ID 2016 Report

*pathways to*

# deep decarbonizing

## *agriculture, forest and other land uses sector in Indonesia*

DDPP
DEEP DECARBONIZATION PATHWAYS PROJECT

INSTITUT PERTANIAN BOGOR

CCROM Southeast Asia and Pacific

INSTITUT TEKNOLOGI BANDUNG 1920

*Published by Deep Decarbonization Pathways Project (DDPP).*



Cite this report as
*Boer, R. et al. (2016). Pathways to deep decarbonizing agriculture, forest and other land uses sector in indonesia, DDPP.*

*A Paper prepared by the Indonesian Deep Decarbonization Pathways Project Team*

## Authors

***Rizaldi Boer, Gito Immanuel, Siddik Thoha, M. Ardiansyah, Anter Parulian***
*Centre for Climate Risk and Opportunity Management in Southeast Asia Pacific - Bogor Agricultural University (CCROM-SEAP - IPB)*

***Ruandha Agung Sugardiman, Belinda A. Margono***
*Ministry of Environment and Forestry - Republic of Indonesia*

***Ucok W.R. Siagian, and Retno Gumilang Dewi***
*Center for Research on Energy Policy - Institut Teknologi Bandung (CREP - ITB)*

## Deep Decarbonization Pathways Project

The Deep Decarbonization Pathways Project (DDPP) is a collaborative global research initiative, that aims to understand how individual countries can transition to a low-emission economy. Built upon a rigorous accounting of national circumstances, the DDPP defines transparent pathways supporting the decarbonization of socio-economic systems while respecting the specifics of national political economy and the fulfillment of domestic development priorities.

The DDPP was launched in October 2013 by the Institute for Sustainable Development and International Relations (IDDRI) and the Sustainable Development Solutions Network (SDSN), as a research collaboration between 16 Country Research Teams, composed of leading research institutions from countries representing about 70% of global GHG emissions and at very different stages of development. These 16 countries are: Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, Russia, South Africa, South Korea, the United Kingdom, and the United States.

In the lead-up to COP21, the first phase of the DDPP resulted in a series of country-specific and cross-cutting publications over 2014-2015 (http://deepdecarbonization.org/). Since 2016, the DDPP Network has engaged, under the IDDRI secretariat, into its second phase, targeted to a refinement of the country studies and the support to new country research teams in countries non-covered during the first phase.

## Disclaimer



Editors : Rizaldi Boer, Henri Waisman
Graphic design : Ivan Pharabod

Contents

# Pathways to deep decarbonizing agriculture, forest and other land uses sector in indonesia

*October 2016*

# Acknowledgements

The authors of the report would like to acknowledge the funding provided by Children's Investment Fund Foundation (CIFF). This report has been prepared in the context of the MILES project, funded by the European Union under contract to DG CLIMA (No. 21.0104/2014/684427/SER/CLIMA.A.4). We wish to thank SDSN Indonesia for supporting us in conducting this Indonesia DDPP Study. We would also like to thank the Ministry of Environment and Forestry of Indonesia for valuable data, analysis insight and modeling inputs. Our special thanks go to the DDPP secretariat at IDDRI, notably Henri Waisman for continuous support during the preparation of this report.

# Executive Summary

The Paris Agreement clearly states the need for global communities to work together to hold the increase of global temperature below 2 °C and pursue efforts to limit the temperature increase to 1.5 °C. The peak of GHG emission should happen as soon as possible and achieve a balance between anthropogenic emissions and removals in the second half of this century. Therefore, it is crucial for all nations to mainstream climate change mitigation strategies into their long-term development plans. For Indonesia, the development of agriculture and forestry sectors has contributed significantly to total GHG emissions. The increase of land demand, that follows the increase of demand for food, pastoral, wood, settlements and other infrastructure development, presents a challenge to deep decarbonizing this sector. This report explores the potential of deep decarbonizing agriculture, forest and other land uses sectors in Indonesia. Specifically, it explores land uses and management choices that can lead to significant reduction of greenhouse emissions, while maintaining government target to meet rice self-sufficiency and production targets for several key agriculture commodities particularly palm oil as well as industrial wood and bioenergy. This report is part of the Deep Decarbonization Pathways Project (DDPP), a collaborative global initiative to explore how individual countries can reduce greenhouse gas (GHG) emissions to levels consistent with limiting the anthropogenic increase in global mean surface temperature to less than 2 °C, which was launched by IDDRI and SDSN.

This report assesses three land-use development scenarios. The Business as Usual (*BAU*) considers a development pathway wherein the implementation of development plans does not consider mitigation policies and measures. This means that no specific mitigation policies and programs are issued in this scenario and that only some of the present policies and programs that may have relationship with mitigation will continue in the future following the historical pattern. The second scenario is DEV, a development pathway that includes mitigation policies and measures in the implementation of development plan. The third scenario is the DDPP scenario, which is similar to DEV but with improved system and intensified mitigation policies and measures. In all scenarios, rice production will be kept to ensure self-sufficiency; land demand for livestock and settlement is always met, as well as the production targets of some strategic commodities as defined in strategic development of the sectors.

Policies and measures to be implemented towards decarbonized development are (i) improving the management of land and forest resources through development of Forest Management Unit in all forest areas, (ii) pushing adoption of sustainable management practices in production forests by implementing mandatory certification systems, (iii) reducing dependency on natural forests in meeting wood demands by accelerating the establishment of timber plantation on community lands and state lands and increasing the use of wood from agricultural plantations,

(iv) reducing pressure on natural forest for establishment of development areas and agriculture expansion by improving varieties, land productivity and cropping intensity, (v) enhancing sink by increasing the implementation of restoration of production forests ecosystem and land rehabilitation, (vi) limiting the use of peatland for timber and agriculture plantations through the issuance of moratorium policies and peatland restoration, and (vii) increasing the adoption of low emission farming practices.

The result of the analysis suggests that BAU total emissions will continue to rise up to 2020 from its 2010 level where it reached 0.464 Gt $CO_2$e or about 1.98 ton/cap, and then slightly decreases thereafter (Figure A). For DEV scenario, the GHG emission starts decreasing from 2010 very slowly, whereas for DDPP scenario, the emission decreases quite rapidly. By 2050, the per capita emission under BAU would be about 1.36 ton $CO_2$e,while under DEV and DDPP scenarios, it would decrease to 0.60 ton $CO_2$e and -0.05 ton $CO_2$e.

Table A summarizes the main indicators characterizing the emission drivers in the three scenarios. The main features of the DDPP scenarios are as follows:

- Rapid decrease in emission occurs as a result of increased land productivity and cropping intensity, leading to fewer demands for crop production land and enhanced mitigation actions.
- The reliance on natural forest for wood production is decreased, in particular as the result of

**Figure A.** Rate of GHG emissions under the BAU, DEV and DDPP scenarios

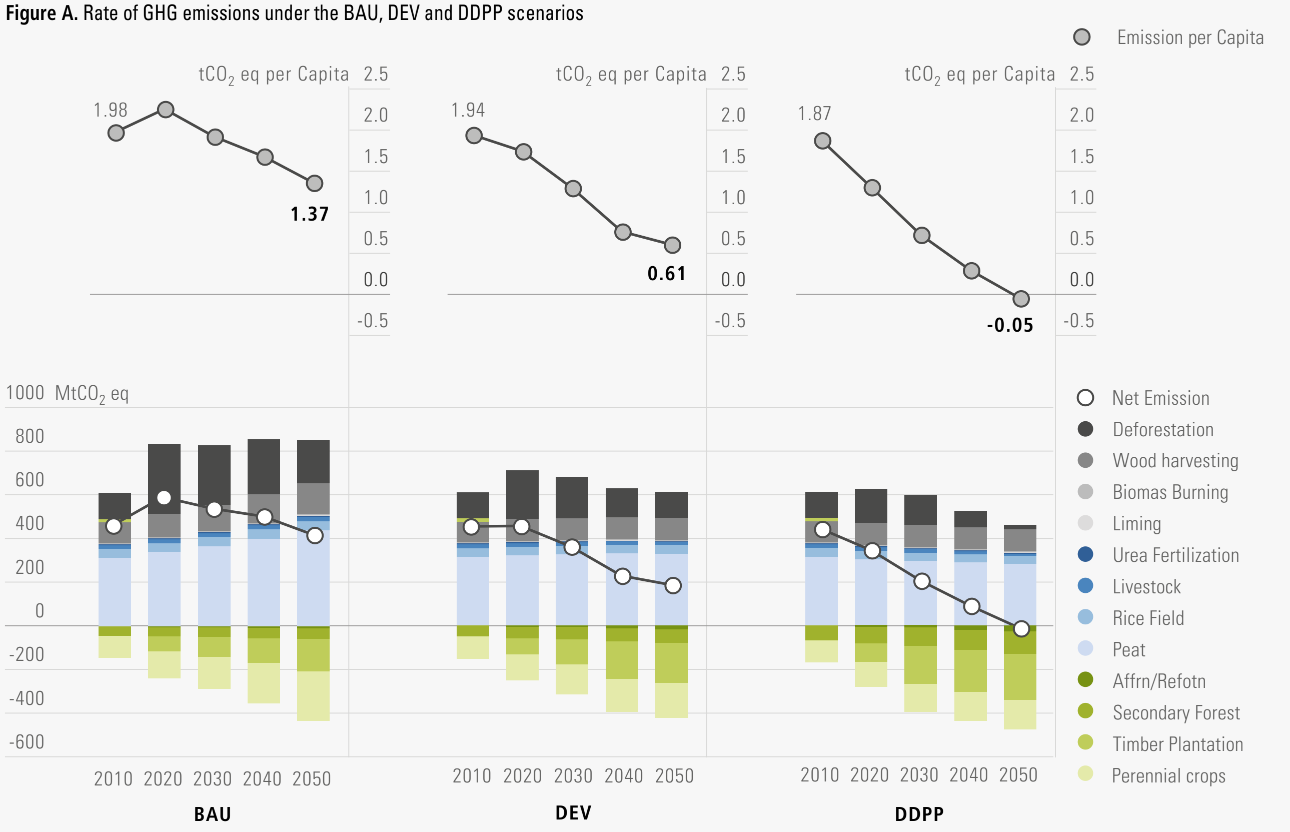


**Table A.** Level of intervention of mitigation measures under the BAU, DEV and DDPP scenarios

| BAU | | 2010 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|---|
| Rice (000 ha) | Rice Field | 8,763 | 8,710 | 8,700 | 8,732 | 8,810 |
| | Low Emmision Variety | - | - | - | - | - |
| | Intermittent Irrigation | - | - | - | - | - |
| Crop lands | Area of Croplands (000 ha) | 54,303 | 61,591 | 66,837 | 72,919 | 80,377 |
| | Nitrogen Application (000 ton urea) | 6,422 | 6,587 | 6,465 | 6,379 | 6,639 |
| Livestock (000 heads) | Total Livestock Population | 443,183 | 460,506 | 478,505 | 497,209 | 516,643 |
| | Feed Supplement | - | - | - | - | - |
| | Biogas | - | - | - | - | - |
| Peat (000 ha) | Total Area of Peatland | 14,585 | 14,508 | 14,440 | 14,381 | 14,327 |
| | Improved Water Management | - | - | - | - | - |
| | Peat Restoration | - | 77 | 145 | 204 | 258 |
| Afforestation/ Reforestation (Aff/Ref; 000 ha) | Land Availablefor Aff/Ref Program | 14,033 | - | - | - | - |
| | Aff/Ref program without Rotation | - | 972 | 1,944 | 2,915 | 3,887 |
| | Survival Rate (%) without Rotation | - | 22% | 24% | 27% | 30% |
| | Aff/Ref program with Rotation | - | 1,098 | 2,196 | 3,294 | 4,392 |
| | Survival Rate (%) with Rotation | - | 54% | 59% | 64% | 70% |
| **DEV** | | **2010** | **2020** | **2030** | **2040** | **2050** |
| Rice (000 ha) | Rice Field | 8,763 | 8,148 | 7,570 | 7,009 | 6,441 |
| | Low Emmision Variety | - | 466 | 958 | 1,491 | 2,082 |
| | Intermittent Irrigation | - | 412 | 849 | 1,325 | 1,855 |
| Crop lands | Area of Croplands (000 ha) | 54,303 | 60,417 | 64,441 | 67,235 | 68,772 |
| | Nitrogen Application (000 ton urea) | 6,422 | 6,462 | 6,233 | 5,881 | 5,441 |
| Livestock (000 heads) | Total Livestock Population | 443,183 | 457,547 | 466,903 | 470,818 | 468,830 |
| | Feed Supplement | - | 2,958 | 11,602 | 26,391 | 47,813 |
| | Biogas | - | 79 | 314 | 725 | 1,333 |
| Peat (000 ha) | Total Area of Peatland | 14,585 | 14,001 | 13,311 | 12,978 | 12,702 |
| | Improved Water Management | - | 342 | 789 | 880 | 914 |
| | Peat Restoration2 | - | 242 | 485 | 727 | 969 |
| Afforestation/ Reforestation (Aff/Ref; 000 ha) | Land Available for Aff/Ref Program | 13,938 | - | - | - | - |
| | Aff/Ref program without Rotation | - | 1,383 | 2,767 | 4,150 | 5,533 |
| | Survival Rate (%) without Rotation | - | 25% | 31% | 40% | 50% |
| | Aff/Ref program with Rotation | - | 1,369 | 2,739 | 4,108 | 5,478 |
| | Survival Rate (%) with Rotation | - | 57% | 67% | 77% | 90% |
| **DDPP** | | **2010** | **2020** | **2030** | **2040** | **2050** |
| Rice (000 ha) | Rice Field | 8,763 | 7,918 | 7,115 | 6,344 | 5,592 |
| | Low Emmision Variety | - | 453 | 902 | 1,351 | 1,808 |
| | Intermittent Irrigation | - | 400 | 798 | 1,197 | 1,605 |
| Crop lands | Area of Croplands (000 ha) | 54,303 | 60,048 | 62,524 | 63,368 | 63,561 |
| | Nitrogen Application (000 ton urea) | 6,422 | 6,422 | 6.048 | 5,543 | 5,028 |
| Livestock (000 heads) | Total Livestock Population | 443,183 | 457,547 | 466,903 | 470,818 | 468,830 |
| | Feed Supplement | - | 2,958 | 11,602 | 26,391 | 47,813 |
| | Biogas | - | 79 | 314 | 725 | 1,333 |
| Peat (000 ha) | Total Area of Peatland | 14,585 | 13,749 | 13,201 | 12,797 | 12,394 |
| | Improved Water Management | - | 432 | 576 | 576 | 576 |
| | Peat Restoration | - | 404 | 808 | 1,212 | 1,615 |
| Afforestation/ Reforestation (Aff/Ref; 000 ha) | Land Available for Aff/Ref Program | 13,843 | - | - | - | - |
| | Aff/Ref program without Rotation | - | 1,789 | 3,578 | 5,368 | 7,157 |
| | Survival Rate (%) without Rotation | - | 27% | 37% | 51% | 70% |
| | Aff/Ref program with Rotation | - | 1,637 | 3,274 | 4,911 | 6,548 |
| | Survival Rate (%) with Rotation | - | 57% | 67% | 77% | 90% |

increasing rate of timber plantation development and increasing rate of land rehabilitation. Therefore, the emission from timber harvesting from natural forest in this scenario, is lower than under the BAU scenario.

- Emissions from peat decomposition also decreases significantly as a result of peatland moratorium policy in which further peatland conversion for large plantation is prohibited, and restoration of larger part of peatland should take place.
- Implementation of mitigation measures through the improvement of manure management and feed supplement, as well as improvement of water management in rice field and peatland, also contributes to the increasing rate of emission reduction.

The implementation of mitigation policies and measures would not significantly affect the production level of agriculture commodities as long as the program for the improvement of crop productivity and cropping intensity is met. However, the food balance may not always be positive, depending on the level of consumption. Today, the balance between supply and demand is positive (surplus) for rice, cassava, oil crops, palm oil and other crops, but negative (deficit) for maize, vegetable, fruits and nuts, and sugar. The surplus for rice, cassava, oil crops, palm oil and other crops can be maintained until 2050 under all scenarios. For other crops, the deficit will increase, except for maize under the DDPP scenario.

Rice self-sufficiency can be maintained in the three scenarios by improving crop productivity of lowland rice in Java from 5.8 t/ha to more than 5.95 t/ha, and outside Java from 4.2 t/ha to more than 5.2 t/ha. Cropping intensity is also increased from 1.8 to 2.11 and 1.45 to 1.70 respectively. By 2050, the rice surplus can reach over 10 million tons, if rice consumption decreases from 141 to below 127 kg/cap/year[1], consistently with food security objectives. For maize, the current level of production is not sufficient to meet demand projections. With the increasing demand due to the increase in population, the deficit would be close to 10 million tons by 2050 in the absence of significant yield improvement. In the last five years, the Government of Indonesia still imported between 1.5 and 3.6 million tons of maize per year. This increasing demand can be met without import if crop productivity can be increased by 60% from the current yield (4.44 to 7.00 t/ha) and the cropping intensity is increased by 7.9% (0.63 to 0.68). Increasing productivity is possible through the introduction of high yielding varieties and implementation of good agricultural practices. Currently, the mean maize yield in Indonesia is still low, i.e. 4.1 t/ha. Other ASEAN countries such as Thailand has already reached 4.3 t/ha, Vietnam 4.4 t/ha, and China 5.2 t/ha. In America, the yield can achieve 9.5 t/ha, followed by Argentina by about 7.5 t/ha and EU about 6.3t/ha[2].

For sugar crops, vegetables, fruit and nuts, the current deficits will increase in the future (2050), even if crop productivity can be increased. For vegetables, by 2050 the deficit may be over 11 million tons in the BAU scenario, about 9 million tons in DEV and 8 million tons in DDPP scenarios. The crop productivities under the three scenarios increase by 7.5% (9.03 to 10 t/ha) in BAU, 18% (9.03 to 11 t/ha) in DEV and 29% (9.03 to 12 t/ha)

1 The decrease in rice consumption is related to the increase of GDP due to change in diets and the impact of food diversification programs.

2 Asworo, H.T.W. 2015. Lahan Luas, Produktivitas Jagung Indonesia Terendah di Asean. Downloaded from http://industri.bisnis.com/read/20150824/99/465290/lahan-luas-produktivitas-jagung-indonesia-terendah-di-asean

**Table B**. Annual rate of planned and unplanned deforestation for the BAU, DEV and DDPP scenarios

| Scenario | Type of deforestation | 2013-2020 | 2021-2030 | 2031-2040 | 2041-2050 |
|---|---|---|---|---|---|
| BAU | Planned Deforestation | 421 | 411 | 640 | 773 |
| | Unplanned Deforestation | 499 | 374 | 0 | 0 |
| DEV | Planned Deforestation | 310 | 305 | 274 | 142 |
| | Unplanned Deforestation | 340 | 245 | 0 | 0 |
| DDPP | Planned Deforestation | 241 | 190 | 111 | 47 |
| | Unplanned Deforestation | 209 | 210 | 0 | 0 |

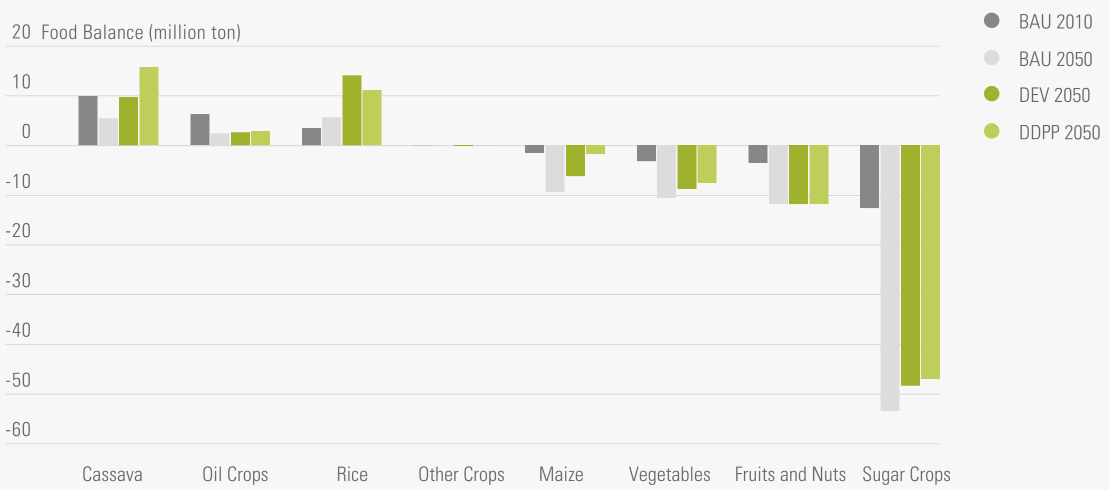
in DDPP scenario. Similarly for fruits and nut, the deficit may be multiplied by 4 compared to current levels (over 12 million tons). For sugar crops the deficit will be over 45 million tons or equivalent to about 3.4 million tons of sugar ('*hablur*') for all scenarios. Currently, demand for sugar is about 5 million tons while the maximum production capacity was only 2.5 million tons. In the last five years, government has imported sugar between 2.0 and 3.0tons. Without expansion of sugar plantation and significant increase in crop productivity, this deficit cannot be off-set. Under the BAU, DEV and DDPP scenarios, sugar productivity would increase by about 39%, 62%, and 67% from the current yields respectively.

