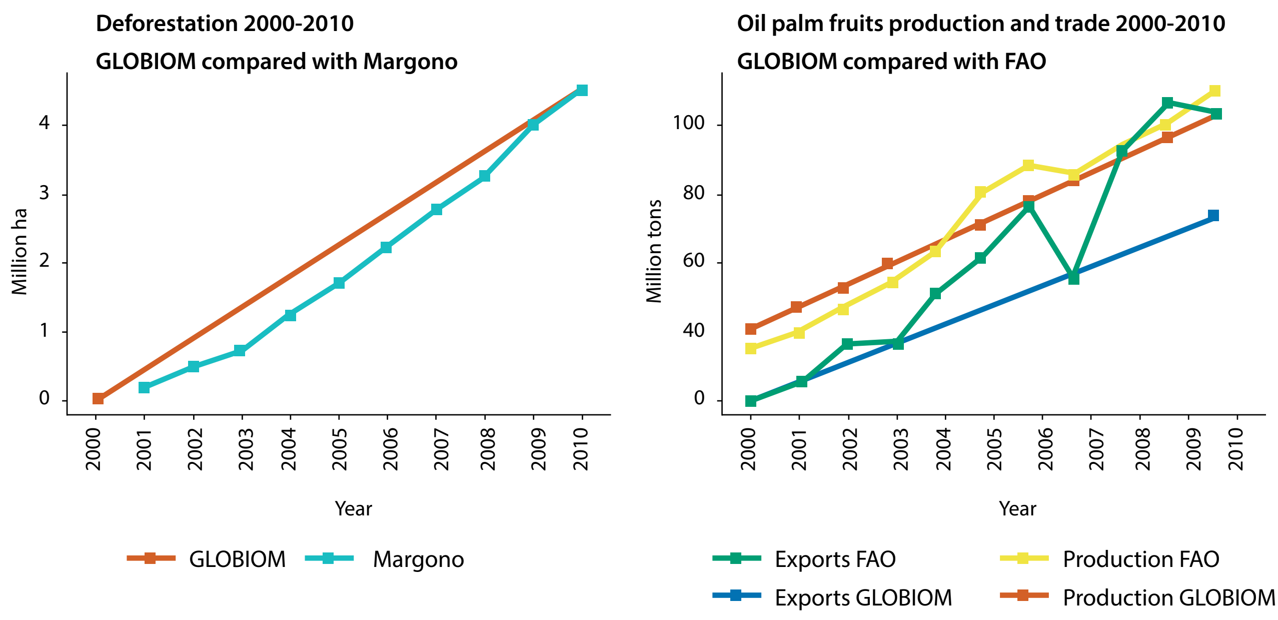


Figure 1. Projected past deforestation trend compared with Margono et al. (2014) and palm oil production and net exports compared with FAO

Table 1. Expansion constraints of large-scale oil palm plantation beyond 2015 in the different scenarios

Scenario	Description
Base	Large-scale oil palm plantations can expand to any other land cover if it is economically profitable
Zero deforestation	Large-scale oil palm plantations can expand to any other land cover except forests and peatland if it is economically profitable
Oil palm moratorium[a]	Large-scale plantations cannot expand oil palm planted area above the 2015 level

a This scenario should not be confused with the presidential instruction number 8 year 2015 that prohibits new license issuance – not limited to oil palm plantation — in primary forest and peatland areas. Instead, this scenario prohibits expansion of large-scale oil palm plantation in all land cover types, including those that might have been designated for agriculture use.

constraints are set for the expansion of smallholder farms in any of the scenarios.

With world demand for oil palm rapidly increasing, oil palm production has proven to be a major driver of past deforestation in Indonesia. Future deforestation therefore depends on the evolution of demand for palm oil, most of which comes from outside Indonesia (Corley, 2009). Considering the uncertainty around demand, we apply three potential scenarios for the rise in world demand for oil palm: low, medium and high. Demand increased by 80% between 2000 and 2010. Between 2010 and 2030, world consumption is projected to increase by 33% in the low growth scenario, by 62% in the medium growth scenario and by 94% in the high demand scenario.

