User Guide For
Agriculture and Plantation Sector

Indonesia 2050 Pathway Calculator

Table of Contents

List of Tables

List of Figures

Introduction

This User Guide is intended for users of Indonesia 2050 Pathway Calculator, especially in the sectors of Agriculture and Plantation. There are four sections in this User Guide; first, the overview section that contains basic information on agriculture and plantations; this section is useful as an introduction to understand the changes in land area, production, and productivity of plants in Indonesia; second, the assumption section that contains the assumption reference of the data used for calculation; third, the methodology section that contains equations and scenario levels used in the models. Finally, the results of modeling will present the projections of food demand, agricultural land area, agricultural productivity, non-palm oil plantation area, and non-palm oil plantation productivity by 2050.

1. Overview of Agriculture and Plantation in Indonesia

Agriculture business is the farming business that aims for addressing the needs of calories from food to support human life. Agriculture refers to the farming business that covers seven staple food crops (rice, corn, and etc.), while the plantation refers to a variety of non-staple food commodities (rubber, coffee, and etc.). The growth of calorie demand is accompanied by the growth of Indonesian population and both factors contribute to the need of increased agricultural land areas. At the same time, the growing need for agricultural land will contribute GHG emissions to Indonesia's agriculture sector that derives from the changes in land cover.

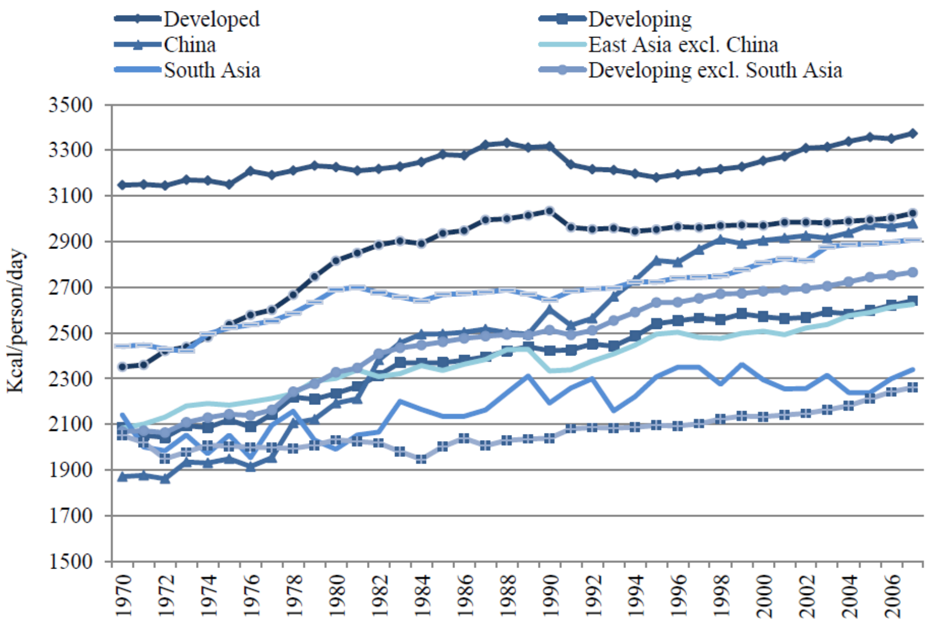

Figure 1. Trend of the increase in calorie consumption across the world (source: Alexandratos & Bruinsma 2012, pg. 24)

According to Indonesian Statisctics Agency (2015), the average calorie consumption of Indonesia is relatively stable over the last 10 years, which ranges from 1,800 to 2,200 calories per day. Yet, the Alexandratos and Bruinsma's study (pg. 23-24, 2012) shows there is a trend of increased consumption of calories across the world. **Figure 1** and **Table 1** show the Indonesia's fluctuating trend of calorie consumption during several decades which is followed by a long term increasing trend, according to the data from the Indonesia Statistic Agency (BPS), is similar to the calorie consumption trend of South Asia countries (India, Pakistan, Bangladesh, and etc.) as highlighted in Alexandratos and Bruinsma study (2012). Therefore, the data and projection of Alexandratos Bruinsma study can be used as a reference to project Indonesia's calorie consumption in the future.