For palm oil, the production target for 2050 in DEV and DDPP scenarios is about half of the 630 million tons of fresh fruit bunch (FFB) –equivalent to about 158 million tons of crude palm oil (CPO)– reached under BAU[3]. With the level of BAU production, the production surplus would reach 140 million tons CPO. The establishment of new oil palm plantations to reach this target, will require expansions of lands which may in turn reduce the expansion opportunity for other crops particularly cereal and horticultural crops (fruits and vegetables), and may increase the risk of deforestation leading to higher greenhouse gas emission. With the increase of crop productivities from the current level and the cut of the production target of palm oil to about half of the BAU, land demand for expansion of food crops and agriculture plantations would be reduced significantly, thereby reducing the rate of deforestation (Table B).

The wood production target of 360 million m$^3$ can be realized before 2050 for the three scenarios (Figure B). The annual rates of planting for timber plantation (HTI) under the BAU, DEV and DDPP scenarios are expected at 150, 250 and 350 thousand hectares respectively. By 2050, the total planted area of HTI will be around 10.5, 11.3, 11.5 million ha for the three scenarios respectively. For DEV and DDPP scenarios, the timber production would be higher than under BAU, due to higher contribution of timber production from afforestation and reforestation programs. In 2050, the contributions of HTI to the total production in each scenario are approximately 68% in BAU, 72% in DEV and 75% in DDPP, while the contribution of natural forest concessions (HPH) are about 5.5%, 5.9% and 3.6% respectively, while the remainings come from agriculture plantations and deforested areas.

3 Production target under the BAU up to 2050 was based on scenario developed by GAPKI (Indonesian Palm Oil Association).

**Figure B.** Food balance (Supply-demand) for agriculture commodities in BAU, DEV and DDPP scenarios




This study indicates that if there are no significant changes in land management practices including restoration and moratorium of peatland, and optimization of the use of low carbon stock land for agriculture expansion and timber plantation, contributions of these sectors to the national emission would be high. The rate of emission until 2050 would remain high, and would not be much different from the present emission. With the improvement of land and forest management as well as optimization of the use of low carbon stock land for agriculture and timber plantation development along with enhanced mitigation policies and measures, particularly moratorium of peatland permits and restorationof peatland, the emission from this sector can be reduced significantly and by 2050, this sector can become a net sink. Thus, the study suggests that drastic reduction of emission from AFOLU can be achieved while reaching the major target, even better than under BAU with exception for palm oil.

Improvement of land and forest management may require high investments particularly for enhancing institutional capacities of forest management units. Investment for producing high yielding varieties suitable for marginal lands and peatland management technology is necessary. Nevertheless, optimizing the use of unproductive land, would face great challenges, in particular with regard to land tenure issues. Incentive system to accelerate timber plantation development on degraded land, and to increase community access for green fund investment would also be required.

## Table of Figures



## Table of Tables



## Table of Annexes

# 1 Introduction

The Paris Agreement clearly states the need for global communities to work together to hold the increase of global temperature below 2 °C (pursuing 1.5 °C). The peak of GHG emission should happen as soon as possible and achieve a balance between anthropogenic emissions and removals in the second half of this century. Therefore, it is crucial for all nations to mainstream climate change mitigation strategies into their long-term development plans.

This report presents the results of a deep decarbonization analysis for agriculture, forest and other land uses sector (AFOLU) conducted by the Indonesian Country Research Team consisted of researchers from the Centre for Climate Risk and Opportunity Management–Bogor Agricultural University and Center for Research on Energy Policy–Institut Teknologi Bandung. It is part of the Deep Decarbonization Pathways Project (DDPP), a collaborative global initiative to explore how individual countries can reduce greenhouse gas (GHG) emissions to levels consistent with limiting the anthropogenic increase in global mean surface temperature to less than 2 °C. The DDPP was convened by SDSN and IDDRI and currently includes 16 country research teams from Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, Russia, South Africa, South Korea, the United Kingdom, and the United States. These countries represent more than 70% of the global emission and at different stages of development.

Our objective is to explore the potential of deep decarbonizing AFOLU sector that is currently a major source of GHG emissions in Indonesia. Increase in land demand that follows the increase in the demand for food, pastoral, wood, and settlements and other infrastructure development present a challenge to deep decarbonizing this sector. Unlike other teams that have focused on energy sector, this report is one of the first attempts to characterize the long-term pathways for AFOLU.

At present, the analysis is limited to exploring land uses and management choices that can lead to significant reduction of greenhouse emission from this sector while maintaining government targets to meet rice self-sufficiency and production of several key agriculture commodities particularly palm oil, industrial wood and bioenergy. The report also explores the key policies required to create the enabling environment for pushing the application of improved land and forest management practices toward deep decarbonization pathway.

# 2 National Circumstances

## *2.1 Socio-Economic Conditions*

Indonesia is the largest archipelago in the world, situated between the Pacific and the Indian Oceans. It bridges two continents: Asia and Oceania consisting of approximately 17,000 islands with a population of 234 million. The majority (almost 80%) of Indonesians live in the Western part of Indonesia on the Islands of Java and Sumatera. The total area of the territory reaches 200 million ha, in which about 50 million ha are devoted to various agricultural activities. About

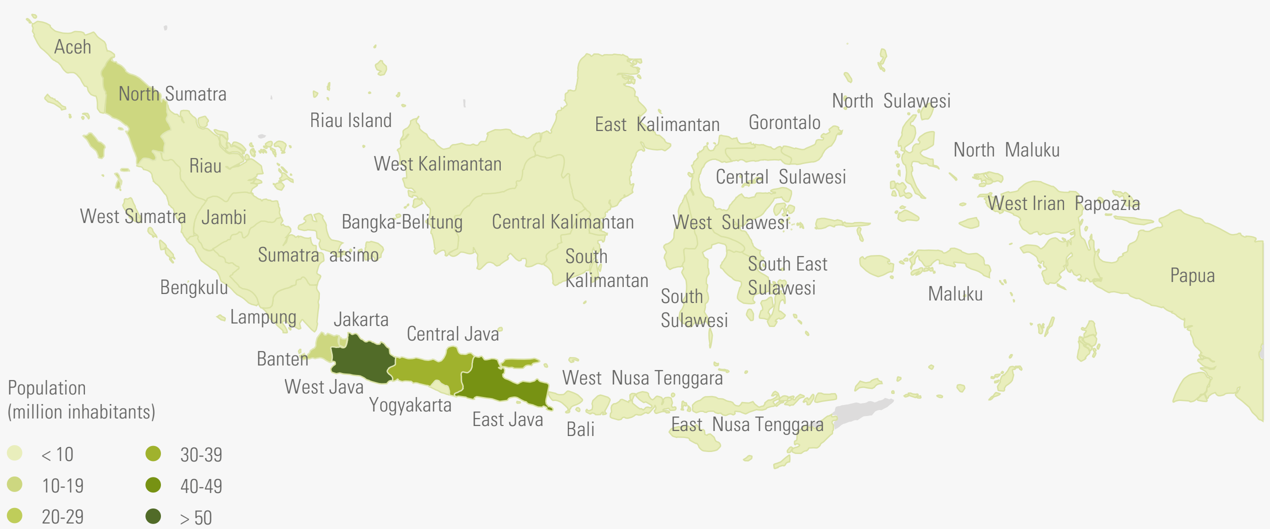
20 million ha are arable land, of which 40% is wetland (e.g., rice fields), 40% dry land, and 15% shifting cultivation. Administratively, the Republic of Indonesia is divided into 34 provinces.

The Indonesian population in 2010 has reached 237 millions (BPS-Statistics Indonesia, 2010). Based on historical trend, the population growth appears to be decreasing, e.g. 1.98% (1980-1990) to 1.49% (2000-2010). Based on projection by BPS, Bappenas and UNFA (2013), the population growth from 2010-2015 will decrease to 1.38%, and further decrease to 1.19% from 2015-2020, 1% from 2020-2025, to 0.8% from 2025-2030 and 0.62% from 2030-3035. The total population by 2035 is projected to exceed 300 million. The population distribution is predicted to be concentrated in Java (167.3 million), followed by Sumatra (68.5 million), Sulawesi (22.7 million), Kalimantan (20.3 million), Bali and Nusa Tenggara (17.5 million) and Maluku and Papua (9.3 million; Figure 1).

Unemployment and underemployment are still relatively high, hence poverty remains a challenge. Nevertheless, employments in Indonesian have been improving in the past 8 years: although the unemployment rate is still relatively high, it has been decreasing from around 10% in 2004 to around 6% in 2013. In 2014, about 27.7 million people (11% of the total population) in Indonesia are considered poor. According to the country's Medium-term Development Plan (RPJMN 2015-2019), the government plans to implement various development and welfare programs to reduce poverty rate to 6.5-8.0 % of the population by 2019.

In the last 10 years, Indonesia's economy has performed quite well. In 2013, the GDP (current price) reached IDR 9,084 trillion (USD 939 billion), much higher than it was nine years ago, i.e. IDR 2,300 trillion (USD 248 billion). In terms of per capita, Indonesia GDP grew from IDR 10.5 million (USD 1,132) in 2004 to IDR 33.3 million (USD 3,442) in 2012, but the growth of GDP has varied significantly during this period, between 4.6% and 6.5% per annum. The RPJMN 2015-2019 sets the

**Figure 1.** Distribution of population by island in 2035



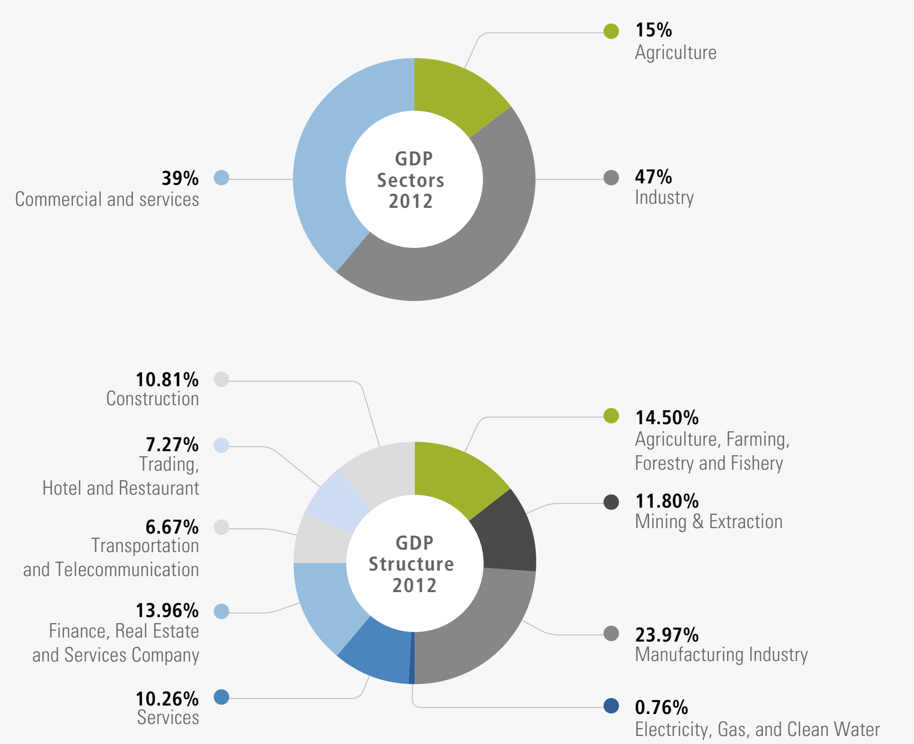
annual economic growth target to be 6% - 8% p.a. in the next five years. Compared to the sixties, Indonesia's economy has experienced structural transformation from agricultural economy to industrial and services economy. Figure 2 shows the aggregate economic structure (GDP) in 2012. It also shows that the share of industry and service, accounts for 85% of the economy. The major contributors in the industrial sectors are manufacturing, mining and extraction, and construction; and trading, hotels, restaurant, finance, real estate, transport and telecommunication are the major contributors in commerce and service sectors.

Life expectancy at birth has also improved significantly in the past four decades. In early 1970s, it was only 47.9 years and it increased to 69.7 years in 2011. BPS estimates that Indonesia life expectancy at birth would increase to 70.1 years for the period of 2010-2015. In education sector, the adult literacy rate would also improved quite significantly as a result of sustained efforts, 95% in 2011, while in 1970, it was only 79%.

## 2.2 Forest and Land Resources

Indonesia has a total land area of about 187 million hectares. This land area is divided into two categories, i.e. forest area (124.0 million ha or 66% of total surface in 2013) and non-forest area (commonly called APL, 63.9 million ha or 34% of total surface in 2013). Some of these lands are categorized as peatland with a total area of about 14.9 million ha (Ritung *et al*. 2011).

**Figure 2.** Distribution of Indonesia GDP in 2012 by (a) sector; (b) structure



According to its functions, a forest area is further divided into:

- Protection forest (HL),
- Conservation forest (HK),
- Production forest (HP)which is classified further into:
  - production forest (HP),
  - limited production forest (HPT)
  - Convertible production forest (HPK). By Law, only the latter category (HPK) can be converted to APL.

Brief description of these forest classes and their conditions are given in Table 1. It shows that some parts of the forest areas have been deforested and degraded due to the conversion to non-forest areas for various activities. By regulation, forest under the category of forest area, should be maintained. On the other hand, some non-forest areas (APL) are still covered by forests (forested land). By regulation, these forested lands belong to HPK and APL, thus are allowed to be converted to non-forest activities. Deforestation in such area is categorized as 'planned deforestation', while deforestation that occurred in other forest area classifications (HP, HPT, HL and HK) is categorized as 'unplanned deforestation'. Unplanned forest losses can arise due to forest fires, forest encroachment and other illegal activities. Planned and unplanned deforestation can also be applied to forest degradation. Planned degradation is caused primarily by the unsustainable levels of logging from legally permitted forest concessions in production forest, while unplanned forest degradation is mainly due to illegal logging activities in forested land area of HP, HL and HK.

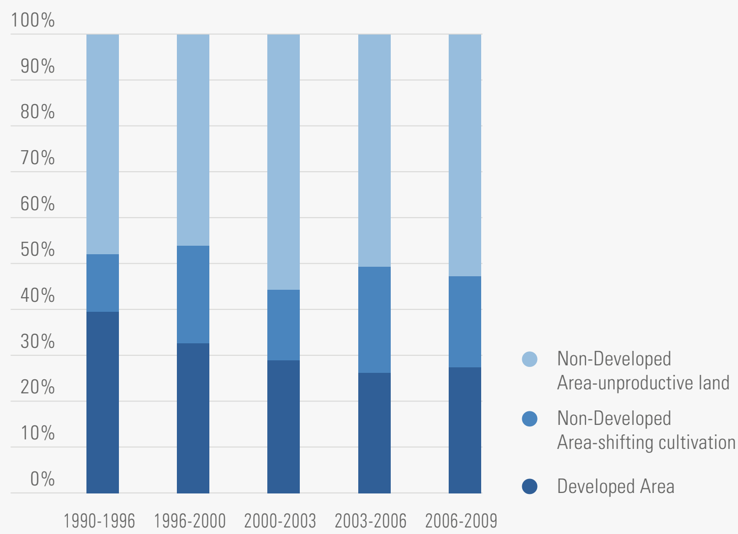
Based on deforestation data in 1990-1996,1996-2000, 2000-2003, 2003-2006, and 2006-2009, large portions of the deforested areas that occurred during these periods, were not used for development[4]. Until 2013, most of these deforested areas remained as unproductive lands[5],

**Table 1.** A summary of Indonesian forest land use zones by function and their condition in 2013 (Ditjenplan, 2014)

| Forest Type by Function | Function | Forest Condition | | | | Total |
|---|---|---|---|---|---|---|
| | | Primary Forest | Secondary Forest | Timber Plantation | Non Forested land | |
| **Forest Area** | | | | | | |
| Conservation Forest (HK) | To preserve biodiversity of flora & fauna and their ecosystems, i.e. Sanctuary Reserves, Nature Preservation Area and Game Hunting Park | 12,521 (6.7%) | 4,885 (2.6%) | 137 (0.1%) | 4,453 (2.4%) | 21,996 (11.7%) |
| Protection Forest (HL) | To serve life support system, maintain hydrological system, prevent flood, erosion control, seawater intrusion, and maintain soil fertility | 14,694 (7.8%) | 9,086 (4.8%) | 311 (0.2%) | 5,827 (3.1%) | 29,917 (15.9%) |
| Production Forest (HP) | For timber and non-timber productions. The sustainable principle is adopted to maintain the forest ecosystems as sources of timber and other non-timber forest products. | 4,569 (2.4%) | 10,032 (5.3%) | 2,709 (1.4%) | 11,587 (6,2%) | 28,897 (15.4%) |
| Limited Production Forest (HPT) | For timber production but with low intensity logging (due to topographical condition). Applied very selective logging, very limited clear cutting, and post-logging silvicultural treatments | 10,010 (5.3%) | 11,374 (6.1%) | 484 (0.3%) | 5,818 (3.1%) | 27,687 (14.7%) |
| Convertible Production Forest (HPK) | Production forest that can be converted into non-forest area (APL) for development (e.g. crops and agriculture plantation (coffee, oïl palm, rubber, etc.), human settlements and other non-forest uses (road, port etc.) | 2,957 (1.6%) | 4,474 (2.4%) | 79 (0.04%) | 8,015 (4.3%) | 15,525 (8.3%) |
| **Non-Forest Area** | | | | | | |
| APL | Non-forest area used for development (non-forest used) | 1,306 (0.7%) | 5,539 (2.9%) | 1,322 (0.7%) | 55,728 (29.7%) | 63,895 (34.0%) |
| TOTAL | | 46,059 (24.5%) | 45,390 (24.2%) | 5,042 (2.7%) | 91,427 (48.6%) | 187,918 (100%) |

and less than 40% were used for development (Figure 3). In total, the deforested area used for development was about 6.6 million ha, in which most were in the form of forest and agricultural plantations, i.e. about 5.2 million ha (79%). On the other hand, most of the deforested area remained as shrubs, grasslands, bare lands and shifting cultivation lands (65%) in both mineral and peatland. In total, the deforested area that remains as unproductive areas was about 13.9 million ha.

**Figure 3.** Fraction of deforested area used and not used for development (based on data from DitjenPlan, 2014)




Spanning from 1990 to 2012, the annual rate of deforestation reached 0.92 million hectares per year, with the highest rate occurred in the period of 1996-2000 that reached 2.1 million hectares per year, and the lowest in the period of 2000-2003 which was only 0.35 million hectares per year (MoEF, 2015). Deforestation can occur not only in convertible production forest, but also in HP, HPT, HK and HL, referenced as unplanned deforestation. Of 124 million ha of forest area, only about 88 million ha is now left as forested land (see Table 1). As previously mentioned, unplanned forest losses can result from forest fires, forest encroachment and other illegal activities. Unplanned deforestation rate is high especially in 'open access' forest areas, i.e., with no management institution on-site, including production forests that have been left by concessionaires or have not been granted with licenses and protection forests. On the contrary, conservation forests with the presence of on-site National Park Agency, are exposed to a lower risk of unplanned deforestation than the open access forest. As shown in Table 1, the lowest non-forested land is located within conservation forest.

The Government of Indonesia has put priority to accelerate the establishment of Forest Management Unit or FMU (*Kesatuan Pengelolaan Hutan*) to guarantee that all forest areas in Indonesia have management unit on-site. Development of FMUs will be prioritized in the open access areas. The presence of on-site management unit is expected to improve the management of forest area and increase the success of sustainable forest management. About 600 FMUs will be established throughout Indonesia . In the 2010-2014 Strategic Plan of the Ministry of Forestry, the Government of Indonesia had targeted to establish 60  MUs in 5 years (12 units per year). This target was doubled to 120 FMUs following the voluntary emission reduction commitment pre-2020

4 Development areas: forest (mostly for timber plantation), agriculture plantation, settlement, dry land agriculture, paddy field, airport, transmigration area, mining and ponds.

5 Unproductive lands are lands which are not used for development, i.e. remain as shrubs, grassland, swamp, swamp shrub, bare land, water body, dry land agriculture mixed with shrubs (shifting cultivation areas).

(Perpres 61/2011) and as many as 120 FMUs have been established over 2009-2013 (MoFor, 2014).

To restore, maintain and improve forests and land areas to maintain their carrying capacity, productivity and roles in supporting life system, the Government of Indonesia has implemented land rehabilitation programs. From 1990 to 2013, about 6.2 million ha of degraded lands in both forest and non-forest areas had been rehabilitated, corresponding to a planting rate of 270 thousand hectares per year. The rate was increased quite significantly after 2010 (Figure 4). It is targeted that by 2030, the total degraded lands that would be rehabilitated will reach 11.6 million ha. Despite such efforts, due to poor maintenance, the successes of land rehabilitation programs are still low with survival rate of about 20% (Boer 2015). Thus, most of the rehabilitated lands still remain degraded, with only a few becoming standing forest.

The role of natural forests for wood production is expected to continue in the future. Indonesia has started using woods originated from natural forests since early 1970s through the establishment of wood processing industries, which were mainly for producing plywoods and small fractions of sawn woods. After 1990s, pulp and paper industries were established and the industries increased rapidly after 2000 (Figure 5a). In 2014, these wood processing industries had consumed about 65 million $m^3$ Round Wood Equivalent (RWE) in which 81% were used for pulp, 12% for plywood, 5% for sawn wood and about 3% for other processed wood products. Compare to the official wood supply data, the wood consumption of these industries were much higher (Figure 5b). The highest gap occurred in 2003 reaching more than 30 million $m^3$ RWE (Figure 5c). Many studies have indicated that illegal woods fulfilled these gaps (MoFor, 2007; Klassen, 2010; Hoare and Welleslay, 2014; Koalisi Anti Mafia Kehutanan, 2015).