Figure 2 shows the evolution of deforestation, natural land, cropland and grassland for different levels of world palm oil demand, and with or without implementation of zero deforestation commitments or moratorium. Depending on the evolution of world palm oil demand and the scenario, GLOBIOM projects that between 7.5–21.1 million ha of forests will disappear over 2010–2030.

The combination of the base and the low growth of world palm oil demand scenarios leads to about the same average annual deforested area as observed over 2000–2010. Average annual deforestation is increased by 70% with a medium growth scenario and more than doubled with a high growth of global palm oil demand. Without any policy action, natural land will also decrease a lot: our results show a 49%-69% loss between 2010 and 2030 depending on the global demand for palm oil. From our results, zero-deforestation and moratorium on the expansion of new large-scale palm oil plantations could significantly reduce cumulative deforestation and loss of other natural land between 2010 and 2030, especially if the world demand for palm oil is high. The zero deforestation scenario could cut deforestation between 16%–44%, and the oil palm moratorium scenario by 14%–47%.

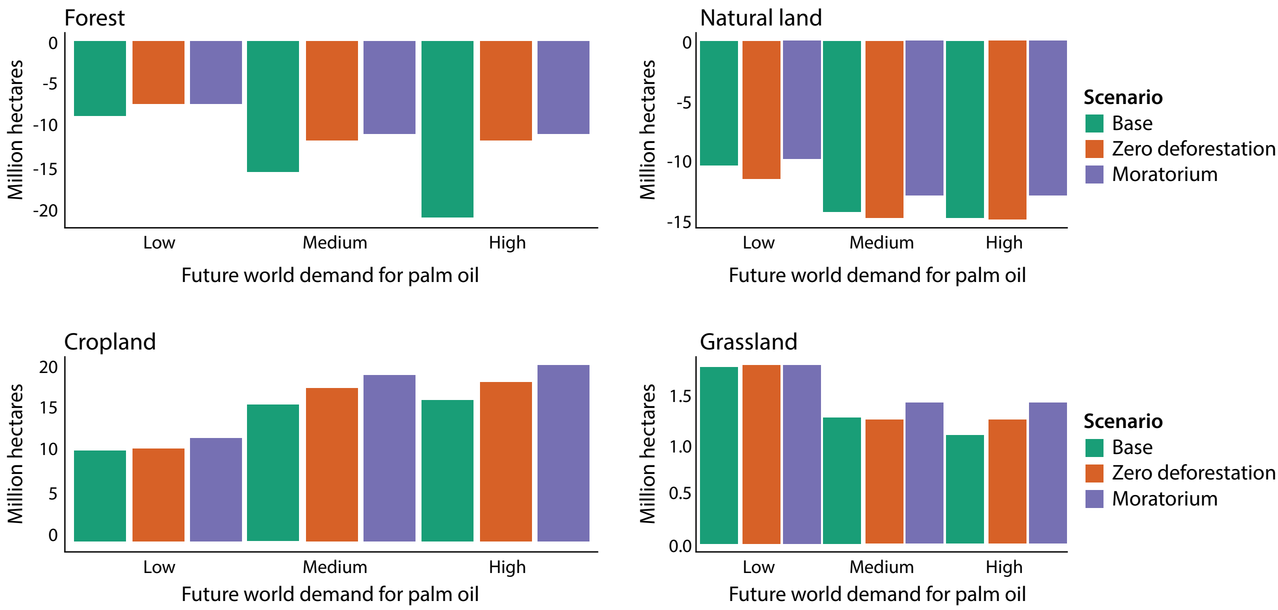


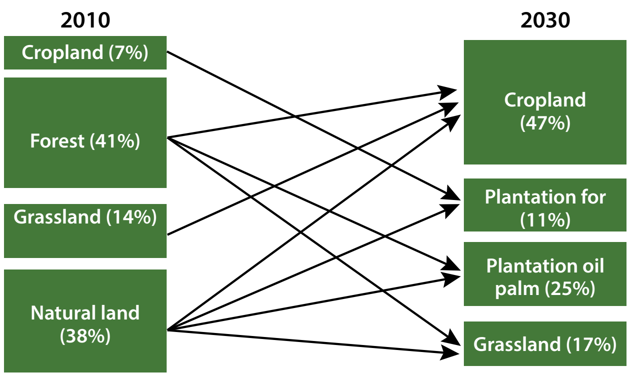
Figure 2. Cumulative land-use change for forest, other natural land, cropland and grassland by scenario in a context of low, medium or high world palm oil demand over 2010–2030

In the medium growth scenario of world demand, large-scale oil palm plantations continue expanding by 7.3 Mha between 2010 and 2030 in the base scenario. With a factor increase in the total area of land cultivated with oil palm of 3.5 over 2000–2030, we are close to the numbers of Carlson et al. (2012) of 3.5 for the whole of Kalimantan and 3.7 of Sumarga and Hein (2016) in Central Kalimantan.