Table 1. World's Calorie Consumption (kcal/person/day)

	New historical data					Projections			Comparison 1999/2001	
	1969/ 1971	1979/ 1981	1989/ 1991	1990/ 1992	2005/ 2007	2015	2030	2050	New	Old
World	**2 373**	**2 497**	**2 634**	**2 627**	**2 772**	**2 860**	**2 960**	**3 070**	**2 719**	**2 789**
Developing countries	2 055	2 236	2 429	2 433	2 619	2 740	2 860	3 000	2 572	2 654
-*excluding South Asia*	2 049	2 316	2 497	2 504	2 754	2 870	2 970	3 070	2 680	2 758
Sub-Saharan Africa	2 031	2 021	2 051	2 068	2 238	2 360	2 530	2 740	2 136	2 194
Near East / North Africa	2 355	2 804	3 003	2 983	3 007	3 070	3 130	3 200	2 975	2 974
Latin America and the Caribbean	2 442	2 674	2 664	2 672	2 898	2 990	3 090	3 200	2 802	2 836
South Asia	2 072	2 024	2 254	2 250	2 293	2 420	2 590	2 820	2 303	2 392
East Asia	1 907	2 216	2 487	2 497	2 850	3 000	3 130	3 220	2 770	2 872
Developed countries	3 138	3 223	3 288	3 257	3 360	3 390	3 430	3 490	3 251	3 257

Source: Alexandratos & Bruinsma 2012, pg. 23

Indonesian's calorie intake sourced from vegetables and animal. Further, according to Indonesian Statistics Agency (2011), 48% of Indonesian's calorie intake is dominated by cereals (p. 24). On the other hand, the consumption of red meat in Indonesia is still low compared to other animal proteins like marine products, chicken meat, and egg (p. 27). In addition, the data from the Indonesia Statistics Agency also reveals that most of Indonesian's calory intake is derived from vegetables source. It shows the importance of agriculture sector in Indonesia.

Table 2. The Development of consumption per capita per day

Uraian	Perkembangan Konsumsi Perkapita Perhari					Pertum-Buhan (%)
	2005	2006	2007	2008	2009	
1. Energi (kkal/kap/hari)	1.996	1.927	2.015	2.038	1.958	-0,40
2. Protein (gram/kap/hari)	55.23	53.66	57.65	57.49	59,17	1,81
Skor PPH	79,1	74,9	82,8	81,9	78,8	0,09

Source: BKP 2011, pg. 17

In line with the increase in calorie needs, the growth of agricultural land area of Indonesia should be considered since it will affect the food availability and the potential emissions due to land use change. The real figure of current agricultural land area in Indonesia can be seen in **Table 3**. The table shows that although there is a declining trend in the total area of agricultural land, there is an increasing trend of rice cultivation area. At the same time, **Table 4** shows that the productivity of the agricultural sector Indonesia tends to increase.

Table 3. Indonesia's agricultural land area

No.	Jenis Lahan/*Land Type*	Tahun/*Year*				
		2008	2009	2010	2011	2012*
1.	Sawah/*Wetland*	7.991.564,00	8.068.427,00	8.002.552,00	8.094.862,00	8.132.345,91
	a. Sawah Irigasi/*Irrigated Wetland*	4.828.476,00	4.905.107,00	4.893.128,00	4.924.172,00	4.417.581,92
	b. Sawah Non Irigasi/*Non Irrigated Wetland*	3.162.988,00	3.163.220,00	3.109.424,00	3.170.690,00	3.714.763,99
2.	Tegal/Kebun/*Dry Field/Garden*	11.707.380,00	11.782.332,00	11.877.777,00	11.626.219,00	11.949.727,00
3.	Ladang/Huma/*Shifting Cultivation*	5.328.863,00	5.428.689,00	5.334.545,00	5.697.171,00	5.260.081,00
4.	Lahan yang Sementara Tidak Diusahakan/*Temporarily Unused Land*	15.003.359,00	14.880.526,00	14.754.249,00	14.378.586,00	14.252.383,00
Jumlah (1+2+3+4)		**40.031.166,00**	**40.159.974,00**	**39.969.123,00**	**39.796.838,00**	**39.594.536,91**

Sumber : BPS

Source : BPS

Keterangan : *) Data hasil kesepakatan Kementerian Pertanian dan BPN (hasil pemetaan lahan sawah)

*Note : *) Data results from the agreement between Ministry of Agriculture and The National Land Agency of Republic of Indonesia (wetland mapping results)*