**Figure 4.** Rate of land rehabilitation inside and outside forest areas (Based on data from Forest Statistics 2001-2013 ; MoFor, 2002, ..., 2014b )

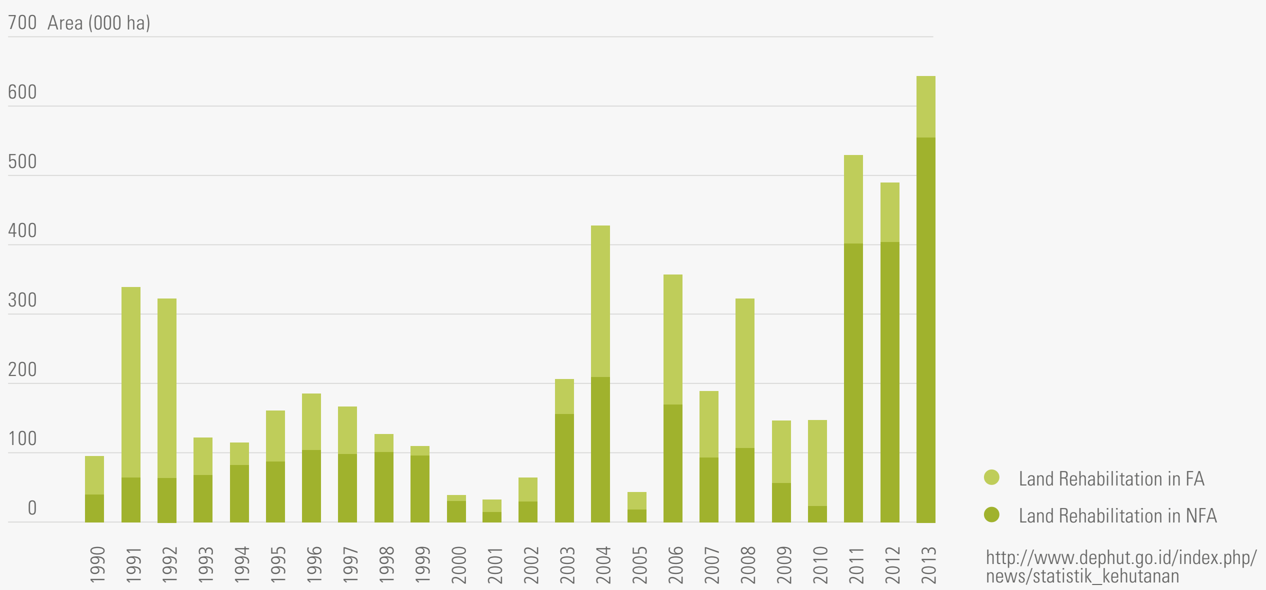


**Figure 5a.** Wood consumption by wood processing industries

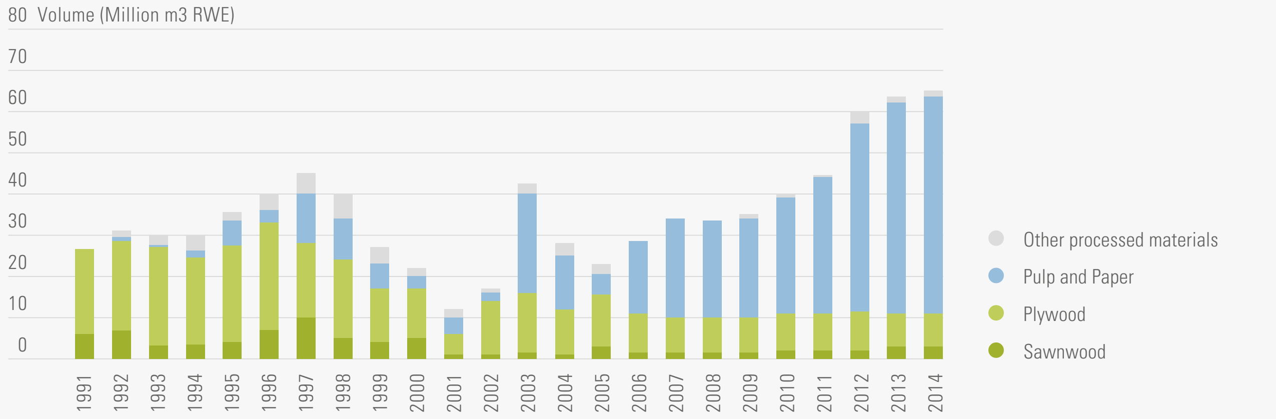



**Figure 5b.** Official wood supply report

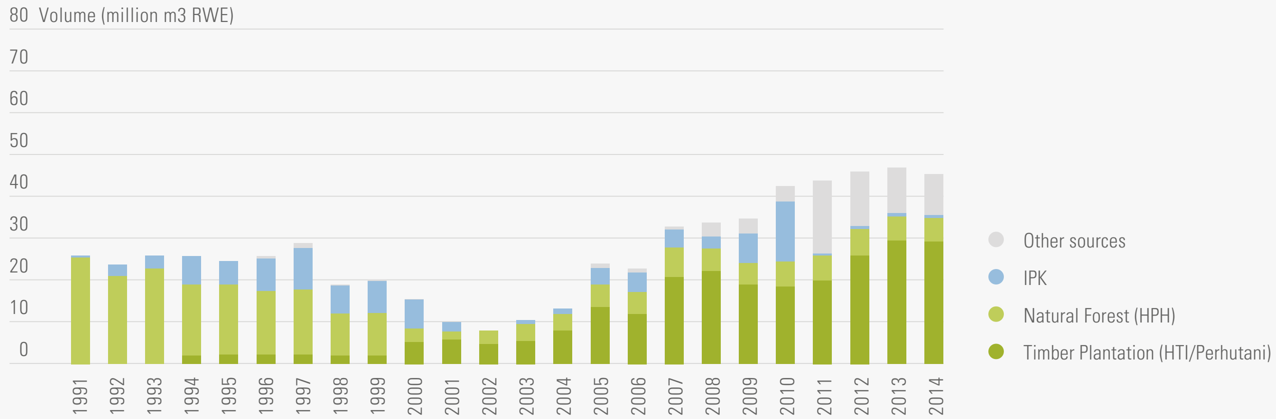
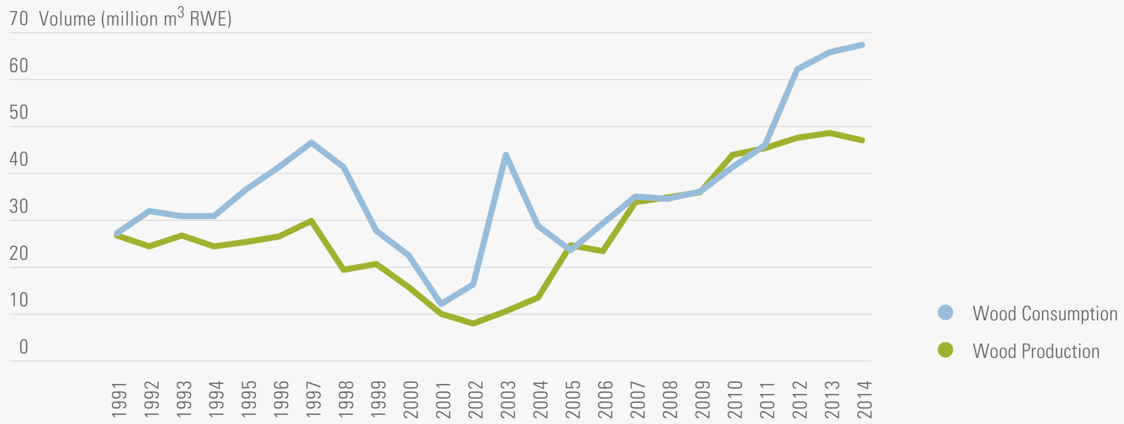



**Figure 5c.** Gaps between wood consumption and supply



Demand for industrial wood is expected to increase in the future, to reach about 350 million $m^3$ RWE by 2030, more than twice the current demand (Figure 6). The Government of Indonesia has targeted to accelerate the establishment of industrial timber plantation (HTI) to reduce the dependence on natural forest to meet the increasing wood demand. By 2030, total area of timber plantation is targeted to reach 14.5 million hectares. With mean annual increment of 25 $m^3$/ha/year, this plantation could produce about 362.5 million $m^3$/ha/year (MoFor, 2011). The contribution of natural forest is estimated at about 14 million $m^3$ annually, from 24.8 million ha. In addition, the government also plans to optimize the use of wood from alternative sources, i.e. agriculture plantations particularly palm oil and rubber trees as indicated in Figure 5b.

Nevertheless, the achievement of the above targets will face some challenges. Up to 2013, the Ministry of Forestry has issued permits to industrial timber plantations for a total area of 10.29 million hectares. However, the actual total planted areas until 2013, was only around 5.7 million hectare. The total annual planted area varied from 67 to 457 thousand hectares (Figure 7). The average rate of annual planting was about 237 thousand ha. One of the main challenges is dealing with land tenure issue. Many of the lands granted to concession com-

**Figure 6.** Projection of wood industrial production (MoFor, 2011)

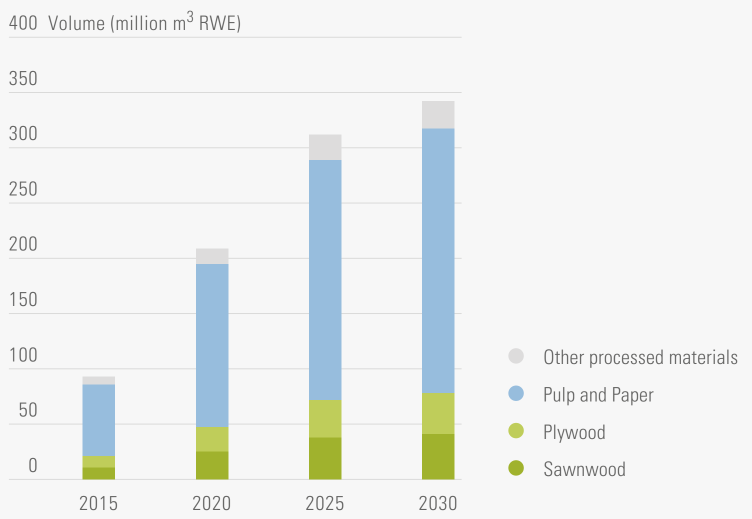
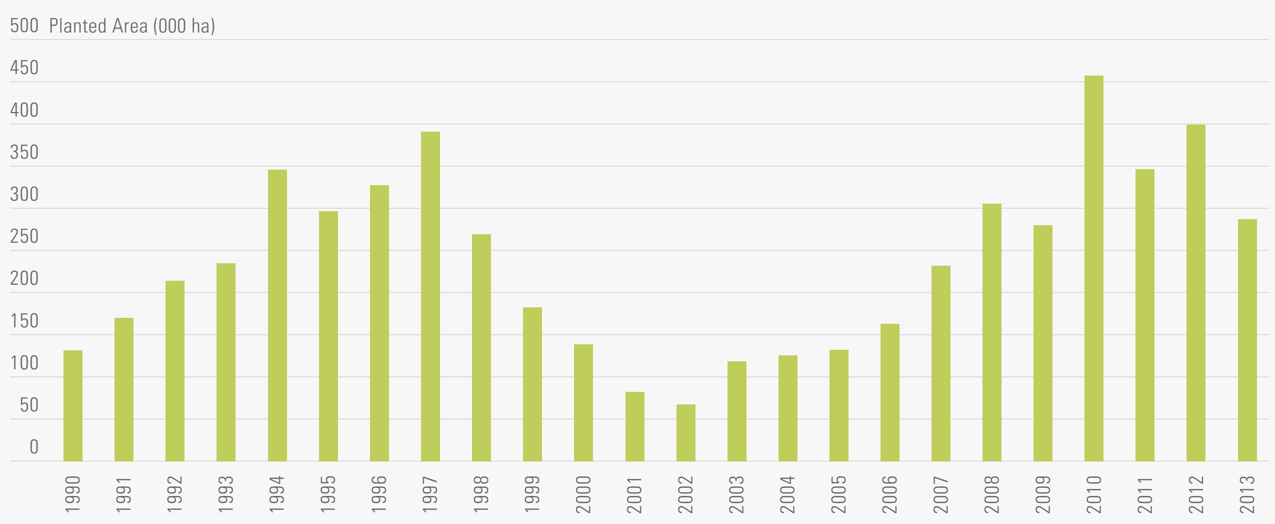



**Figure 7.** Rate of timber plantation establishment from 1990-2013 (Based on data from Forest Statistics 2001-2013; MoFor, 2002, ..., 2014b)

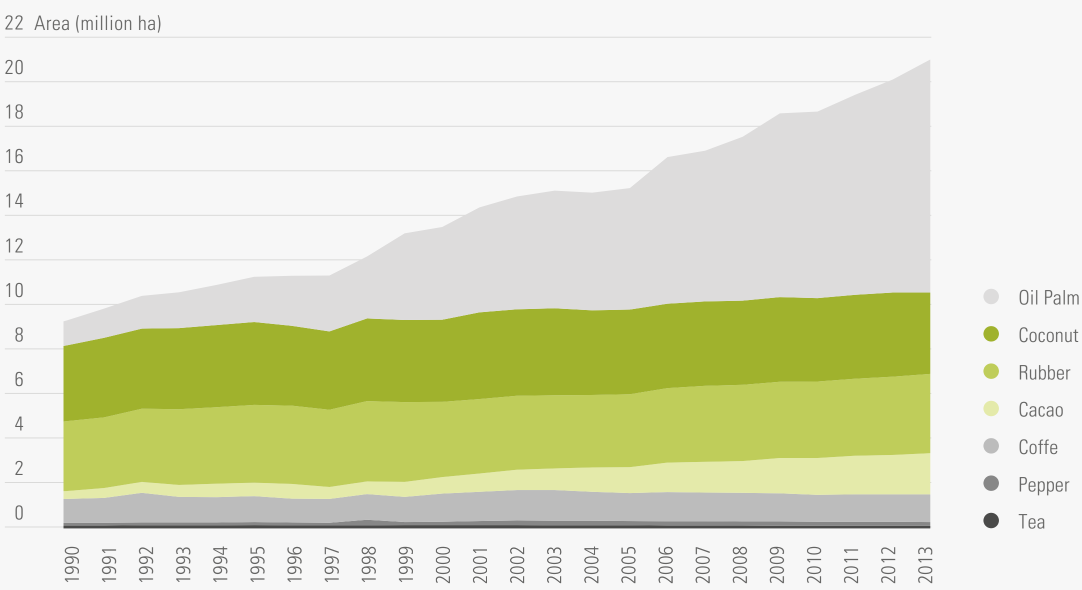


panies were also claimed by the communities. Social costs for addressing this issue were too high. The Indonesian Forest Business Association (APHI) in its revised roadmap, proposed to accelerate the establishment of community based timber plantation. By 2025, permit for industrial timber plantation (private) is expected to reach 12.7 million ha, 3.5 million ha for community timber plantation (HTR), and 2.8 million ha for private forest (*hutan rakyat*), and 1 million ha for village forest and community forest[6].

## 2.3 Agriculture Sector

Use of lands for development mainly concerns croplands for both commercial and subsistence agriculture. In 1990, croplands only represented 21% of the total land area and increased to 29% in 2013. The increased in land demand for agriculture was mainly for the establishment of large agricultural plantations. Rapid increase in agricultural plantation areas was primarily due to the high growth of oil palm plantation, which increased exponentially at an average rate of 12% annually, from about 0.3 Mha in 1980 to 10.5 Mha in 2012 (Figure 8a). This rapid increase was driven by the increasing demand for domestic and international markets, including demand for bio-diesel. Areas of cacao and coffee plantations have also increased, although not as drastically as oil palm (Figure 8a). The contribution of oil palm industry to regional and national economic development is very significant, hence a significant support to poverty alleviation through farm cultivation and downstream processing. It is estimated that the oil palm industry has absorbed about 6 million workers (Goenadi, 2008). In 2008, the national earning from palm oil exports and its related products has reached 14.5 billion USD, equivalent to 2.8% of 2008 Indonesia's GDP (Indonesian Palm Oil Commission, 2008; GAPKI, 2009).

**Figure 8a.** The growth of croplands by commodities from 1990-2013



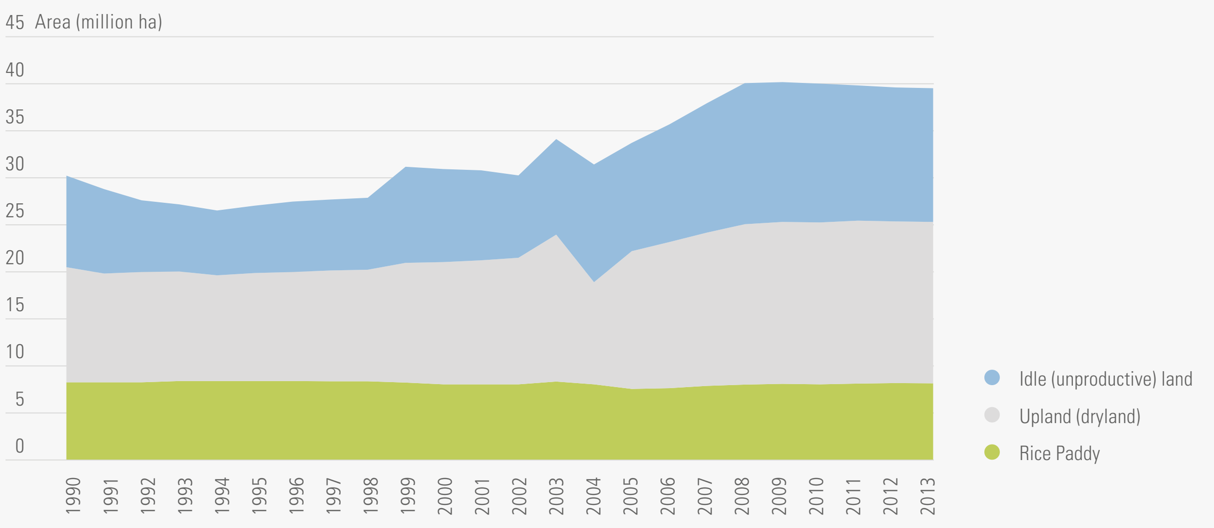

6 http://industri.bisnis.com/read/20160203/99/515771/aphi-usulkan-percepatan-perizinan-industri-kehutanan-ke-presiden

Contrary to agriculture plantation, growth of annual crops areas were relatively low. There was a slight increase in upland crops area (annual crops) but a decline was observed for *sawah* (rice field) area (Figure 8b). On average, the decreasing rate of rice field during 1990-2013 was about 17,200 ha per year or about 0.2% per year. Many studies have stated that the conversion of rice field mainly occurred in Java due to the increased of land demand for urban areas and settlement developments (Agus *et al.* 2006). If this trend continues, rice self-sufficiency that has been achieved in 2008 would not be sustained. On the other hand, many lands were abandoned (idle lands), and these areas tend to increase (see Figure 8b).

Expansion of oil palm plantations may well continue in the future as demand for palm oil is also expected to increase together with the demand for food and biodiesel, not only for international market, but also for domestic use. The Indonesian Palm Oil Association (GAPKI, 2014) has projected that the domestic demand for crude palm oil (CPO) would increase from 6.16 million tons in 2013 to 7.62 million tons in 2020 and to 13.88 million tons in 2050. Similarly, the diesel consumption in Indonesia is also projected to increase from 39.4 billion liters in 2013 to about 50.94 billion liters in 2020 and to 100 billion liters in 2050. These numbers suggest that Indonesia might face greater economic risk in the future in absence of a fundamental efforts to reduce the dependence on diesel. Acceleration of diesel substitution with palm oil biodiesel (FAME) is expected to be one of the solutions to achieve future energy independence.