In the zero deforestation scenario, expansion is limited to 4.4 Mha; in the moratorium scenario it is fixed to zero. However, the negative impact of the zero-deforestation and no-expansion constraints towards oil palm fruits production is partly compensated by two factors. First, there is a higher conversion of other natural land into large-scale oil palm plantations. Second, there is an increase of small-scale oil palm plantations in our simulations (Figures 2 and 3).

In a context of medium growth of world demand for palm oil, the additional expansion of industrial oil palm plantations to other natural land in the zero deforestation scenario is about 0.6 Mha. This represents only 11% of the total expansion to forests in the base scenario. We also observe an additional increase of 2 Mha of oil palm area cultivated by smallholders in the zero deforestation scenario and 4 Mha in the oil palm moratorium scenario compared to the base scenario to compensate for the reduction of large-scale oil palm plantations (Figure 4). Due to lower productivity of smallholders, this does not fully compensate for the loss in production due to restriction on large-scale oil palm cultivation (Figure 4). However, the decrease of production is limited to 17% and 28% for the zero-deforestation and oil palm moratorium scenarios, respectively, compared to the base scenario. In fact, despite a zero-deforestation constraint,

a. Land cover transitions in the base scenario



b. Land cover transitions in the zero deforestation scenario

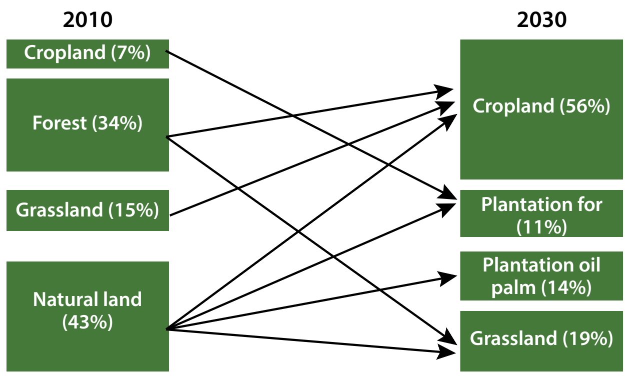


Figure 3. Land cover change between initial land cover in 2010 and final land cover in 2030 for the base and zero deforestation scenarios

Note: Percentages represent the percentage of land in total land cover change..

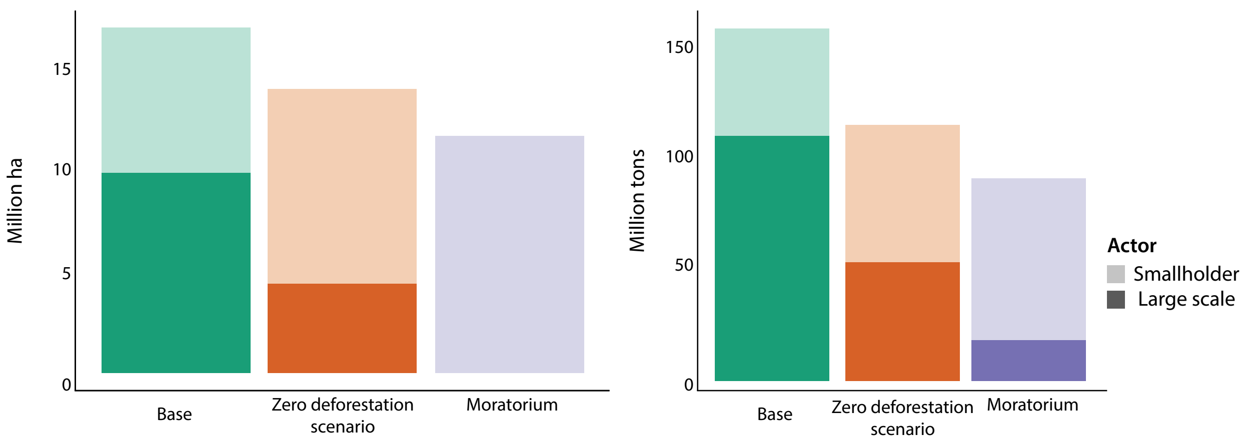


Figure 4. Projected increase in area (left) and palm oil fruit production (right) from smallholder and industrial oil palm producers between 2010 and 2030 according to the three scenarios