Sumber: Pusdatin 2013, hal. 4

Table 4. Agricultural productivity in Indonesia

Tahun	Padi	Jagung	Kedelai	K Tanah	K Hijau	U Kayu	U Jalar
2000	44.01	27.65	12.34	10.77	8.95	125.30	94.08
2001	43.88	28.45	12.18	10.82	8.87	129.41	96.62
2002	44.69	30.88	12.36	11.10	9.19	132.49	99.94
2003	45.38	32.41	12.75	11.50	9.73	148.84	100.83
2004	45.36	33.52	12.80	11.58	9.95	154.68	103.05
2005	45.74	31.78	13.00	11.61	10.08	159.22	106.37
2006	46.20	34.70	12.88	11.86	10.23	162.83	105.05
2007	47.05	36.60	12.91	11.95	10.53	105.01	106.64
2008	48.94	40.78	13.13	12.15	10.72	180.57	107.80
2009	50.00	42.30	13.50	12.15	10.79	187.50	107.48
2010	50.10	44.30	13.70	12.56	11.30	202.20	113.27
Laju 2000-2010 (%/th)	1.39	4.60	1.04	1.46	2.36	3.78	1.56

Source: BPPP 2011, pg. 4

Table 5 . Horticultural land area in Indonesia

Tahun	Buah	Sayur	T.Obat	T. Hias	Total
2000	505,349	849,265	12,316	3,804	1,370,734
2001	825,536	857,211	12,279	2,841	1,697,867
2002	714,851	878,679	11,271	3,290	1,608,091
2003	791,103	913,445	12,650	2,527	1,719,725
2004	783,291	977,552	14,420	2,584	1,777,847
2005	785,311	944,695	18,911	2,458	1,751,376
2006	800,608	1,007,839	23,533	1,282	1,833,262
2007	727,196	1,020,623	25,055	1,147	1,774,021
2008	843,172	989,809	23,484	1,,287	1,857,752
2009	880,637	1,070,331	21,220	1,548	1,973,737
2010	719,763	1,103,890	17,853	1,902	1,843,408
Laju (%/th)	1.97	2.25	2.72	-11.05	2.64

Source: BPPP 2011, pg. 59

Table 5 and **Table 6** show that both acreage and production of horticulture in Indonesia tend to increase. However, horticulture productivity trend must still be considered since those tables shows that the increase of area will not directly result in the increase in productivity.

Table 6. Horticulture production in Indonesia

Tahun	Buah	Sayur	T.Obat	T. Hias	Total
2000	9,127	7,981	179	97	17,384
2001	12,249	8,228	210	118	20,806
2002	14,076	8,476	240	140	22,932
2003	15,372	8,723	271	162	24,527
2004	16,377	8,970	301	184	25,832
2005	17,198	9,217	332	205	26,953
2006	17,893	9,465	362	227	27,947
2007	18,494	9,712	393	249	28,848
2008	19,025	9,959	424	271	29,,678
2009	19,499	10,206	454	292	30,452
2010	19,929	10,454	485	314	31,181
Laju (%/th)	4.98	1.32	5.45	10.16	3.68

Source: BPPP 2011, pg. 59

Table 7. Plantation Area and Production in Indonesia

Komoditas	Luas Areal			Produksi		
	Pertumbuhan (%/tahun)		Luas 2010 (ha)	Pertumbuhan (%/tahun)		Prod 2010 (ha)
	2000-2005	2005-2010		2000-2005	2005-2010	
Kelapa sawit	4.98	7.30	8,036,431	10.15	8.09	23,712,013
Kelapa	0.23	0.04	3,808,263	0.08	1.14	3,266,448
Karet	-0.64	0.94	3,445,121	8.33	1.22	2,591,935
Kakao	8.90	6.63	1,651,539	10.97	2.39	844,626
Kopi	-0.28	-0.15	1,268,476	3.11	1.04	684,076
Cengkeh	1.36	1.11	470,045	3.88	7.06	110,807
Tebu/Gula	1.51	2.45	434,257	5.31	4.43	2,694,227
Tembakau	-4.94	1.14	193,916	-5.57	-1.58	122,276
Lada	4.16	-0.82	186,296	1.26	1.84	84,218
Teh	-2.05	-2.51	124,573	0.34	-0.79	150,342
Panili	11.05	-0.48	27,256	3.67	1.86	3,059
Jambu mete	16.02	-11.01	1,020	12.39	1.12	145,081

Source: BPPP 2011, pg. 13

Table 7 shows the data on the land area and production of Indonesia's plantation sector. According to the data, after palm oil, coconut and rubber come second and third as the plantation with the largest area and highest production. The table also shows that some commodities such as tobacco and coffee experienced negative growth both in reduction of land area and production. In modeling I2050PC, palm oil is separated from other commodities because of its historically extensive development and productivity.