Expansion of oil palm plantations has attracted the attention of global communities given the serious environmental problems it causes. The main concern is that the conversion of forest land to oil palm is a major contributor to $CO_2$ emissions and also to the loss of biodiversity. Palm cultivation on peatlands is often cited as the major threat to climate change. Related to this, the Government of Indonesia in May 2010, has announced a policy to develop oil palm plantations on degraded

**Figure 8b.** The growth of croplands by commodities from 1990-2013

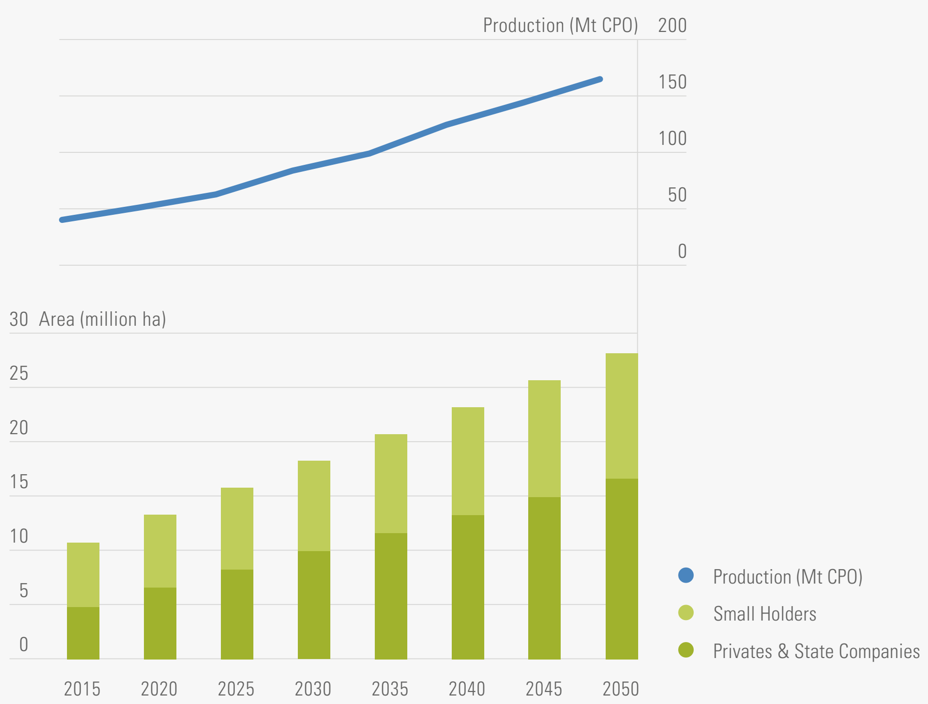


lands in place of forest or peatland. In addition, efforts to increase the palm oil production will be done mainly through productivity increase. GAPKI (2014) has set up a target to increase the productivity of palm oil from 17 to 35 ton of fresh fruit bunch (FFB) per hectare or equivalent to 9 tons CPO per hectare by 2050 through the use of high yielding varieties/new varieties on the replanting and improvement of crop management. The initial target is to increase the productivity to 20-23 tons FFB per hectare (5-6 ton CPO/ha) for the 2016-2025 period, to 28-32 tons FFB per hectare (7-8 ton CPO/ha) in the period 2026-2030 and to 32-35 ton FFB per hectare (8-9 ton CPO/ha) in 2031-2050.

To meet the future demand for palm oil, the Government of Indonesia has set up a target to increase production of palm oil up to 40 million tons CPO by 2020, almost twice the production level in 2012 (Ditjenbun, 2015; GAPKI, 2014). By 2050, palm oil production is projected to reach about 160 million tons CPO, about eight times its production level in 2012 (GAPKI, 2014). The total oil palm plantation by 2020 and 2050 is estimated to be around 13.3 and 28.2 million hectares respectively (Figure 9), and of these, between 50%-60% will be managed by smallholders.

For food crops, the Government of Indonesia has targeted to reach self-sufficiency in five main commodities namely rice, maize, soybean, sugar and meat. However, only rice has currently achieved self-sufficiency, while other crops/commodities are still imported (even rice is still imported for certain years to secure national rice stock). To increase the production,

**Figure 9.** Projection of area and production of oil palm plantations between 2013-2050 (GAPKI, 2014)

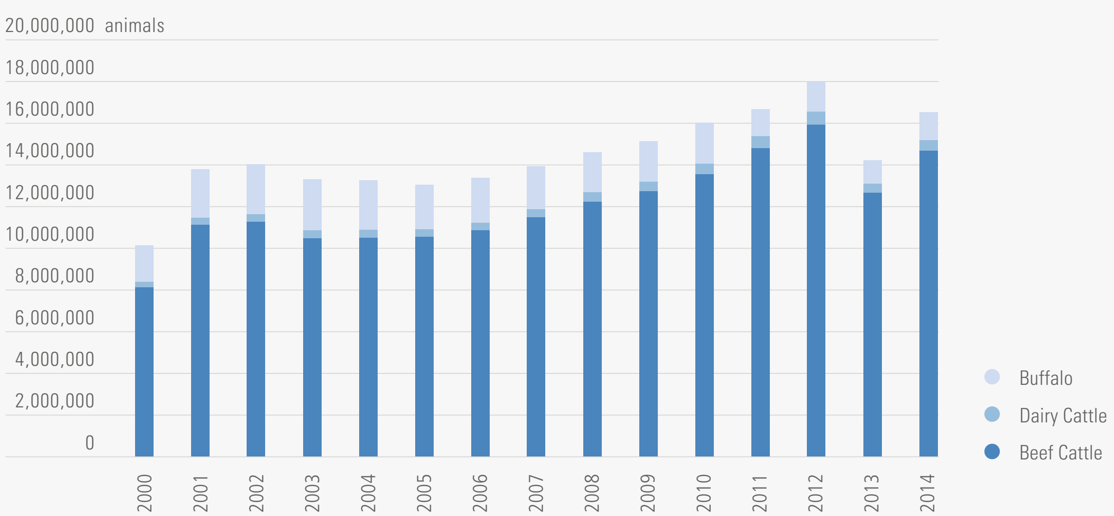


the Government of Indonesia plans to expand new rice fields outside Java and dry land area (for maize, soybean and other annual crops) by one million hectare each, as well as to increase planting intensity (through the application of intercropping system), crop productivity and use of unproductive land. Similarly for sugar, the government has also targeted to increase production by 1.65% annually. In particular, the programs include expanding new sugarcane plantation to about 200,000 ha and increasing the use of unproductive (marginal) lands, notably through improvement of crop productivity and revitalization of sugar industries and financial access (BAPPENAS, 2014).

Based on Statistics, trade balance for some food crops and horticulture show some deficits for the period of 2010 to 2014, meaning that Indonesia is still a net importer (Kementan, 2015). For food crop, the main imported commodities were maize and soybean followed by maize and rice, while the major export commodity is cassava. With regard to rice, the import only occurred in particular years when rice production target could be achieved. The deficits of food crop trade during these periods were between 3.4 to 6.4 billion USD with a mean of about 5.28 billion USD. The highest deficit occurred in 2011. Similarly for horticultural crops, the trade balance is still in deficit, particularly for fruits and vegetables. The main imported horticulture crops were durian, orange, onions, garlic, potato and carrots. The deficits for horticulture in this period were between 0.90 and 1.31 billion USD with a mean of about 1.05 billion USD. The highest deficit occurred in 2012.

Concerning meat, Directorate General of Animal Husbandry (Ditjen Perternakan, 2015) reported that national production was only able to meet about 65% of the demand (the current meat demand is about 385.035 tons, while the meat supply is only about 249.925 tons). Indonesia is still importing meat every year with increasing rate. Meat import increased at a rate of 5.5% per year, while the growth rate of beef cattle population is only 3.7% per year (Figure 10). Similarly,

**Figure 10.** Livestock population



Indonesia still imports milk. Between 2010 and 2014, the value of import of these commodities ranged between 1.23 and 3.03 billion USD with a mean of about 2.23 billion USD. Therefore, it is very challenging for Indonesia to be self-sufficient in these commodities. The Indonesian Second National Communication (MoE, 2011) reported that Indonesia might still import meat and milk in the future if the growth of animal population follows the historical population growth rate (5% per year for beef cattle and dairy cattle, 3% for broiler and layer, 2% for sheep, goat, pig and local chicken 2%, and 1% for horse and duck).

## 2.4 Current GHG Emissions

Greenhouse gas emissions from agriculture, forest and other land uses (AFOLU) have remained the main source of Indonesian emissions. In 2000, the total emissions from this sector was about 601.67 Mt$CO_2$e and in 2012 it had increased to 807.71 Mt$CO_2$e. Its contributions to the total national emissions in these two years were 60% and 56% respectively (Figure 11), while the energy sector accounted for 30% and 35%. The energy sector has the highest emission growth, at 5.8% per year followed by the waste sector (5% per year), AFOLU sector (2.1% per year) and industrial process and product utilization (IPPU) (0.05% per year).

The inter-annual variability of emissions from AFOLU sector is very high (Figure 12), essentially because of high fluctuation of emissions from peat fire and forest conversion or deforestation (Figure 12). Indeed, emissions from peat fire usually increase quite significantly during drought, which is commonly associated with the El Nino events (Murdiyarso & Adiningsih, 2006; Putra *et al*. 2008; Putra & Hayasaka 2011; Yulianti *et al*. 2012; Yuliyanti & Hayasaka 2013). Between 2000 and 2012, the annual rate of deforestation varied from 0.335 million ha/year up to 1.106 million ha/year.

The average net GHGs emission of the AFOLU sector in 2000-2012 reached 741.35 Mt $CO_2$e. The four main sources of emissions , representing about 95% of the total emissions of this sector were: peat decomposition (39%), peat fire (26%), forest conversion (23%) and rice cultivation (10%; including the use of nitrogen

**Figure 11.** The 2000 and 2012 sectoral greenhouse gas emissions (MoEF, 2015)

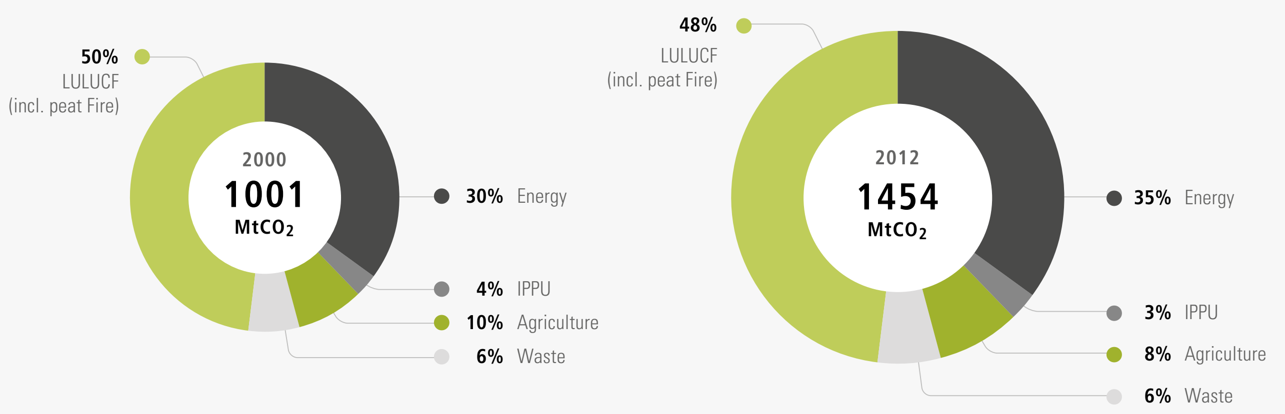
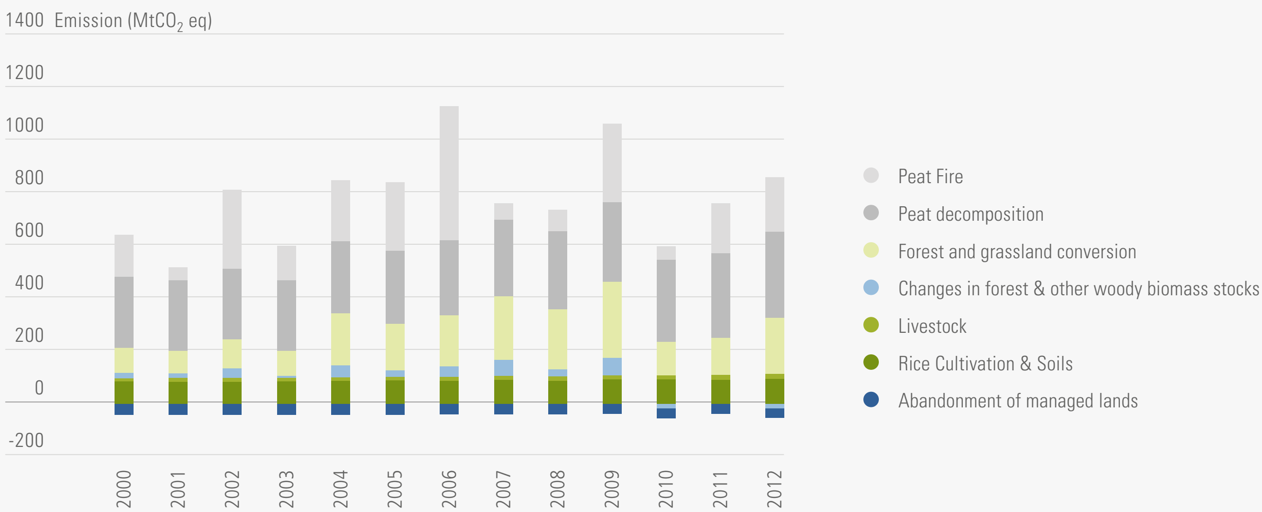


**Figure 12.** Rate of GHG emissions from AFOLU sector from 2000 to 2012 (MoEF, 2015)




fertilizers, lime, etc.). Emissions from peat decomposition will continue to be the main source of emission from this sector, mostly originating from peatland clearance for agriculture activities, agriculture plantation and timber plantation. Most of the peatland used for agriculture activities and plantations, have canal system for water drainage to allow crops and trees to grow. However this practice has exposed the peat to oxidation. Therefore ceasing emission in an opened and used peatland is very unlikely, unless the peatland is rewetted through restoration. This option is possible in unused peatland (degraded peatland). One possible option to reduce the emissions from used peatland is through the improvement of water management, to avoid over drainage and to maintain water table at high level still providing optimum condition for crops and trees to grow.

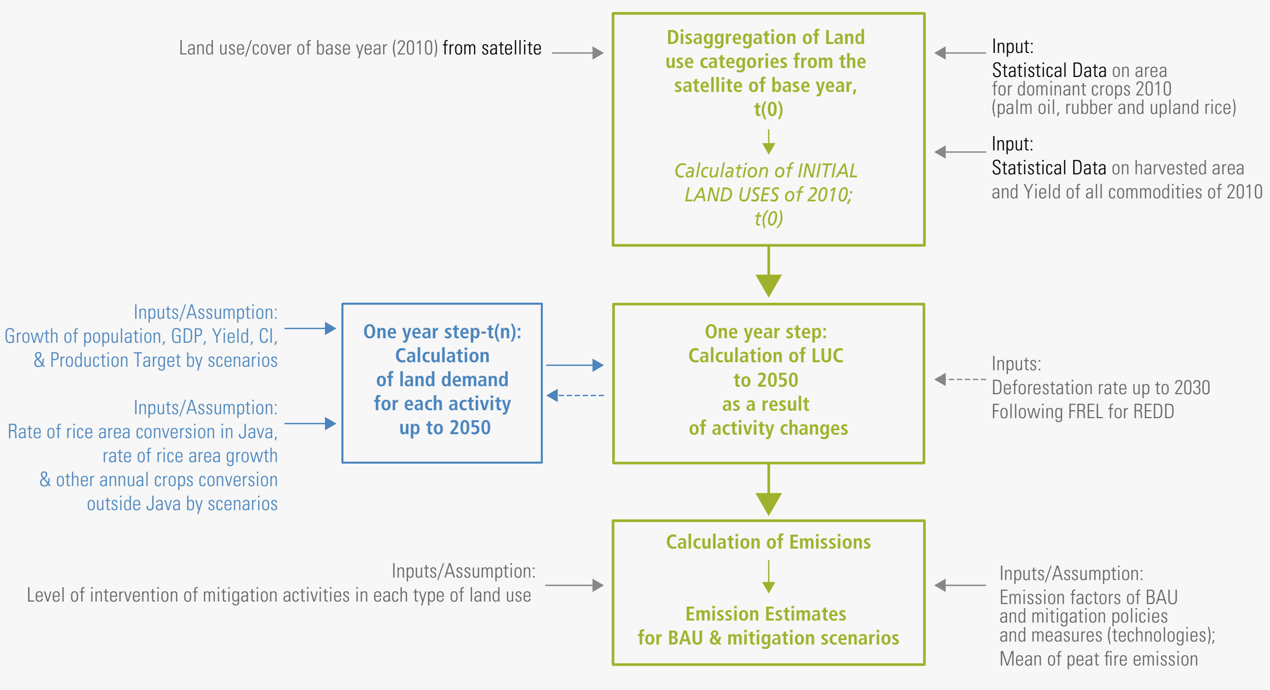
# 3 Methodology

The Indonesian DDPP for the AFOLU sector was prepared by a team consisted of researchers from the Centre for Climate Risk and Opportunity Management-Bogor Agricultural University and Institut Teknologi Bandung, particularly the Center for Research on Energy Policy – Institut Teknologi Bandung. The AFOLU and GHG emission scenarios of DDPP were analyzed using a spreadsheet model (the AFOLU Dashboard) developed by the team in collaboration with the SDSN/IDDRI DDPP secretariat. The model was intended to analyze future land demands and land uses under different sets of development scenarios and estimated greenhouse gas emission related to the land use changes under the scenarios. The model was also equipped with equations consistent with the IPCC Good Practice Guideline for GHG Inventory to estimate the emission reductions due to the implementation of mitigation technologies on a given land use. The process of land use analysis and calculation of emission reduction of the AFOLU Dashboard is given in Figure 13.

The AFOLU dashboard calculated future land use changes on an annual basis, starting in 2010. The step began with an analysis to determine the area of land use categories in 2010 based on satellite images and statistical data (see Annex 1). Changes of land use in the following years were determined by the production targets of particular commodities (i.e. palm oil, rice and wood) and demand level of other commodities (food, feed, and settlement area). Demand levels for food, feed and settlement were determined by the changes in human and animal populations, along with consumption level for the commodities. The consumption level of food crops commodities (rice and other cereals) was influenced by the change in GDP (Boer *et al.* 2014; Chern *et al.* 2003; Anghelache, 2011; Diacon & Maha, 2015). The capacity of land to produce the commodity would depend on crop/plant productivities and cropping intensity/land use efficiency. Thus, future changes of land use would depend on the changes of the assumption used for land use drivers (i.e. population and GDP growth, livestock/animal population growth, crops productivity, cropping intensity, feed and food consumption level and production targets for some key strategic commodities).

The DDPP scenario was the results of iterative discussions among researchers and consultations with broader climate change mitigation stakeholders. In addition, it has also been discussed in national

**Figure 13.** Process of the land use analysis and emission reduction calculation of the AFOLU Dashboard



workshops and meetings such as in meeting with the Advisory Board of Climate Change Indonesia during the preparation of Indonesian INDC, International Seminar on Environmental Management and Development in Indonesia coordinated by Forestry and Environment Research, Development and Innovation Agency-Ministry of Environment and Forestry, Republic of Indonesia and National Institute for Environmental Studies – Japan. Based on these discussions, deep decarbonizing of the AFOLU sector seems to be technically feasible; however, strong coordination across sectors, the presence of strong policy in addressing land tenure, availability of funding and support for the implementation of high cost mitigation technologies, are vital for the successful implementation of the DDPP.

At this stage, Indonesia deep decarbonization pathways should be treated as a scientific assessment that indicates the technical potential of Indonesia in reducing GHG emissions; it is neither the Indonesian government's plan nor commitment in climate change mitigation. However, the results of this study were discussed with government officials and have been used to facilitate the process of designing low carbon development strategies for this sector.

# 4 Scenarios and Assumptions

This study analyzed three scenarios, i.e. Business as Usual (*BAU*), Development (*DEV*) and *DDPP* Scenarios. The BAU scenario considers that development plans are implemented without mitigation policies and measures. This means that no specific mitigation policies and programs were used in this scenario. Some of the current policies and programs that could be related to mitigation are assumed to continue following historical patterns. DEV is a development scenario that includes mitigation policies and measures in the implementation of development plans and achieving production targets. DDPP scenario is similar to DEV but with improved system and intensified mitigation policies and measures. For all scenarios, the rice production is kept to self-sufficiency levels; land demand for livestock and settlement are always be met, as well as the productions of some strategic commodities as defined in strategic development of the sectors (i.e. wood see Figure 6; MoFor, 2011; palm oil see Figure 9). In addition, the availability of biomass and CPOs for producing biogas and biofuel as defined in the DDPP scenarios for energy (Siagian *et al.* 2015) was also assessed in each scenario. This is the first step in the integration between energy and AFOLU sectors, which is a crucial methodological progress.

For the three scenarios, the macroeconomic drivers are identical. The economy and population grow significantly in the next four decades. The scenarios assume a constant rate of increase in GDP per capita at 4.8% throughout the 2010-2050 period, consistent with development needs. The annual population growth rate is about 1.1% up to 2020, and then declines to 0.6% to reach 2050 total population at about 300 million people (Annex 2). For other drivers, the assumptions vary across the scenarios (Annex 3 and 4) to reflect the government's plans and targets (Bappenas, 2013; Kementan, 2014; Ditjenbun, 2015). As defined above, the rise of population (both for people and animal) triggers an increase of land demand for settlement, food, and feed. To meet the increasing land demands, the model uses some of the grassland and unproductive land (i.e. including in other lands of Annex 2), in which grassland was used for food and settlement under the condition that demands for livestock are met. Under insufficient availability of grassland and unproductive land, the model increases the deforestation rate. This means that deforestation would occur only to meet land demands for development, which is termed *planned deforestation*. With the exception of Java, rice fields were normally converted to settlements and commercial areas, while outside Java, development of rice fields would generally occur in dry land agriculture. Taking these historical land use patterns into account, the conversion of rice fields in Java and dry land agriculture outside Java are taken as inputs (Table 2).