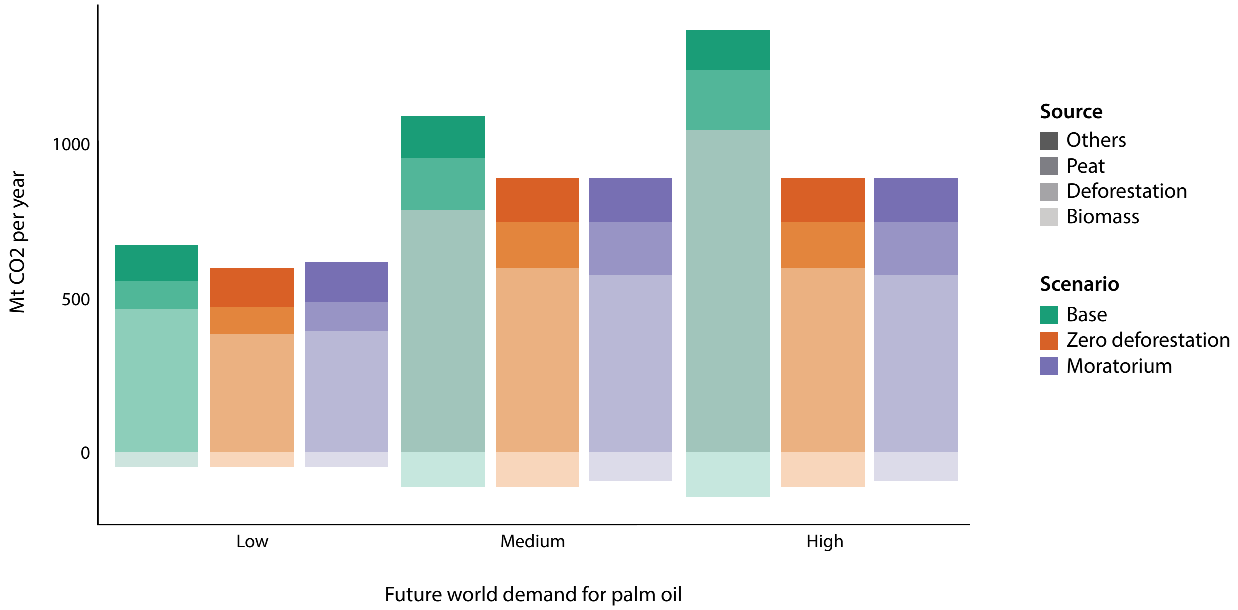


Figure 5. Projected average annual GHG emissions per source over 2010–2030 in MtCO2eq across scenarios

Indonesia is able to increase its palm oil production by 88% by 2020, which is close to the objective of doubling its production.

Indirect effects of zero deforestation or oil palm moratorium scenarios are mostly related to the increase of smallholder oil palm cultivated area. This also leads to higher deforestation by smallholders and, to a lower extent, reduction of cultivated area of corn. However, the increasing smallholder deforestation amounts to only 23% of the area that is spared from deforestation by large-scale oil palm plantations, thus leading to a net reduction of deforestation. Other crops do not experience major changes due to the decrease in large-scale cultivation and increase in smallholder oil palm cultivation. The production of rice is expected to remain almost stable, decreasing by only 0.7% and 1.3% in the zero deforestation and oil palm moratorium scenarios, respectively.

As previously seen, the model currently underestimates peatland conversion as compared to remotely sensed data. Consequently, three-quarters of the land use, land-use change and forestry (LULUCF) emissions in 2010 are directly linked to deforestation in our simulations. Compared to the base scenario, the zero deforestation scenario leads to a reduction in total GHG emissions of 13% and the oil palm moratorium scenario to a reduction of 16% (Figure 5). This lower relative reduction of emissions compared to reduction in deforestation is partly explained by the reduction of carbon sequestration in oil palm plantations. This reduction of carbon sequestration, in turn, is due to lower areas in the zero deforestation and oil palm moratorium scenarios.