Consistent with observations of historical land use patterns (Figure 3), the conversions of forests are not systematically used in the development (to meet the demands for settlement, food, feed and production targets), but remains as unproductive land or are not used for development (unplanned deforestation). The Government of Indonesia has developed Forest Reference Emission Level (FREL) to evaluate the performance of REDD+ implementation of (MoEF, 2015). In FREL, the rate of deforestation until 2020 is assumed to be the same as the historical rates during 1990-2012. This relatively long reference period was used to capture the general condition of forest transition in Indonesia, and to reflect the national circumstances, policy dynamics and impacts (biophysical, social, economic growth, political and spatial planning). Deforestation in FREL includes both the planned and unplanned deforestations. Thus, the model uses the data gathered in Table 2 as inputs, wherein the deforestation rate under BAU scenario is the same as that of FREL until 2020, before slightly decreasing over 2021-2030. For DEV and DDPP, these rates were further reduced. After 2030, no more deforestation is considered into the model, meaning that no more unplanned deforestation occurs and the model only calculates the planned deforestation. Hence, the rate of unplanned deforestation in 2013-2030 is calculated as the difference with the aggregate number (Table 2).

As shown in Figure 5c, the gap between wood supply and industrial demands was met by

**Table 2.** Inputs for deforestation rate for BAU, DEV and DDPP scenarios

| | Historical[1] | BAU | DEV | DDPP |
|---|---|---|---|---|
| Rice in Java (000 ha/yr)[1] | -52.311<br>-1.34%/yr | -27.59<br>(-0.83%/yr) | -22.710<br>(-0.66%/yr) | -22.710<br>(-0.66%/yr) |
| Rice Outside Java (000 ha/yr)[1] | 48.405<br>1.31% | 28.76<br>(0.68%/yr) | 63.10[2]<br>(1.31%/yr) | 28.76<br>(0.68%/yr) |
| Rate of deforestation (000 ha/yr)[3] | 920 | 2013-'20:920<br>2021-'30:785 | 2013-'20:650<br>2021-'30:550 | 2013-'20:450<br>2021-'30:400 |
| Other annual crops (000 ha/yr)[3] | -36.4 | -35 | -30 | -25 |

1 Mean annual rate of conversion up to 2050; Reference period for rice is 2000-2010 and for deforestation is 1990-2012 (MoEF, 2015).

2 Rate following the government plan (Bappenas, 2013; Kementan, 2014);

3 Total deforestation from planned and unplanned deforestation, and after 2030 only planned deforestation (deforestation only occurs when there is insufficient area of non-forested land). The deforested area is assumed to be converted into grassland and lands that were allocated for settlement and other development areas.

4 Areas used for settlement and other development areas (road, airport etc.) do not always originated from conversion of forest area, but might be from agricultural lands. Based on historical data (1990-2013), about 36 thousand ha of agricultural lands have been converted to other development areas such as settlement and grassland.

Illegal logging. To accommodate this condition, the model assumes that current wood extraction from natural forest is higher than the sustainable extraction rate, i.e. 50 $m^3$ per ha, and in the future, for all three scenarios, wood extraction would follow the sustainable rate, i.e. 30 $m^3$/ha. However, the sustainable rate occurs earlier for DDPP (2030), followed by DEV (2040) and BAU (2050).

Wood production from natural forests reaches 20 million $m^3$ annually by 2050 (based on APHI scenario), while for DEV and DDPP scenarios, it is limited to only 14 million $m^3$ annually by 2020 (based on RKTN). The volume of wood produced from deforested area is assumed to be 50 $m^3$/ha. Currently, not all of the woods obtained from deforested areas were used for wood industries. Some are left on site, particularly in areas with

**Table 3.** Inputs used for the estimation of wood production for BAU, DEV and DDPP scenarios

| Commodities | 2010 | BAU | DEV | DDPP |
|---|---|---|---|---|
| Wood volume extracted from 1 ha of Natural Forest ($m^3$/ha)[1] | 50 | 30 | 30 | 30 |
| Wood production target from natural forest (million $m^3$)[2] | 13.4 | 20.0 | 14.0 | 14.0 |
| Rate of timber plantation establishment (000 ha/yr)[3] | 150 | 150 | 250 | 350 |
| Percentage of wood from deforested area used for timber[4] | 50 | 100 | 100 | 100 |
| Percentage of wood from palm oil and industrial crops used for timber[5] | 10 | 50 | 50 | 50 |

1 Sustainable wood extraction from natural forest ranges from 20 - 35 $m^3$/ha. This study assumed the extraction rate was about 50 $m^3$/ha in 2010, indicating that the excess representing wood extraction from illegal logging, and by 2050 it become 30$m^3$ , indicating no more illegal logging took place. This level of extraction will occur in 2030, 2040 and 2050 for the DDPP, DEV and BAU respectively;

2 Wood production target from natural forest for DEV and DDPP scenarios following the RKTN (MoF , 2011) would be achieved by 2020, while under BAU, is slightly higher following the Forest Concession Holders Association (APHI, 2007 ) which would be achieved by 2050;

3 Rate of industrial timber plantation (HTI) establishment under the BAU following historical rate (1990-2012; see Figure 9) and percentage of plantable was only 63% based on APHI assumption (APHI, 2007). Establishment of HTI is limited to 14.5 million ha (MoF, 2012 );

4 Percentage of deforested area used for wood production will reach 100% in 2030, 2040 and 2050 for DDPP, DEV and BAU scenarios respectively. The volume of wood produced from deforested area was assumed to be about 50 $m^3$/ha;

5 Percentage of agriculture plantations (palm oil and rubber) used for wood production at the end of rotation partly would reach 50% in 2030, 2040 and 2050 for DDPP, DEV and BAU scenarios respectively. Wood volume from agriculture plantation is assumed at 50 $m^3$/ha.

**Table 4.** Inputs on mean annual increment (MAI) of trees for BAU, DEV and DDPP scenarios

| Commodities | Rotation (year) | BAU | DEV | DDPP |
|---|---|---|---|---|
| MAI Fruit and Nuts (tC/ha/y) | 60 | 2 | 2 | 2 |
| MAI Industrial Crops (tC/ha/y) | 35 | 4 | 4 | 4 |
| MAI Palm oil (tC/ha/y) | 35 | 3.5 | 3.5 | 3.5 |
| MAI Secondary Forest (tC/ha/y)[1] | 35 | 0.25 | 0.30 | 0.40 |
| MAI HTI (tC/ha/y)[2] | 6 | 7.34 | 8.02 | 8.70 |
| MAI Aff/Ref program with rotation (tC/ha/y)[2] | 10 | 7.27 | 7.94 | 8.61 |
| MAI Aff/Ref program without rotation (tC/year/ha) | 40 | 4.00 | 4.00 | 4.00 |

1 The estimated mean annual increment (MAI) of natural forest was based on diameter growth ($m^3$/ha/yr), thus it was converted to biomass growth, Biomass Expansion Factor (BEF) of 1.4 and wood density of 0.7 t/$m^3$(Ruhiyat, 1990 ); The increase of the MAI of natural forest under the DEV and DDPP scenarios is to reflect the improvement of forest management through enrichment planting;

2 The MAI of HTI was calculated based on the potential of wood volume of HTI in $m^3$/ha divided by the rotation length (6 years). The wood volume potential of HTI under the three scenarios was 120 $m^3$/ha, and in 2050 the wood volume potential under the BAU, DEV and DDPP scenarios increased to 140, 160 and 200 $m^3$/ha respectively as a result of improvement of variety and technology (Suhartati and Rahmayanti, 2013; ). The increase of wood volume potential was due to technology and variety improvement that occurred every 10 years. For converting the wood volume into ton carbon, BEF of 1.67 (IPCC Default), wood density of 0.4 t/$m^3$ (FAO, 1997) and carbon fraction of 0.5 were used. The MAI was calculated by dividing the total carbon with rotation. The MAI presented in this table is the average value of MAI between 2011-2050.

difficult access (e.g. forest area encroached by communities for agriculture activities). It is assumed that, although only 50% of the woods collected from deforested areas were used by wood industries, all would eventually be used in the future. However, this condition occurs earlier under the DDPP scenario (2030), and later in DEV and BAU scenarios (Table 3). Similarly for wood from agriculture plantation, the percentage was much lower (Table 3). Assumptions for the three scenarios on the rate of tree growth from timber plantation, natural forest (forest regeneration), afforestation and reforestation programs, and agriculture plantations are presented in Table 4.

# 5 Decarbonizing Strategy

Strategies for reducing GHG emission from land-based sectors have been defined in the National Action Plan under the Presidential Regulation Number 61/2011. There are five main strategies namely (i) improving the management of land and forest resources by accelerating the establishment of forest management unit (FMU) in all forest areas, (ii) pushing the adoption of sustainable management practices in production forests by implementing mandatory certification systems[7], (iii) reducing dependency on natural forests in meeting wood demands through increasing establishment of timber plantation on community lands and state lands and increasing the use of wood from agriculture plantations, (iv) reducing pressures on natural forests for establishment of development areas and agriculture expansion through improvement of land use spatial plan, optimization of the use of unproductive lands and improvement of crop productivity and cropping intensity, (iv) enhancing sink through restoration of production forests ecosystem and land rehabilitation and (v) reducing emission from peatland through improvement of peat management, peat restoration and moratorium of new permits/concession on peatlands.

The Government of Indonesia has issued a number of mitigation policies that support the implementation of mitigation strategies. In order to support the effort to reduce unplanned deforestation, the Government of Indonesia will accelerate the establishment of Forest Management Unit (FMU) in all forest areas, particularly in areas that have no on-site management agencies (mostly are areas where concession permits have been terminated; see section 2.2).

To reduce planned deforestation and use of peatlands, the Government of Indonesia has also enacted a policy on moratorium of new permit/concession. The moratorium was first declared under the Presidential Instruction No.10/2010, and renewed every two years (Presidential Instruction 6/2013, 8/2015). In addition, the Government of Indonesia has

7 Government of Indonesia has applied Timber Legality Assurance System (TLAS) by issuing the Minister of Forestry Regulation Number P.38/Menhut-II/2009 on Standard for Evaluating Performance of Implementation of Sustainable Production Forest Management (PK-PHPL) and Verification of Legality of Logs (SVLK). PK-PHPL is mandatory for all permit holders in state forests and private forests, and SVLK is mandatory for all permit holders in state forests and private forests and also for all upstream and downstream wood industries. These are expected to reduce trading of illegal logs and to push application of sustainable forest management practices leading to the decrease of forest degradation and deforestation.

**Table 5.** Assumptions on the limitation of the use of peatlands in BAU, DEV and DDPP scenarios

| Conversion of peatland and natural forest to other land uses | Historical | BAU | DEV | DDPP |
|---|---|---|---|---|
| HTI | ● | ● | ○ | ○ |
| Palm oil | ● | ● | ● | ○ |
| Rubber | ● | ● | ● | ● |
| Other perennial crops | ● | ● | ● | ○ |
| Rice outside Java | ● | ○ | ○ | ○ |
| Other annual crops | ● | ● | ● | ● |
| Grassland | ● | ○ | ○ | ○ |

Note: ○ and ● mean new development activities cannot and can still occur in peatland respectively

also established a new agency, called the National Agency for Peatland Restoration (*Badan Restorasi Gambut*; BRG), enacted through Presidential Regulation No. 1/ 2016. BRG will be in charge for coordinating and facilitating restoration of degraded peatland. It is designed that BRG will facilitate and coordinate the restoration of peatlands with a total target of about 2 million ha (Jurnal Asia, 2016), i.e. about 65% of the degraded peatlands.

Currently, conversion of forested peatland is still ongoing. To accommodate the impacts of the moratorium policies on the peatland, a set of assumptions was developed for each scenario. Under the BAU, it is assumed that the use of peatland for the expansion of rice field is prohibited and that grassland area will remain constant or decrease if it is used for other development activities (Table 5). Under DEV scenario, an additional condition is applied, according to which no further peatland conversion to new timber plantation (HTI) is permitted, and under the DDPP, such condition is also applied for conversion to agriculture plantations (palm oil and other perennial crops). However, the establishment of new rubber plantation and other annual crops may still continue as part of communities' activities (Table 5). Effective implementation of this policy is expected to reduce deforestation and GHG emissions from peatland.

To further reduce the emissions, a number of mitigation measures are implemented on certain land categories as follows:

1. Measures for reducing CH4 emission from rice cultivation through improvement of irrigation management (intermittent irrigation) and use of low emission varieties.
2. Measures for reducing CH4 emission from ruminant (livestock) through the use of manures for biogas production and feed supplement.
3. Measures for reducing N2O emission from the use of nitrogen fertilizers through practicing organic farming (increasing the use of organic fertilizers).
4. Measure for reducing $CO_2$ emission from peat decomposition through improving water management and peat restoration.
5. Measures to increase carbon removal through the use of unproductive lands for timber plantation and agroforestry.

The level of intervention of the mitigation measures in each scenario is designed based on historical condition and considering the government plans, as presented in Table 6.

**Table 6.** Rate of implementation of mitigation measures under the BAU, DEV and DDPP scenarios

| Mitigation Measure | BAU | | DEV | | DDPP | |
|---|---|---|---|---|---|---|
| | Growth (%/yr) | 2050 (%) | Growth (%/yr) | 2050 (%) | Growth (%/yr) | 2050 (%) |
| Rice cultivation | | | | | | |
| Use of low emission variety in Java | 0 | 0 | 0.70 | 28.00 | 0.70 | 28.00 |
| Use of low emission variety outside Java | 0 | 0 | 0.50 | 20.00 | 0.50 | 20.00 |
| Irrigation management in Java | 0 | 0 | 0.60 | 24.13 | 0.60 | 24.13 |
| Irrigation management outside Java | 0 | 0 | 0.46 | 18.21 | 0.46 | 18.21 |
| Cropland | | | | | | |
| Reducing Nitrogen Application in cropland | 0.01 | 0.40 | 0.01 | 0.40 | 0.01 | 0.40 |
| Livestock | | | | | | |
| Manure management (biogas) | 0 | 0 | 0.375 | 15.00 | 0.375 | 15.00 |
| Feed supplement for dairy cattle | 0 | 0 | 1.00 | 40.00 | 1.00 | 40.00 |
| Feed supplement for other cattle | 0 | 0 | 0.50 | 20.00 | 0.50 | 20.00 |
| Peatland Management[1] | | | | | | |
| Improvement of water management | 0 | 0 | 2.00 | 20.00 | 3.00 | 40.00 |
| Peat restoration | 0.25 | 10.00 | 0.75 | 30.00 | 1.25 | 50.00 |
| Land rehabilitation[2] | | | | | | |
| Survival rate of Aff/Ref with rotation | 0.87 | 70 | 1.52 | 90.00 | 1.52 | 90.00 |
| Survival rate of Aff/Ref without rotation | 1.02 | 30 | 2.40 | 50.00 | 3.25 | 70.00 |

1 For peatland management, area of plantations (timber and palm oil) that could improve the water management was limited to 40% of the total plantation area (1.44million ha), while peat restoration was directed to non-productive land (grassland/shrubs) and limited to about 50% of the total grassland area (3.23 million ha).

# 6 Results

## 6.1 Land Uses

Dynamics of land use patterns is driven by the assumptions on the change of the crucial drivers discussed in the previous section (i.e. population and GDP growth, livestock/animal population growth, crops productivity, cropping intensity, feed and food consumption level and production targets for some key strategic commodities). The result of the analysis indicates that, over the period 2013-2020, planned deforestation (i.e. the conversion of forest required to fulfill land demands for food, feed production, settlement and production target of key commodities) is lower than the deforestation rate used in determining FREL for REDD+ in the three scenarios – 0.421, 0.310 and 0.241 thousand hectare per year under the BAU, DEV and DDPP scenarios respectively – (Figure 14; c.f. Table 2).

Under both DEV and DDPP scenarios, the need to convert natural forests to meet future land demands is decreasing, although it is the opposite for BAU (Figure 14). This is primarily due to the ambitious production target of palm oil in BAU scenario, which is twice the production target under DEV and DDPP scenarios (see Figure 9). In 2010, natural forest area is at a total of 92.74 million hectares, and by 2050 the remaining natural forests in BAU would only be 60.45 million hectares with only 4.1% remaining as primary forest. Under DEV and DDPP scenarios, the remaining natural forest would be about 73.67 and 79.69 million ha, and about 14.1% (10.3 Mha) and 17.2 % (13.7 Mha) still remain as primary forests respectively. This significantly higher outcome can be attributed to the decreased number of illegal loggings and increased rate of establishment of timber plantation as well as increased of land productivity and cropping intensity and consumption level under DEV and DDPP scenarios (see Annex3, 4, and Table 3, 4).

**Figure 14.** Annual rate of planned and unplanned deforestation in BAU, DEV and DDPP scenarios

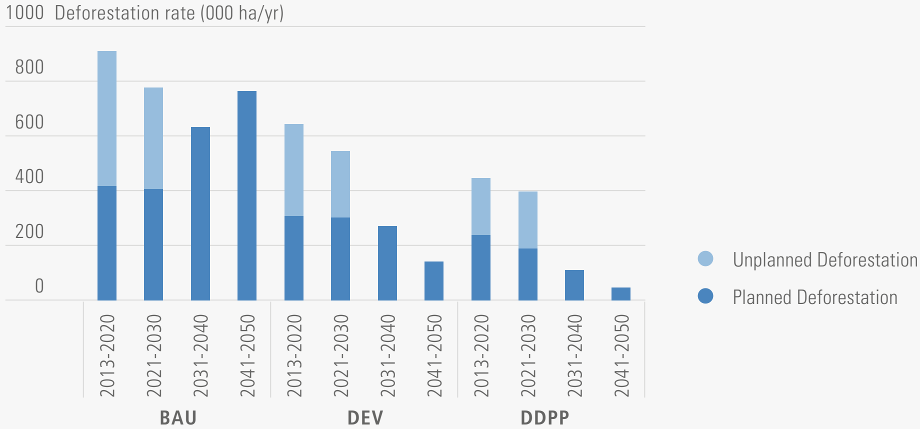
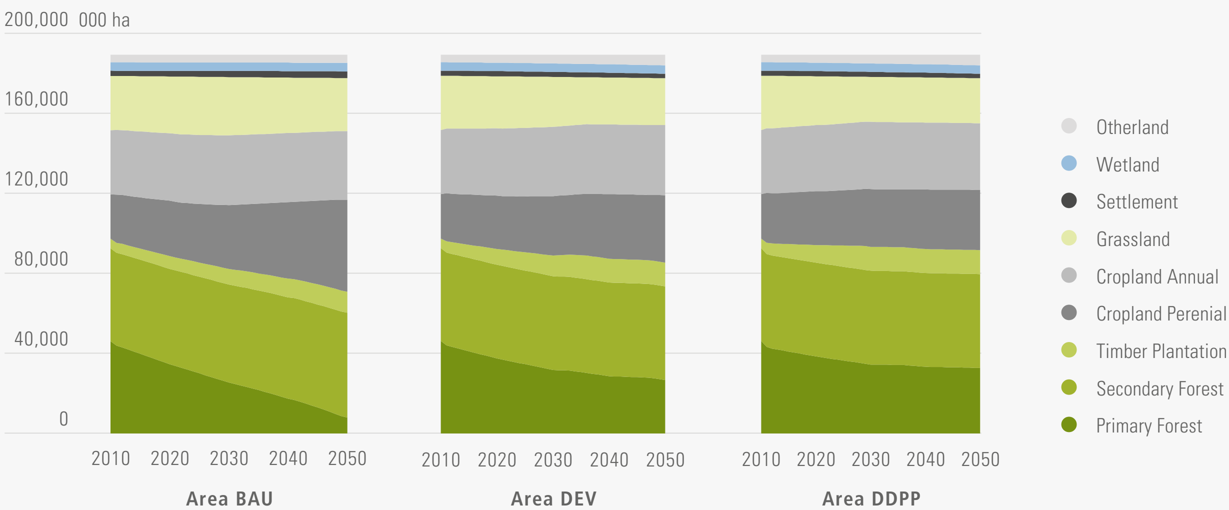



**Figure 15.** Land use change from 2010 to 2050 under the BAU, DEV and DDPP scenarios



The land use change pattern under the three scenarios and the proportion of land use by categories are presented in Figures 15 and 16 respectively.

Figure 16 shows that grassland area under BAU is higher than in DEV and DDPP scenarios, and lower in 2050 than in 2010, basically because of the assumptions on the improvement of grassland capacity in producing feed for animal. Under BAU, DEV and DDPP, it is assumed that the capacity of grassland for feed production is increased by 1.0%, 1.1% and 1.2% per year respectively, leading to an absolute increase from 0.5 to 0.74, 0.77 and 0.81 kg per $m^2$ for BAU, DEV, DDPP respectively. The capacity of pasture land to produce feed is also increased from 5 to 7.44 kg per $m^2$ for BAU, to 7.74 kg per $m^2$ for DEV and to 8.06 kg per $m^2$ for DDPP. In addition, under DEV and DDPP, the duration of pasture land producing feed also increases thanks to the improvement of pasture management, particularly in Java and Sumatra, to 60 days and 75 days in a year respectively (against 45 days in BAU). The demand of land for animal, particularly for ruminants, could be reduced significantly if large parts of the grassland area is converted into pasture land, coupled with good management, or increased the use other sources of forage (e.g. rice husk, cassava leaves, tofu ground etc.) to allow the increase use of grassland area to meet the land demands of other commodities. This might further reduce the need for natural forest conversion.

## 6.2 *Level of Emissions*

At base year (2010), the gross emission reaches 0.610 Gg$CO_2$e, and the carbon removal about 0.145 Gg, resulting in a net emission of about 0.464Gg $CO_2$e. These net emission estimates are not significantly different from the estimates

**Figure 16.** Comparison of present and future percentages of land use by categories under the BAU, GOV and DDPP scenarios

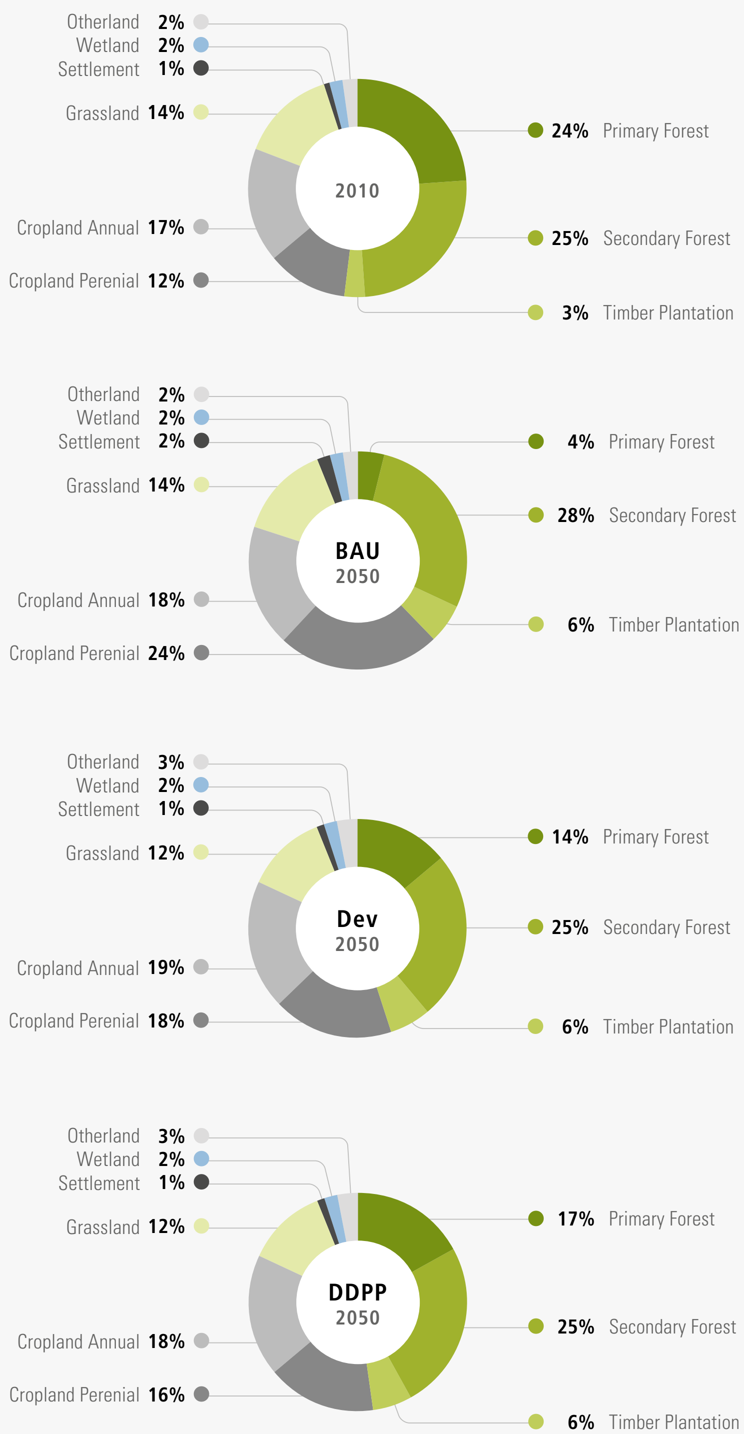
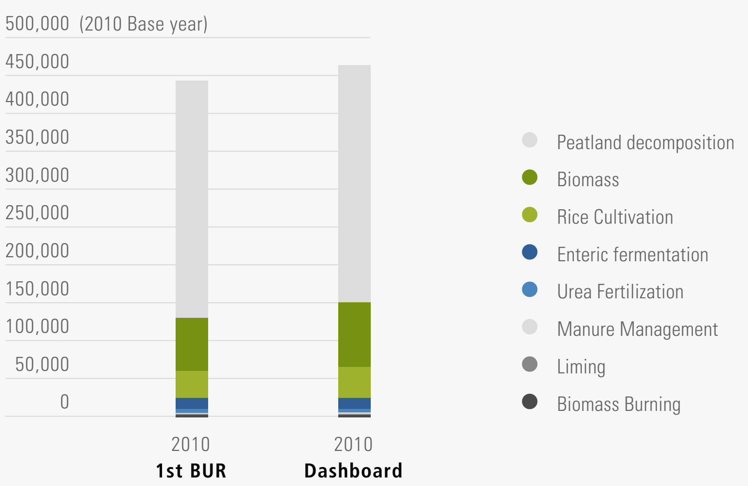


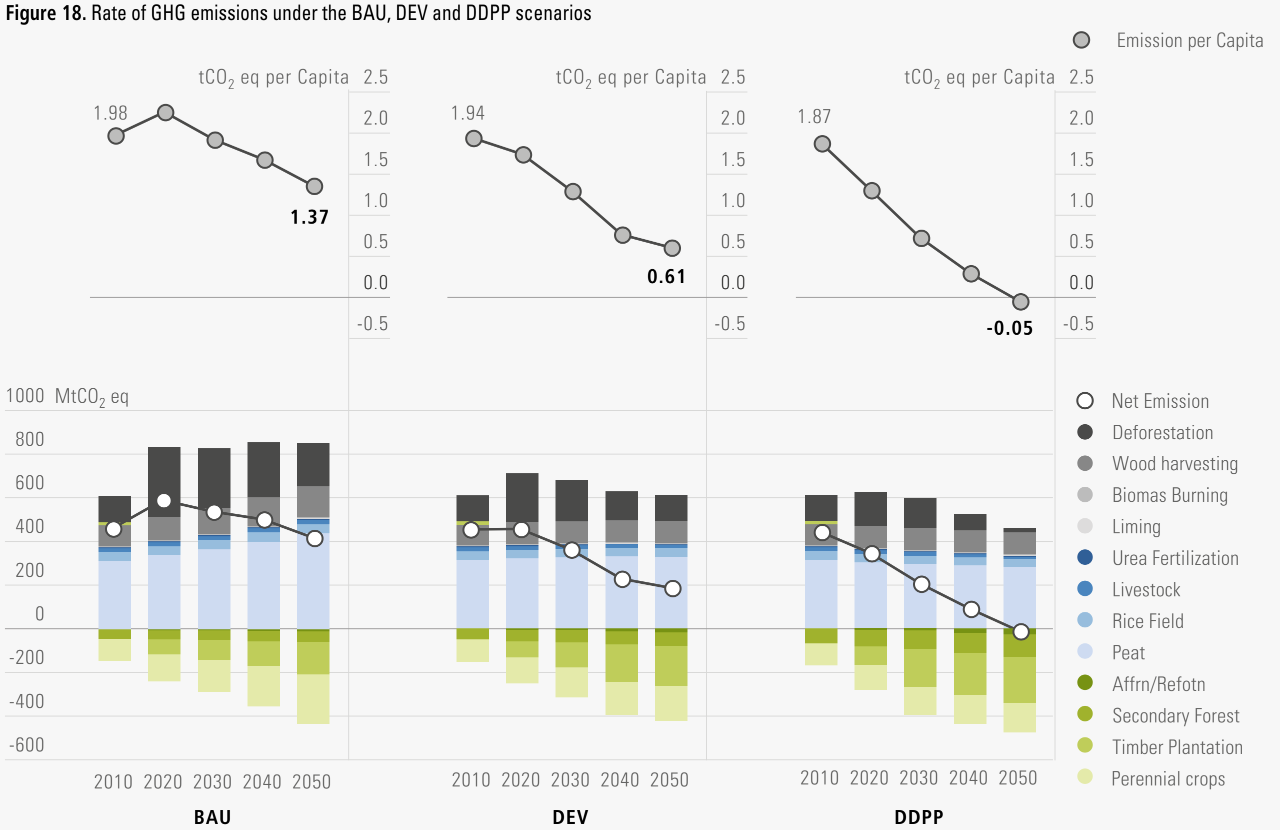
**Figure 17.** Net emission of AFOLU sector in 2010 (Base year) from AFOLU Dashboard and 1st BUR. Note: Emission from peat fire is not included in the AFOLU Dashboard




of the 1st BUR (Figure 17). The main differences come from rice cultivation and from biomass removal. For rice cultivation, the aggregation level for the calculation of emission was made at the provincial level for BUR while it was done at the national level for the dashboard. Thus the dashboard used national average emission factor, whereas for biomass removal, BUR did not disaggregate the agriculture plantation and other annual crops into different crop types as the dashboard (see Annex 4).

Under the BAU scenario, emissions from AFOLU increase until 2020 and then decrease slightly thereafter (Figure 18). In DEV scenario, the GHG emission start decreasing very slowly from 2010, whereas in DDPP scenario, the emission decrease

**Figure 18.** Rate of GHG emissions under the BAU, DEV and DDPP scenarios



quite rapidly. By 2050, per capita emissions under BAU are still high, (about 1.36 ton $CO_2e$) while under DEV and DDPP scenarios, they decrease to 0.60 ton $CO_2e$ and -0.05 ton $CO_2e$. In all cases, emissions from peat decomposition continue to be a major source of GHG emission.

The rapid decrease in emissions under DDPP scenario occurs as a result of increased land productivity and cropping intensity leading to less demand for land to be used for crop production (see Annex 3) and enhanced mitigation actions. Under DDPP, the dependence on natural forest for producing wood decreases, in particular as the result of increasing rate of timber plantation establishment, and increasing rate of land rehabilitation. The survival rate of trees of land rehabilitation in DEV and DDPP is higher than under BAU (Table 7). Therefore, the resulting emissions from wood harvesting from natural forests under this scenario, are lower than under BAU. In addition, emissions from peat decomposition also declines significantly as a result of peatland moratorium policy, in which further peatland conversion for large plantation is prohibited (see Table 5), and restoration of the larger parts of peatland (Table 7). In BAU, the total area of degraded peatland being restored is about 0.25Mha of the 3 million hectares, while in DEV and DDPP scenarios this number is increased to about 0.96 and 1.60Mha respectively. Implementation of mitigation measures through improvement in manure management and feed supplement, as well as improvement of water management in rice field and peatland, also contributed to the increasing rate of emission reduction in this scenario.

## 6.3 Crop Production and Food Balance

The implementation of mitigation policies and measures would not significantly affect the production level of agriculture commodities or even better (Figure 19; Annex 5). The productions of all agriculture commodities in DEV and DDPP are higher than those of BAU. Positive balances between supply and demand (surplus) aref ound for rice, cassava, oil crops, palm oil and other crops.

**Figure 19.** Food balance (Supply-demand) for agriculture commodities in BAU, DEV and DDPP scenarios

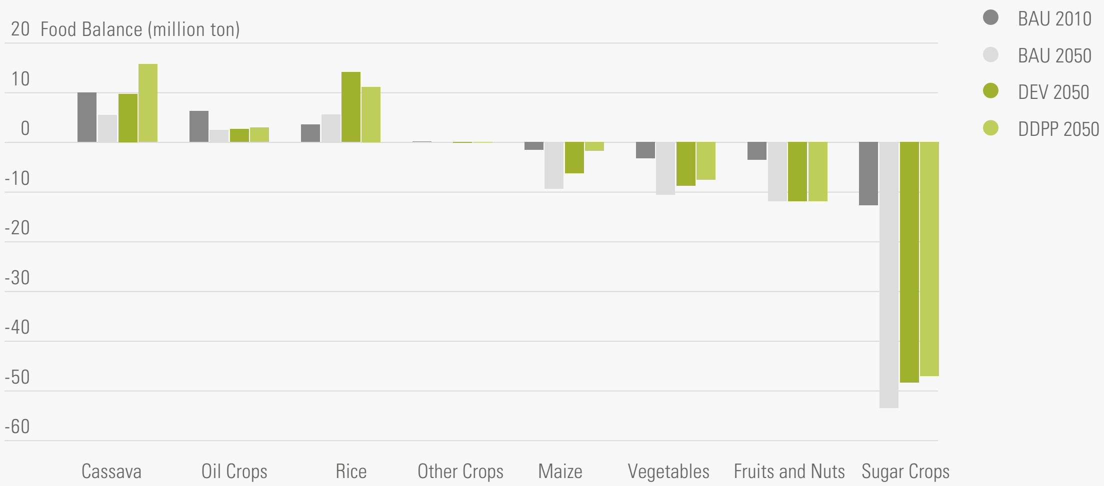


**Table 7.** Level of intervention of mitigation measures[1] under the BAU, DEV and DDPP scenarios

| BAU | | 2010 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|---|
| Rice (000 ha) | Rice Field | 8,763 | 8,710 | 8,700 | 8,732 | 8,810 |
| | Low Emmision Variety | - | - | - | - | - |
| | Intermittent Irrigation | - | - | - | - | - |
| Crop lands | Area of Croplands (000 ha) | 54,303 | 61,591 | 66,837 | 72,919 | 80,377 |
| | Nitrogen Application (000 ton urea) | 6,422 | 6,587 | 6,465 | 6,379 | 6,639 |
| Livestock (000 heads) | Total Livestock Population | 443,183 | 460,506 | 478,505 | 497,209 | 516,643 |
| | Feed Supplement | - | - | - | - | - |
| | Biogas | - | - | - | - | - |
| Peat (000 ha) | Total Area of Peatland | 14,585 | 14,508 | 14,440 | 14,381 | 14,327 |
| | Improved Water Management | - | - | - | - | - |
| | Peat Restoration | - | 77 | 145 | 204 | 258 |
| Afforestation/ Reforestation (Aff/Ref; 000 ha) | Land Availablefor Aff/Ref Program | 14,033 | - | - | - | - |
| | Aff/Ref program without Rotation | - | 972 | 1,944 | 2,915 | 3,887 |
| | Survival Rate (%) without Rotation | - | 22% | 24% | 27% | 30% |
| | Aff/Ref program with Rotation | - | 1,098 | 2,196 | 3,294 | 4,392 |
| | Survival Rate (%) with Rotation | - | 54% | 59% | 64% | 70% |
| **DEV** | | **2010** | **2020** | **2030** | **2040** | **2050** |
| Rice (000 ha) | Rice Field | 8,763 | 8,148 | 7,570 | 7,009 | 6,441 |
| | Low Emmision Variety | - | 466 | 958 | 1,491 | 2,082 |
| | Intermittent Irrigation | - | 412 | 849 | 1,325 | 1,855 |
| Crop lands | Area of Croplands (000 ha) | 54,303 | 60,417 | 64,441 | 67,235 | 68,772 |
| | Nitrogen Application (000 ton urea) | 6,422 | 6,462 | 6,233 | 5,881 | 5,441 |
| Livestock (000 heads) | Total Livestock Population | 443,183 | 457,547 | 466,903 | 470,818 | 468,830 |
| | Feed Supplement | - | 2,958 | 11,602 | 26,391 | 47,813 |
| | Biogas | - | 79 | 314 | 725 | 1,333 |
| Peat (000 ha) | Total Area of Peatland | 14,585 | 14,001 | 13,311 | 12,978 | 12,702 |
| | Improved Water Management | - | 342 | 789 | 880 | 914 |
| | Peat Restoration2 | - | 242 | 485 | 727 | 969 |
| Afforestation/ Reforestation (Aff/Ref; 000 ha) | Land Available for Aff/Ref Program | 13,938 | - | - | - | - |
| | Aff/Ref program without Rotation | - | 1,383 | 2,767 | 4,150 | 5,533 |
| | Survival Rate (%) without Rotation | - | 25% | 31% | 40% | 50% |
| | Aff/Ref program with Rotation | - | 1,369 | 2,739 | 4,108 | 5,478 |
| | Survival Rate (%) with Rotation | - | 57% | 67% | 77% | 90% |
| **DDPP** | | **2010** | **2020** | **2030** | **2040** | **2050** |
| Rice (000 ha) | Rice Field | 8,763 | 7,918 | 7,115 | 6,344 | 5,592 |
| | Low Emmision Variety | - | 453 | 902 | 1,351 | 1,808 |
| | Intermittent Irrigation | - | 400 | 798 | 1,197 | 1,605 |
| Crop lands | Area of Croplands (000 ha) | 54,303 | 60,048 | 62,524 | 63,368 | 63,561 |
| | Nitrogen Application (000 ton urea) | 6,422 | 6,422 | 6.048 | 5,543 | 5,028 |
| Livestock (000 heads) | Total Livestock Population | 443,183 | 457,547 | 466,903 | 470,818 | 468,830 |
| | Feed Supplement | - | 2,958 | 11,602 | 26,391 | 47,813 |
| | Biogas | - | 79 | 314 | 725 | 1,333 |
| Peat (000 ha) | Total Area of Peatland | 14,585 | 13,749 | 13,201 | 12,797 | 12,394 |
| | Improved Water Management | - | 432 | 576 | 576 | 576 |
| | Peat Restoration | - | 404 | 808 | 1,212 | 1,615 |
| Afforestation/ Reforestation (Aff/Ref; 000 ha) | Land Available for Aff/Ref Program | 13,843 | - | - | - | - |
| | Aff/Ref program without Rotation | - | 1,789 | 3,578 | 5,368 | 7,157 |
| | Survival Rate (%) without Rotation | - | 27% | 37% | 51% | 70% |
| | Aff/Ref program with Rotation | - | 1,637 | 3,274 | 4,911 | 6,548 |
| | Survival Rate (%) with Rotation | - | 57% | 67% | 77% | 90% |

1 In the model, the change of the level of intervention was inputted in the form of growth rate;

2 The current total deforested peatland area is about 6.1 million ha, and only 47.5% were used for development activities (palm oil, HTI and other croplands) and the remaining (about 3 million hectare) were still in the form of grassland area (non-productive).

Furthermore, the surpluses could be maintained until 2050 in all scenarios (Figure 19 and 20). For rice and cassava, the surpluses under the DEV and DDPP scenarios are more than twice that of BAU.

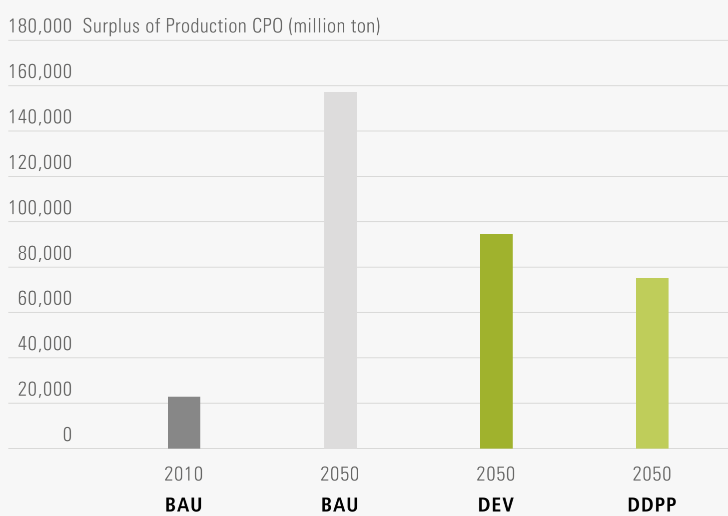
Rice self-sufficiency could be maintained in all scenarios by improving crop productivity in lowland rice of Java from 5.8 t/ha to more than 5.95 t/ha, and outside Java from 4.2 t/ha to more than 5.2 t/ha. Similarly, cropping intensity was also increased from 1.8 to 2.11 and 1.45 to 1.70 respectively (see Annex 3). By 2050, the rice surplus could well be over 10 million tons for DEV and DDPP scenarios, if rice consumption decreased from 141 to below 127 kg/cap/year. At this level of surplus, the ratio between rice availability and demand would be about 1.2. FAO (2001) suggests that this ratio could be used as an indicator to define percentage of population exposed to food shortage. When the ratio is higher than 1.2, the level of national rice stock is considered as secured.

For cassava with consumption growth per capita of 0.67% per year, and considering the historical growth and increasing use of cassava for food industries, the current level of surplus cannot be maintained under the BAU scenario. By 2050 the surplus is only half of the current level even the yield is increased from 20.22 to 26.41 t/ha. The surplus can be over 10 million tons if crop productivity could be increased to 30 t/ha, and close to 20 million tons if it is increased to 35 t/ha (Figure 20).

In the case of maize, at the present time the level of production is already not sufficient to meet the demand. With the increasing demand due to the increase in population (see Table 1) and consumption per capita (see Annex 4), the deficit would reach around 10 million ton by 2050 in absence of significant yield improvement. In the last five years, the Government of Indonesia still imported maize between 1.5 and 3.6 million ton per year. This increasing demand can be met without import if productivity of the crop can be increased by 60% above the current yield (4.44 to 7.00 t/ha) and if the cropping intensity is increased by 7.9% (0.63 to 0.68; see Annex 3).