Discussion

When the expansion of large-scale oil palm plantations is constrained either completely in the case of the oil palm moratorium scenario, or only to forests and peatland in the zero-deforestation scenario, different mechanisms could partially compensate the palm oil production. The mechanisms can also partially offset the benefits on reduced deforestation from large-scale oil palm plantations in the model. In both scenarios, smallholders increase their oil palm area and production. In the zero deforestation scenario, large-scale oil palm plantations also expand to other types of land e.g. natural land.

This research, with the best data available, aims to show to what extent these options are chosen, and the consequences of these choices for production and deforestation. In GLOBIOM, this is related to the relative profitability of oil palm production on different types of land and under different management. It also depends on the evolution of its consumption in Indonesia and in the rest of the world. Further improvements of the database and parametrization of the model will help to investigate more accurately the potential impacts of future developments of land-based sectors in Indonesia.

In terms of the database, the land cover map should be elaborated to also include degraded land. Not doing so may lead to an overestimation of the productive potential of the other natural land category. This, in turn, may lead to an underestimation of future deforestation. The underlying database for peatland and the representation of coastal areas also need to be refined in the future; GHG emissions from peatland are currently underestimated. Including information on the location of mills would also help explain the lower profitability of oil palm in certain areas such as Papua.

For this study, we updated our oil palm suitability map (Pirker et al. 2016). We take into account local soil map (RePPPRoT project), which had large consequences on the extent and localization of suitable areas. This highlights the sensitivity of our analysis to the quality of underlying data. In reality, the oil palm moratorium scenario would still give some freedom for expansion of planted oil palm area inside existing concessions. However, we were not confident enough to make this case from the limited information we could obtain on concessions.

In terms of parameterization, the role of intensification in this study needs further investigation. In the current model, both large-scale plantations and smallholders are not able to increase their yields beyond the past historical trend. To capture correctly the potential for intensification, we need to define alternative production systems for both smallholders and large-scale plantations, with associated yields, production costs and current area allocation (Goh, 2004; Euler et al., 2016). Moreover, the characterization of smallholders and large-scale could also be refined. Their respective investment capacity, for example, might influence their expansion rate. The integration of further information from agronomic models, household data or field trials is needed for this. More confidence on the parameterization of macro-economic variables, such as the world palm oil demand, may further refine the results. Finally, agricultural policies are not yet included. For instance, price controls are still applied to nine essential food items in Indonesia.

Conclusions and recommendations

The two scenarios — zero deforestation and oil palm moratorium of large-scale oil palm expansion — both have an obvious potential to reduce deforestation. Based on our results, the zero deforestation commitments linked to pledges of major palm oil corporate groups, as well as a moratorium on future expansion of large-scale oil palm plantations, would reduce the cumulated deforestation over 2010–2030 between 14% and 47%. The actual percentage would depend on the growth of future world palm oil demand. Indonesia could still increase its national palm oil production by 86% in the zero deforestation scenario and by 60% in the moratorium scenario in 2020 (compared to 2010 in a context of medium growth of international demand). Emissions from land use and land-use changes are projected to rise even further. However, the zero deforestation commitment or the moratorium on expansion of large-scale oil palm plantations beyond the current level could help reduce total GHG emissions between 13% and 16% respectively by 2030.

Closing the yield gaps could improve the use of planting material and higher input. This, in turn, could possibly help further reduce deforestation and increase production. Major palm oil groups should support continuous research and development and accompany planters toward more sustainable practices. Independent, widespread land monitoring should provide incentives to implement good practices.

It is likely that tied-smallholders are better placed for improving incomes through collaborative agreements with companies. The challenge, however, is to ensure improved seeding material and improved technical services are available for independent smallholders so they can also enhance productivity. Such strategies and schemes have already been investigated. Now public and private stakeholders must take further action to make them happen. Finally, the definition and identification of degraded lands, and the implications of using them, need further research. This has potentially strong impacts on reaching national objectives toward agricultural production expansion, climate change mitigation and biodiversity conservation in Indonesia.

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