For sugar crops, vegetables, fruit and nuts, the current deficit will increase by 2050, even if productivity can be increased. For vegetables, the deficit may be over 11 million tons in BAU by 2050, about 9 million tons in DEV, and 8 million tons in DDPP scenarios (Figure 20). The crop productivity under the three scenarios increase by 7.5% (9.03 to 10 t/ha), 18% (9.03 to 11 t/ha) and 29% (9.03 to 12 t/ha) respectively (see Annex 3). Similarly for fruits and nuts, the deficit is multiplied by four above the current figure (over 12 million ton; Figure 20). For sugar crops the deficit would be over 53 million tons or equivalent to about 5.3 million ton of sugar ('*hablur*'). Based on BAPPENAS (2013), the deficit for sugar in 2010 reached 1.8 million tons and in 2012 has increased to 2.7 million tons.

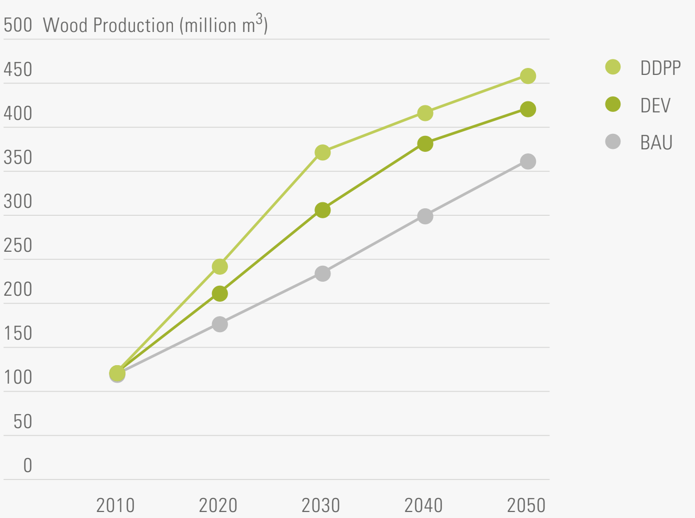
**Figure 20.** Production surplus for palm oil for the BAU, DEV and DDPP scenario



The deficit growth for sugar reached 25.7% per year. Without the expansion of sugar plantation and significant increased in crop productivity, this deficit could not be off set. Under the BAU, DEV and DDPP scenarios, the productivity of the crops have increased by about 39%, 62%, and 67% respectively, from current yields.

The palm oil production by 2050 for BAU scenario would reach about 630 million tons of FFB (equivalent to about 158 Mt CPO (Annex 5). With this level of production, the production surplus reaches 140 million tons CPO. Under this scenario, the establishment of new palm oil plantation requires very large lands and this might reduced the expansion opportunities for other crops particularly for cereal and horticultural crops (fruits and vegetables), as well as increasing the risk of deforestation that led to higher greenhouse gas emission (see Figure 18; Figure 20). In BAU (GAPKI scenario), the production target for 2050 is almost 8 times the 2010 production level, while under DEV and DDPP scenarios, the production targets were cut by about half of that of BAU scenario, i.e. about 4 times of the 2010 production level. This indicated that further decreased in GHG emission could be expected if production target for palm oil could be further reduced.

**Figure 21.** Wood production under the BAU, DEV and DDPP scenarios




## *6.4 Wood Production*

The wood production target of 360 million $m^3$ as stated in the RKTN (Kemenhut, 2011) will be achieved in 2030, 2040 and 2050 for the DDPP, DEV and BAU scenarios respectively (Figure 21). This is achieved by accelerating the establishment and improving the productivity of timber plantations (see Table 4). The rate of planting under the BAU, DEV and DDPP in timber plantations (HTI) is targeted to reach 150, 250 and 350 thousand hectares per year respectively. By 2050, the total planted area in HTI should reached 10.5, 11.3, 11.5 million ha for the three scenario respectively. As mentioned above, at present, a total of 10.29 million hectares has been issued for HTI, although the total actual planted area was only around 5.7 million hectare due to land tenure issues. Total area targeted for timber plantation under the RKTN was 14.5 million ha, however not all of this land could be used for timber plantation. In general, the concession area that could be planted only ranged between 60%-70% (APHI, 2007) due to the presence of land conflicts with communities and also the requirement to conserve part of the concession area for conservation.

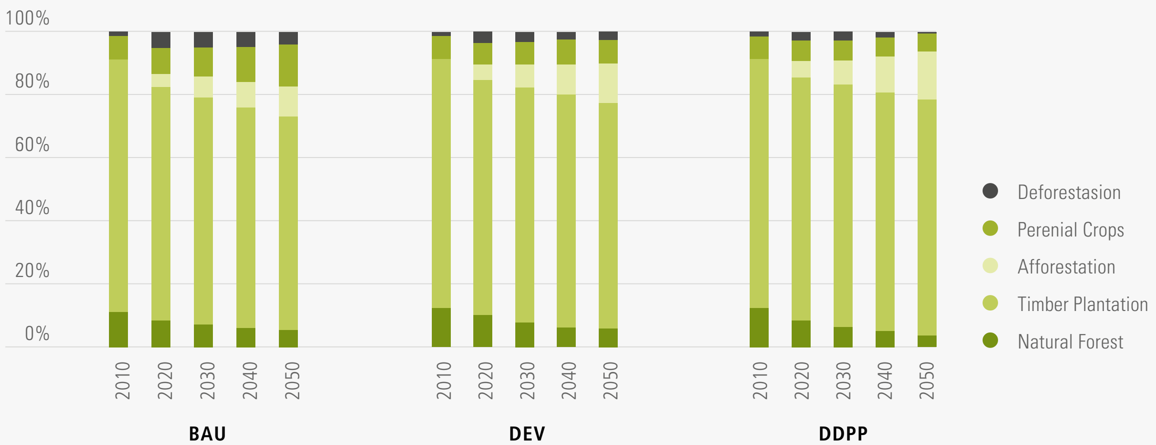
Higher production of wood in DEV and DDPP scenarios compared to BAU was not only due to the higher area of HTI, but also due to higher contribution of wood production from afforestation and reforestation programs (Table 8). Nevertheless, the contributions of agriculture plantation and deforested area to the total wood production are lower in DEV and DDPP scenarios than that of BAU, as the total areas of agriculture plantation and deforestation in the two scenarios had significantly declined (See Figure 21 and Figure 15).

The contributions of HTI to the total production in each scenario in 2050, is about 68% for BAU, 72% for DEV and 75% for DDPP, while the contributions from natural forest concessions (HPH) would be about 5.5%, 5.9% and 3.6% respectively. The remaining comes from agriculture plantations and deforested areas. Under the three scenarios, the dependence on natural forest to meet the wood production target decreases (Figure 22).

**Table 8.** Production of woods by sources under the BAU, DEV and DDPP scenarios

| Wood Production (000 m$^3$) | | 2010 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|---|
| BAU | Natural Forest | 13,430 | 15,073 | 16,715 | 18,358 | 20,000 |
| | Timber Plantation | 96,547 | 131,819 | 169,592 | 209,865 | 245,638 |
| | Afforestation | - | 7,420 | 15,567 | 24,459 | 34,115 |
| | Perennial Crops | 8,842 | 14,546 | 21,693 | 33,110 | 48,656 |
| | Deforested area | 1,729 | 9,200 | 11,775 | 14,650 | 14,292 |
| DEV | Natural Forest | 13,430 | 21,573 | 24,065 | 23,643 | 24,927 |
| | Timber Plantation | 96,547 | 158,759 | 229,304 | 283,183 | 302,062 |
| | Afforestation | - | 10,196 | 22,294 | 36,374 | 52,518 |
| | Perennial Crops | 8,842 | 14,655 | 21,892 | 30,030 | 31,862 |
| | Deforested area | 1,729 | 7,573 | 10,065 | 9,643 | 10,927 |
| DDPP | Natural Forest | 13,430 | 20,000 | 22,750 | 21,614 | 16,702 |
| | Timber Plantation | 96,547 | 187,365 | 286,933 | 315,627 | 344,320 |
| | Afforestation | - | 12,656 | 28,553 | 47,828 | 70,625 |
| | Perennial Crops | 8,842 | 15,772 | 23,664 | 25,115 | 25,588 |
| | Deforested areas | 1,729 | 6,000 | 8,750 | 7,614 | 2,702 |

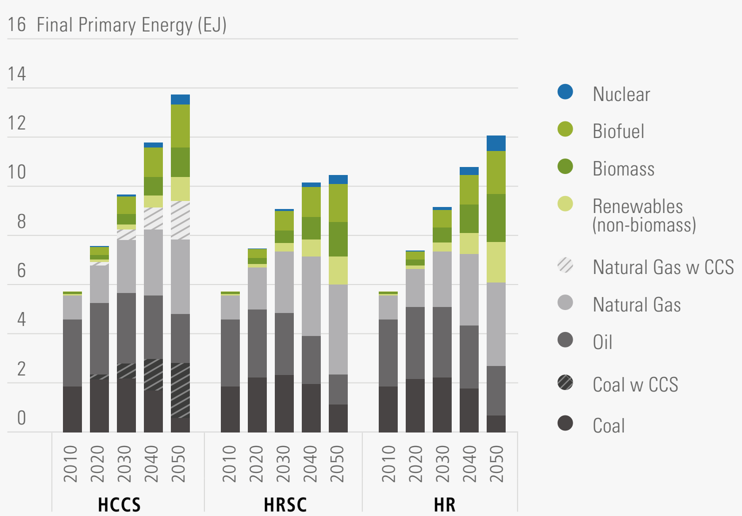
**Figure 22.** Contributions of natural forest, timber plantation, afforestation, perennial crops and deforested area to wood production under the BAU, DEV and DDPP scenario



### 6.5 Use of Biomass and CPO for producing Biogas and Biofuel

In the energy sector, the pathways towards deep carbonization could be achieved through three scenarios namely Renewable Scenario (H_R), Carbon Capture and Storage (H_CCC) and Economic Structural Change Scenario (H_RSC) (see; Siagian *et al.* 2015). The H_R places emphasis on large-scale deployment of renewable-based power generation complemented with nuclear energy. The H_CCC considered a more balanced technological deployment in power generation, in which renewables would still play an important role but be complemented by the diffusion of CCS and nuclear power. This scenario may be considered as the back-up option if resource or technology constraints limits the deployment of renewables in the energy system. The H_RCS takes into account the role of structural changes in the Indonesian economy, with the implementation of a more service-oriented economy, combined with more energy efficiency measures, and more fuel switching to low or non-carbon energy by end-users. In the three scenarios, the level of energy-related $CO_2$ emission by 2050 reaches about 402 million tons which is equivalent to 1.3 ton $CO_2$/capita.

**Figure 23.** Share of biomass and biofuel to primary energy (Data of Siagian *et* al., 2015)




To deep decarbonize the energy sector through the three scenarios, the share of bio-energy for the transportation and power sector increases significantly. Currently, the transportation activities do not use biofuel or biodiesel, and the power sector uses biomass energy with a share of only about 0.05%. By 2050, the share of bio-energy (bio-fuel and bio-diesel) in the transportation sector for the first two scenarios will increase to 20%-30% and for the H_RSC to 40%-50%. Similarly, the use of biomass and bio-fuel for the power sector, will also increase. The share of biomass and bio-fuel is targeted to reach about 12% and 2% for H_R, 6% and 3% for H_CCC, and 10% and 2% for H_RSC respectively (Siagian *et al.*, 2015). Thus, the three scenarios will require biomass and CPO for producing biomass energy and biofuel respectively. Shares of biomass and biofuel to the total primary energy in the three scenarios are presented in Figure 23.

Production of biomass and CPO under the BAU, DEV and DDPP scenarios are sufficient to meet the demands from energy sector. Under the BAU scenario, the percentage of wood production used to produce energy in the three scenarios would be about 10% in 2010 and increases to about 84% in 2050, while that of palm oil production would be about 4%in 2010 and up to 43% in 2050 (Figure 24). Under the DEV and DDPP, as the level of wood production increases, the percentage of wood production used for energy would be lower than under the BAU. On the other hand for palm oil production after 2030 under DEV and DDPP scenarios, more than half of the CPO productions would be used for production of biofuel. In the case of wood production as stated in the National Forestry Plan (RKTN; Kemenhut 2011), the future demands for wood industries are expected to be around 350 million $m^3$ (see Figure 6). In the case of CPO, under DEV and DDPP, most of the CPO productions by 2050 would be used to produce biofuel. However, surplus of the CPO was still adequate to meet the domestic demands. For the DDPP scenario, the remaining CPO were not used to produce biofuel will be about 8 million tons CPO, while the domestic demand was only 0.4 million tons CPO. Thus more lands are required to decarbonizing energy sector through increasing the shares of biomass energy as defined in the three scenarios.

**Figure 24a.** Amount of biomass used to meet the energy demand in the three energy scenarios H_CCS, H_RSC and H_R

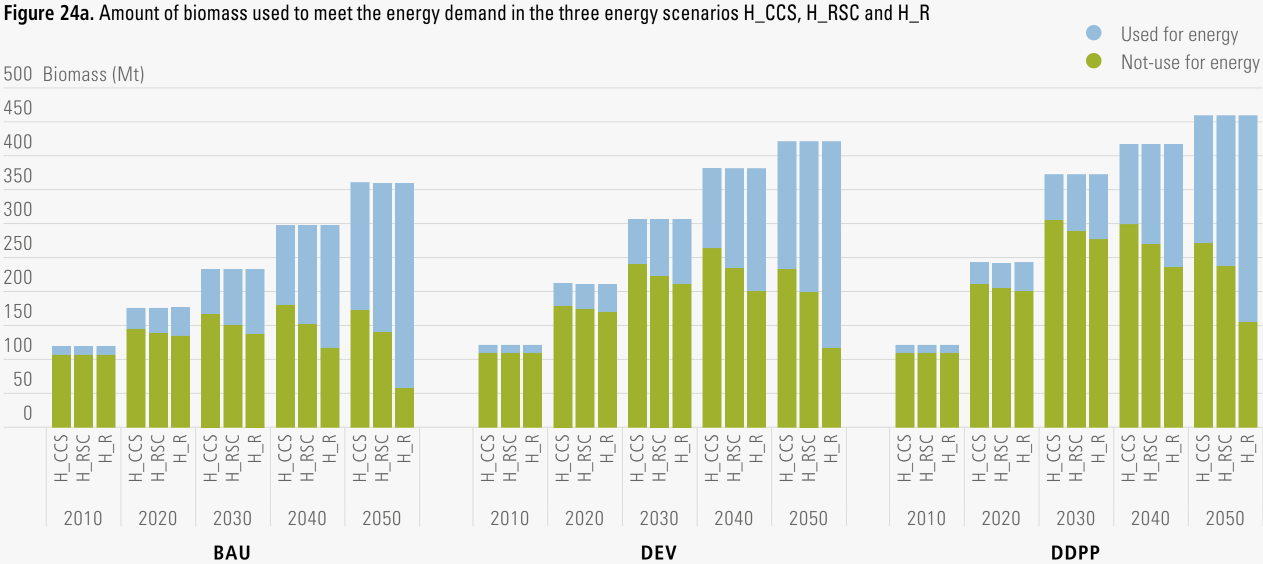
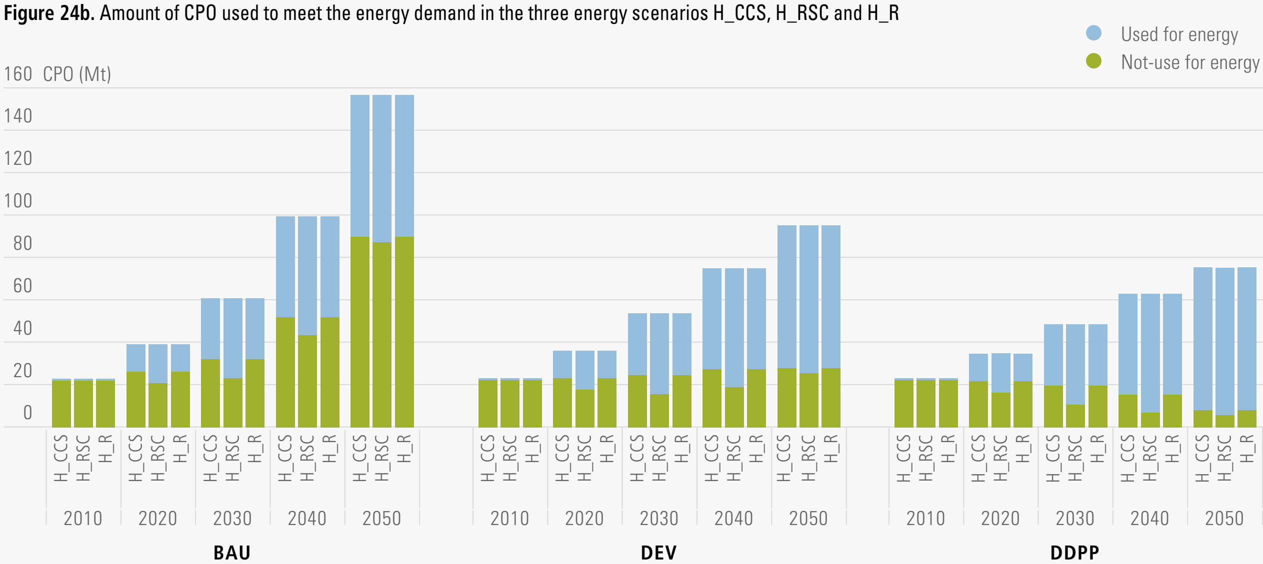



**Figure 24b.** Amount of CPO used to meet the energy demand in the three energy scenarios H_CCS, H_RSC and H_R



# 7 Challenges, Opportunities and Enabling Conditions

The optimization of the use of unproductive lands for the development of agriculture and timber plantations reveals major challenges. Many degraded lands in forest area are being claimed by the local communities and many studies have found that conflicts between timber plantation companies and communities are very common. Notably, when a permit has been granted to a company, land conflict always emerged. For this reason, private entities prefer to use forested land in forest area for timber plantation or peatland, as these areas usually feature no or less conflicts (given the absence of community claims on the land). To overcome this issue, the government needs to issue incentive system to entities that have been granted the permit to use unproductive and degraded land with high social conflict. Mapping of high social-conflict area is required and this could be used as the basis in defining the incentive. High incentive could be granted to entities with potential land conflict. The incentive could be in the form of reducing or exemption of administration/retribution fees for certain period of time depending on the level of conflict. With this policy, one could expect that the establishment of timber plantation on degraded land could be accelerated and that there would be less dependency on natural forest for wood supplies. Alternative policy in dealing with conflicted land is by providing or allocating the conflicted lands for the establishment of community timber plantation (HTR). In this regards, the Government might withdraw the permit that has been issued to a private company in case it is not able to establish the plantation within the given period of time.

Involving the communities in managing land in forest area, particularly to accelerate the rehabilitation of degraded land using trees, has high economic values. Various forms of Community-Based Forest Management programs have been implemented such as Community Timber Plantation (HTR), Community Forest (HKm) and Village Forest (*Hutan Desa*). Funding to support the program was provided with over one billion USD. However, the absorption and the use of the fund were very low, reaching less than 1% (Boer, 2015). Among the reasons causing such conditions, one can highlight the complex bureaucracy procedure for obtaining the permit and for accessing the fund, as well as the requirements that the lands is cleaned and cleared (free of conflict), which was not the case in most situations Simplifying the process for obtaining the permit and accessing the fund would be required to increase the involvement of communities in managing forest land which could eventually lead to a reduction of forest encroachment.

Improvement of crops productivities has been considered as an effective strategy to deep decarbonizing the AFOLU sector. However, improving the productivities creates many challenges; notably, lands outside Java are mainly less fertile than in Java, and hence would require higher investment costs, whereas in Java, crop productivities, particularly for food crops, have almost reached the attainable yield. Producing new varieties with very high productivity is time-consuming and costly, while on the other hand, funding for research remains very limited. Currently, funding for research allocated by the Government is only about 0.09% of national GDP, the lowest among ASEAN countries[8]. The highest is Singapore, i.e. 2.6% of the GDP, followed by Malaysia and Thailand, while the developed countries such as Japan and USA have reached more than 3% of the GDP. The involvement of private sectors in providing research fundings is very low. In Indonesia, funding from private sectors represents only 26% of the total, the remaining 74% being supported by the government. This is to be compared with, for example, the situation in Singapore where about 80% of research fundings comes from private sectors. Another challenge is that the number of field facilitators (extension workers) who facilitated the transfer of improved technology and good agricultural practices for farmers (communities) remains also very limited. Ideally, one extension worker serves one agriculture village as mandated by Act 19/2013 on Farmers Protection and Empowerment. However, currently, there are only 47 thousands extension workers, while the number of agriculture villages is 71 thousands[9]. Finally, access of farmers to financial resources for improving agriculture practices is also limited. Policies for addressing these issues will be crucial for deep decarbonizing this sector.

# 8 Conclusions

This study indicates that without significant changes in the improvement of land management practices and optimization on the use of low carbon stock land for agriculture expansion and timber plantation, contributions of these sectors to the national emissions would remain high, as in the current situations.

Deep decarbonizing the AFOLU sector is possible through the improvement of land and forest management and the optimization of  the use of low carbon stock land for agriculture and timber plantation development along with enhanced mitigation policies and measures, particularly moratorium of peatland permit and peat restoration. The emissions from this sector can be reduced significantly to reach negative emissions for below zero by 2050, i.e. -0.05 ton $CO_2$e per capita.

Improvement of land and forest management may require high investments and institutional changes particularly to enhance institutional capacity of forest management unit in all open access areas. Investment for producing high yielding varieties suitable for marginal lands and technology for peatland management would also be required. Optimizing the use of unproductive land is also one of the main challenges, in particular in addressing land tenure issues. Incentive system for accelerating the development of timber plantation on degraded land, and increasing community access to fund for green investment would  finally also be a key condition to implement deep decarbonization

8 http://www.beritasatu.com/kesra/238392-2019-anggaran-riset-05-pdb-indonesia.html

9 https://tirto.id/20160720-50/jumlah-tenaga-penyuluh-masih-kurang-ideal-275668

# References


- Anghelache, C. 2011. "Analysis of the Correlation between GDP and the Final Consumption". Theoretical and Applied Economics Vol. 18: pp. 129-138.
- Bappenas. 2013. *Studi Pendahuluan Rencana Pembangunan Jangka Menengah Nasional (RPJMN) Bidang Pangan dan Pertanian 2015-2019*. Jakarta: Directorate of Food Crop and Agriculture, Ministry of National Development Planning/National Development Planning Agency.
- Boer, R. 2016. "Potential of Reducing GHG Emission from REDD+ Activities in Indonesia". *In* S. Nishioka.Enabling Asia to Stabilise Climate. Singapore: Springer.
- Boer, R., A. Rakhman, K. Kartikasari, D. Black, M. Fernando, and F. Leippert. 2014. "Food Security in Asean and Climate Change: An Assessment of Vulnerabilities of Staple Food Crops in ASEAN Member States". Jakarta: German-Asean Climate Change Project Report
- BPS– Bappenas–UNPPA. 2013. Indonesia Population Projection 2010 – 2035. Jakarta
- Chern, W.S., Ishibashi, K., Taniguchi, K., &Tokoyama, Y. 2003. Analysis of the Food Consumption of Japanese Households. Food and Agriculture Organization of United Nation, Rome
- Diacon, P.E., L.G Maha. 2015. "The Relationship Between Income, Consumption and GDP: A Time Series, Cross-Country Analysis". Procedia Economics and Finance Vol.23: pp 1535 – 1543.
- [Dephut] *Departemen Kehutanan*. 2007. "*Roadmap Revitalisasi Industri Kehutanan Indonesia* (Roadmap for Revitalization of Indonesian Forest Industry)". Jakarta: Departmen Kehutanan.
- [Dirjenbun] Direktoral Jenderal Perkebunan. 2015. "*Rencana Strategis Direktorat Jendral Perkebunan 2015-2019*". Jakarta: Direktorat Jendral Perkebunan Kementrian Pertanian.
- EIA. 2014. *Permitting Crime: How Palm Oil Expansion Drives Illegal Logging In Indonesia. Environmental Investigation Agency*.https://eia-international.org/wp-content/uploads/Permitting-Crime.pdf
- FAO. 2001. "The State of Food Insecurity in the World, 2001". Rome: Food and Agriculture Organization of the United Nations.
- FAO. 1997. "Estimating Biomass and Biomass Change of Tropical Forests: A Primer". FAO Forestry Paper – 134.
- FAO. 2009. Indonesia Forestry Outlook Study. Working Paper No.APFSOS II/WP/2009/13, Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific, Bangkok. http://fao.org/docrep/014/am608e/am608e00.pdf
- [GAPKI] *Gabungan Pengusaha Kelapa Sawit Indonesia*. 2014. *Industri Minyak Sawit Indonesia Menuju 100 Tahun NKRI: Membangun Kemandirian Ekonomi, Energi dan Pangan Secara Berkelanjutan*. Jakarta: Gabungan Pengusaha Kelapa Sawit Indonesia. http://dokumen.tips/download/link/industri-minyak-sawit-indonesia-menuju-100-tahun-nkri
- Jurnal Asia. 2016. *BRG Target Restorasi 600.000 Hektar Gambut 2016*. http://www.jurnalasia.com/bisnis/agribisnis/brg-target-restorasi-600-000-hektare-gambut-2016/
- [Kemenhut] Kementerian Kehutanan, 2011. "*Rencana Kehutanan Tingkat Nasional (RKTN) Tahun 2011-2030*". Lampiran Peraturan Menteri Kehutanan Nomor P. 49/Menhut-II/2011. Jakarta: Kementrian Kehutanan Republik Indonesia.
- [Kementan] Kementerian Pertanian. 2014. "*Rencana Strategis Kementerian Pertanian 2014-2019*". Jakarta: Kementrian Pertanian Republik Indonesia.
- [Kementan] Kementerian Pertanian. 2015. *Rencana Strategis Kementrian Kehutanan 2015-2019 (*Strategic Plan of Ministry of Agriculture). Kementrian Pertanian, Republik Indonesia. http://www.pertanian.go.id/file/RENSTRA_2015-2019.pdf
- Koalisi Anti Mafia Hutan, 2015. *Kesenjangan Persediaan Kayu Legal dan Implikasinya Terhadap Peningkatan Kapasitas Industri Kehutanan di Indonesia: Sebuah Kajian Peta Jalan Revitalisasi Industri Kehutanan, Fase 1*. Eyes on the Forest, GAPETA Borneo, Indonesian Corruption Watch, Indonesia Working Group on Forest Finance, Jikalahari, RPHK, Auriga, Transparency International Indonesia, Walhi & WWF-Indonesia
- Lawson, S & L. Macfaul. 2010. "Illegal Logging and Related Trade: Indicators of the Global Response." London: Chatam House.
- Luttrell, C., Obidzinski, K., Brockhaus, M., Muharrom, E., Petkova, E., Wardell, A. and Halperin, J. 2011. *Lessons for REDD+ from measures to control illegal logging in Indonesia*. Jakarta and Bogor: United Nations Office on Drugs and Crime and Center

for International Forestry Research. http://www.cifor.org/publications/pdf_files/WPapers/WP74Obidzinski.pdf

- [MoEF] Ministry of Environment and Forestry, 2015. "Indonesia First Biennial Update Report (BUR) Under the United Nations Framework Convention on Climate Change". Jakarta: Ministry of Environment and Forestry.
- [MoF], Ministry of Forestry 2007.*A Road Map for the Revitalization of Indonesia's Forest Industry*. http://rimbawan.com/images/stories/makalah/roadmap_for_revitalization_of_indonesia_s_forest_industry_nov_indo_2007_i ndo.pdf
- Murdiyarso D, and E. Adiningsih. 2006. "Climate Anomalies, Indonesian Vegetation Fires and Terrestrial Carbon Emissions". Mitigation Adaptation Strategy Global Change: pp. 101-112.
- Putra, E.I., H. Hayasaka. 2011. "The Effect of the Precipitation Pattern of the Dry Season on Peat Fire Occurrence in the Mega Rice Project Area, Central Kalimantan, Indonesia". Tropics Vol.19: pp. 145-156
- Putra, E.I.,H. Hayasaka, H. Takahashi, and A. Usup. 2008. "Recent Peat Fire Activity in the Mega Rice Project Area, Central Kalimantan, Indonesia". Journal of Disaster Research Vol.3: pp. 1-8.
- Santoso, H. 2005. *Arah Kebijakan dan Implementasi Rehabilitasi Hutan dan Lahan*. Presented in the "National Workshop Review of Rehabilitation Initiatives: Lessons From the Past". CIFOR, Bogor, February 22nd-23rd 2005.
- Sathaye, J.A., W.R. Makundi, and K.E. Andrasko. 1995. "A Comprehensive Mitigation Assessment Process (COMAP) for the Evaluation of Forestry Mitigation Option". Biomass and Bioenergy Vol. 8 No.5: pp. 345–356.
- Siagian, U.W.R. *et al*. 2015. "Pathways to Deep Decarbonization in Indonesia". SDSN - IDDRI.
- Suhardi, E. F. and H.N. Handojo. 2007. *Rehabilitation of Degraded Forests in Indonesia. In Don Ko Lee (ed). Keep Asia Green Volume 1: Southeast Asia*. International Union of Forest Research Organizations.pp: 27-56 *www.iufro.org/download/file/7379/5120/Indonesia_pdf/*
- Suhartati and S. Rahmayanti. 2013. "Seed Source Evaluation of *Acacia mangium* and *Eucalyptus pellita* at South Kalimantan". Tekno Hutan Tanaman Vol.6: pp 47 – 54.
- UNCCD and MoEF. 2015. *Indonesia - Land Degradation Neutrality National Report*. United Nation Convention on Desertification and Ministry of Environment and Forestry, Republic of Indonesia. http://www.unccd.int/en/programmes/RioConventions/RioPlus20/Documents/LDN%20Project%20Country%20Reports/indonesia_ldn_country_report.pdf
- Wardojo, W., Suhariyanto, and Purnama, B.M. 2001. "Law Enforcement and Forest Protection in Indonesia: A Retrospect and Prospect". Presented on "The East Asia Ministerial Conference on Forest Law Enforcement and Governance". Bali, September 11-13, 2001.
- Yulianti, N., H. Hayasaka. 2013. "Recent Active Fires under El Niño Conditions in Kalimantan, Indonesia". American Journal of Plant Sciences Vol.4: pp. 685-696.
- Yulianti, N., H. Hayasaka, and A. Usup. 2012. "Recent Forest and Peat Fire Trends in Indonesia, the Latest Decade by Modis Hotspot Data". Global Environmental Research Vol.16: pp. 105-116.

# Annexes

**Annex 1.** Land use categories used in the dashboard

| Soil Types | IPCC Land Use Categories | National land Use Categories | Source of Data |
|---|---|---|---|
| Mineral | Forest lands | Primary Forests | Satellite |
| | | Secondary Forest | Satellite |
| | | Timber plantation | Satellite |
| | Croplands | Palm oil | Statistical Data |
| | | Rubber | Statistical Data |
| | | Other perennial crops<br>• Fruits and nuts<br>• Other industrial crops | Satellite<br>Statistical Data<br>Statistical Data |
| | | Rice in Java | Satellite |
| | | Rice outside Java | Satellite |
| | | Other annual crops<br>• Upland rice<br>• Cassava<br>• Other cereal (maize)<br>• Vegetables<br>• Oil Crops<br>• Sugar crops (sugarcane)<br>• Vegetable oils<br>• Other annual crops | Satellite Data<br>Statistical Data<br>Statistical Data<br>Statistical Data<br>Statistical Data<br>Statistical Data<br>Statistical Data<br>Statistical Data<br>Statistical Data |
| | Grassland | Grassland (including shrubs) | Satellite |
| | Wetlands | Wetlands (swamp) | Satellite |
| | Settlement | Settlement (including transmigration) | Satellite |
| | Other lands | Other lands (bare land, mining etc.) | Satellite |
| Peatland | Forest lands | Primary Forests | Satellite |
| | | Secondary Forest | Satellite |
| | | Timber plantation | Satellite |
| | Croplands | Palm oil | Statistical Data |
| | | Rubber | Statistical Data |
| | | Other perennial crops<br>• Fruits and nuts<br>• Other industrial crops | Satellite<br>Statistical Data<br>Statistical Data |
| | | Rice outside Java | Satellite |
| | | Other annual crops<br>• Cassava<br>• Other cereal (maize)<br>• Vegetables<br>• Oil Crops<br>• Sugar crops (sugarcane)<br>• Vegetable oils<br>• Other crops | Satellite<br>Statistical Data<br>Statistical Data<br>Statistical Data<br>Statistical Data<br>Statistical Data<br>Statistical Data<br>Statistical Data |
| | Grassland | Grassland (including shrubs) | Satellite |

All statistical data are used to disaggregate a land use category from satellite, i.e. agriculture plantation as land area used for perennial crops and dry land agriculture as land area used for annual crops. Agriculture plantation area is divided into land area of dominants crop i.e. palm oil and rubber plantation, and the remaining area as other perennial crops. Other perennial crop is further divided into several other perennial crops based on the harvested area of the corresponding crops. Similarly, dry land agriculture is divided into several annual crops, i.e. cassava, maize, etc.

**Annex 2.** Projection of Human and Animal Population and GDP

| | 2010 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|
| Population [Millions] | 234 | 262 | 280 | 299 | 307 |
| GDP per capita [$/capita] | 2,306 | 3,454 | 5,680 | 9,086 | 14,974 |
| Animal Populations (000 heads) | | | | | |
| Dairy Cattle | 366 | 390 | 415 | 441 | 469 |
| Other Cattle | 9,727 | 10,107 | 10,502 | 10,912 | 11,338 |
| Buffalo | 1,440 | 1,496 | 1,554 | 1,615 | 1,678 |
| Sheep | 10,725 | 11,144 | 11,580 | 12,032 | 12,502 |
| Goat | 16,620 | 17,269 | 17,943 | 18,644 | 19,372 |
| Horse | 419 | 435 | 452 | 470 | 488 |
| Swine | 7,477 | 7,769 | 8,073 | 8,389 | 8,717 |
| Local Breed Chicken | 84,672 | 87,979 | 91,416 | 94,987 | 98,697 |
| Egg chicken/Layer | 105,210 | 109,320 | 113,590 | 118,026 | 122,637 |
| Broiler | 162,225 | 168,562 | 175,146 | 181,988 | 189,096 |
| Duck | 44,302 | 46,035 | 47,835 | 49,706 | 51,650 |

The projection of animal population follows historical trend (based on data from Ditjenbun, 2015).

**Annex 3.** Projection of yield and cropping intensity for BAU, DEV and DDPP scenarios

| Commodities | 2010 | BAU 2050 | DEV 2050 | DDPP 2050 |
|---|---|---|---|---|
| | Yield of annual crops (t/ha) | | | |
| Rice field in Java | 5.80 | 5.95 | 6.11 | 6.11 |
| Rice field Outside Java | 4.20 | 5.20 | 5.20 | 5.20 |
| Rice field Upland National | 3.04 | 3.04 | 3.04 | 3.04 |
| Other cereals (mainly Maize) | 4.44 | 5.00 | 6.00 | 7.00 |
| Vegetables[2] | 9.03 | 10.00 | 11.00 | 12.00 |
| Oil Crops[2] | 5.27 | 7.00 | 7.00 | 7.00 |
| Other Crops[2] | 0.87 | 1.30 | 1.30 | 1.30 |
| Cassava | 20.22 | 26.41 | 29.99 | 35.00 |
| Sugar crops (mainly sugar cane) | 47.89 | 66.53 | 77.64 | 80.00 |
| | Yield of perennial crops (t/ha) | | | |
| Fruits and Nuts[2] | 10.71 | 12.01 | 13.01 | 14.00 |
| Industrial crop[2] | 0.85 | 1.20 | 1.31 | 1.40 |
| Palm oil (FFB)[3] | 16.10 | 32.00 | 34.01 | 36.00 |
| | Crop Intensity for annual crops[4] | | | |
| Rice in Java | 1.80 | 2.11 | 2.11 | 2.11 |
| Rice Outside Java | 1.45 | 1.70 | 1.70 | 1.70 |
| Rice Upland National | 0.90 | 0.90 | 0.90 | 0.90 |
| Maize | 0.63 | 0.63 | 0.68 | 0.68 |
| Vegetables | 0.63 | 0.63 | 0.67 | 0.67 |
| Oil Crops | 0.67 | 0.67 | 0.67 | 0.67 |
| Other Crops | 0.56 | 0.56 | 0.56 | 0.56 |
| Cassava | 0.63 | 0.63 | 0.63 | 0.63 |
| Sugar crops | 1.00 | 1.00 | 1.00 | 1.00 |
| | Crop Intensity for perennial crops[4] | | | |
| Fruits and Nuts | 0.14 | 0.14 | 0.14 | 0.14 |
| Industrial crop | 1.00 | 1.00 | 1.00 | 1.00 |
| Palm oil | 0.64 | 0.64 | 0.64 | 0.64 |
| | Grass/Animal Feed Productivity (kg/m$^2$)[5] | | | |
| Natural grass[6] | 0.5 | 0.74 | 0.77 | 0.81 |
| Pasture[7] | 5.0 | 7.44 | 7.74 | 8.06 |

1 Inputs for dashboard are in the form of yield growth (% per year) based on historical data and government target (Bappenas, 2013; Kementan, 2014; Ditjenbun, 2015).

2 For multiple crops, the yield is calculated by summing up the production of all crops divided by the total harvested areas of the crops.

3 Based on yield target of GAPKI (2014);

4 Cropping Intensity (CI) is define as the ratio between harvested area and crop area. For annual crop, the CI reflects the number of crop planting in a year in the same land (if CI=2, the crop is planted twice a year on the same land); for perennial crop, the CI reflects fraction of crop areas that has reached productive age.

5 Proportion of animal feed by natural grass (not from pasture) for dairy cattle is 98%, for other cattle 44%, buffalo 23%, sheep 93%, goat 57%, horse 10%, local breed chicken 40%, layer 56%, broiler 67%, and duck 48% (Based on Statistik Perternakan, 2012).

6 Time for grass to produce naturally is 365 days.

7 Length of period for pasture producing grass in BAU, DEV, DDPP scenarios are 45, 60 and 75 days respectively.

**Annex 4.** Projection of consumptions level for each commodity in BAU, DEV and DDPP scenarios

| Commodities | 2010 | BAU 2050 | DEV 2050 | DDPP 2050 |
|---|---|---|---|---|
| | Consumption of annual Crops (kg/cap/year) | | | |
| Rice[1] | 141.20 | 127.75 | 127.75 | 115.55 |
| Maize | 84.77 | 93.67 | 103.49 | 103.49 |
| Vegetables | 55.55 | 67.82 | 67.82 | 67.82 |
| Oil Crops | 65.05 | 79.41 | 79.41 | 79.41 |
| Other Crops | 13.80 | 15.54 | 15.54 | 15.54 |
| Cassava | 59.78 | 78.08 | 78.08 | , 78.08 |
| Sugar Crops | 147.00 | 266.66 | 266.66 | 266.66 |
| | Consumption of perennial Crops (kg/cap/year) | | | |
| Fruits and Nuts | 80.33 | 98.07 | 98.07 | 98.07 |
| Palm oil | 4.29 | 5.23 | 5.23 | 5.23 |
| | Grass consumption by animal (kg/day/head) | | | |
| Dairy cattle, other cattle and buffalo | 35 | 35 | 35 | 35 |
| Horse | 20 | 20 | 20 | 20 |
| Sheep and goat | 5 | 5 | 5 | 5 |
| Swine | 3 | 3 | 3 | 3 |
| Native chicken | 0.10 | 0.10 | 0.10 | 0.10 |
| Layer | 0.09 | 0.09 | 0.09 | 0.09 |
| Broiler | 0.09 | 0.09 | 0.09 | 0.09 |
| Duck | 0.16 | 0.16 | 0.16 | 0.16 |

1 This consumption includes daily intake as staple food, seeds, animal feed, raw material for food and non-food industries (BAPPENAS, 2013).

**Annex 5.** Production of agriculture commodities under BAU, DEV and DDPP scenarios

| Commodity | Scenario | Production in thousand ton | | | | |
|---|---|---|---|---|---|---|
| | | 2010 | 2020 | 2030 | 2040 | 2050 |
| Rice | BAU | 36,544 | 38,107 | 39,960 | 42,493 | 44,740 |
| | DEV | 36,544 | 40,422 | 45,260 | 49,110 | 53,241 |
| | DDPP | 36,544 | 39,423 | 42,717 | 44,708 | 46,564 |
| Cassava | BAU | 23,918 | 25,186 | 26,516 | 27,908 | 29,367 |
| | DEV | 23,918 | 26,058 | 28,384 | 30,912 | 33,660 |
| | DDPP | 23,918 | 27,461 | 31,524 | 36,184 | 39,632 |
| Oil Crops | BAU | 21,440 | 24,508 | 27,601 | 27,175 | 26,748 |
| | DEV | 21,440 | 24,562 | 27,723 | 27,358 | 26,992 |
| | DDPP | 21,440 | 24,615 | 27,845 | 27,540 | 27,236 |
| Palm oil (FFB) | BAU | 92,386 | 157,809 | 245,139 | 399,288 | 630,000 |
| | DEV | 92,386 | 144,852 | 214,445 | 299,645 | 380,187 |
| | DDPP | 92,386 | 139,407 | 194,796 | 251,897 | 301,367 |
| Other Crops | BAU | 3,291 | 3,581 | 3,895 | 4,236 | 4,606 |
| | DEV | 3,291 | 3,588 | 3,912 | 4,265 | 4,648 |
| | DDPP | 3,291 | 3,596 | 3,929 | 4,293 | 4,690 |
| Maize | BAU | 18,328 | 18,602 | 18,876 | 19,149 | 19,421 |
| | DEV | 18,328 | 19,909 | 21,623 | 23,480 | 25,493 |
| | DDPP | 18,328 | 20,738 | 23,462 | 26,542 | 29,986 |
| Vegetables | BAU | 9,780 | 9,882 | 9,983 | 10,082 | 10,179 |
| | DEV | 9,780 | 10,305 | 10,855 | 11,433 | 12,040 |
| | DDPP | 9,780 | 10,563 | 11,406 | 12,316 | 13,255 |
| Fruits and Nuts | BAU | 15,235 | 15,918 | 16,633 | 17,379 | 18,159 |
| | DEV | 15,235 | 15,918 | 16,633 | 17,379 | 18,159 |
| | DDPP | 15,235 | 15,918 | 16,633 | 17,379 | 18,159 |
| Sugar crops | BAU | 21,750 | 23,258 | 24,866 | 26,577 | 28,400 |
| | DEV | 21,750 | 24,226 | 26,980 | 30,042 | 33,445 |
| | DDPP | 21,750 | 25,119 | 29,007 | 33,493 | 34,773 |