2. Assumptions

To calculate the potential emissions of the Indonesia's agricultural sector in 2050, Indonesia's population growth will utilize the same population growth as the one used in the calculator I2050PC for energy and industrial sectors. Moreover, agricultural productivity will be calculated according to the pattern of Indonesian food consumption Indonesia (Indonesia Statistics Agency, 2011, pg. 27). Furthermore, the scenario for the change in agricultural land and plantation area in the future show a tendency to increase broadly that is in line with the agricultural outlook data (BPPP 2011, pg 33, 35, 38, 45, 47, 51). Nevertheless, the results of the discussion in the stakeholder consultation resulted in several important points such as the uncertainty of the land area affected by climate change, the intensity of climate change impacts and the difficulty in ensuring the accuracy of the long-term projection. Therefore, the decision makers more likely agree that the total area of agricultural and plantation Indonesia may increase significantly along with the population growth and increasing food demand.

Meanwhile, similar to the assumptions used in the land use sector, the figures of above ground carbon (AGC) will be used to calculate the emissions from agriculture and plantation by referring to National Development Planning Agency/BAPPENAS (2015). The new land clearing will be taken from the primary forests with the AGC of 195.4 tons/ha and the reforestation of degraded land that becomes secondary forest with the AGC of 169.7 tons/ha. Furthermore, assuming that the AGC figure for various types of plantations is uniform, then the AGC figure for a variety of non-palm oil plantations is 63 tons/ha. In terms of agricultural AGC figure, it is assumed that the figure used is single dry land farming, not the figure of mix dry land agriculture, that is 10 tons /ha.

In addition, during the stakeholder consultation, there are many problems encountered in determining the precise figure of agricultural land area. In addition, the nature of agricultural in Indonesia is still market demand-driven. The commodities may be harvested more than once in a year depend on the variants, the location and planting method. Therefore, this model will combine the figures of agriculture and horticulture areas since the farmers often plant agricultural and horticulture products interchangeably in the same year. Furthermore, instead of using the figures of the harvested area and productivity from BPPP, this model will use real data on the agricultural land area from PUSDATIN and this model will calculate the area of idle land that continues to shrink as the land has been categorized as agricultural land, although it has not been used for agricultural production yet. Given the overlapping of many land use permits and the allocation of forest land, the current model of I2050PC will assume that the use of idle land refers to the change of forest cover to agricultural land similar to the situations in other sectors when new land clearing occurs. If more coherent data is available in the future, then the figure can be corrected so the model will be able to produce land use change simulation and emission potential outcomes with greater accuracy.

3. Methodology

There are several things to be considered in making a model for the calculator as designed in I2050PC. In addition to ease of use and user-friendliness, each level should explain to the users, especially lay users, on how the policy options can affect the emissions of agriculture and plantation sectors.

Therefore, based on the method of the National Development Planning Agency, the background of sector, the assumptions, the results of stakeholder consultation, the easy to understand principal, and the use of the model, author suggests that the emission of agriculture and plantation sector should be calculated using the use of land area and changes in soil carbon content that occurs as a result of the land use.

The approach can be simplified into the following equation:

$$Emission = Total\ Area \times Carbon\ Stock$$

or

$$E = A \times AGC$$

where

E = Emission (ton CO_{2eq})

A = Total Area (hectare/ ha)

AGC = Above ground carbon stock (ton CO_{2eq} per hectare)

Moreover, based on the exposure of the background and the assumptions above in stakeholder consultations, it is agreed upon that the projected future **demand for Indonesian food** can be presented into four levels:

Level 1

Level 1 assumes the level of Indonesia's food consumption in 2050 will pursue the level of consumption in developed countries at present, that is 3250 kcal/person /day. This can only happen when there is a drastic change in the consumption pattern of Indonesian society.

Level 2

Level 2 assumes the level of Indonesia's food consumption in 2050 will reach the level of consumption in the East Asia countries, that is currently 2750 kcal /person/day. It is possible to occur by looking at the high rate of consumption increase in rapid developing countries like China and Brazil.

Level 3

Level 3 assumes the level of Indonesia's food consumption in 2050 will increase to 2500 kcal/person/ day. This scenario is likely to occur when the economic growth and food access in Indonesia continues to grow at the current rate.

Level 4

Level 4 assumes the level of Indonesia's food consumption in 2050 will only reach 2250 kcal /person/ day. It is still possible if the Indonesia's economic growth in the future does not strongly influence the pattern of food consumption of Indonesian society.

Meanwhile, in terms of the **area of agricultural land**, changes that may occur include are:

Level 1

Level 1 assumes the effective area of agricultural land in Indonesia in 2050 will increase twenty percent (20%) as compared to the 2011 level. This may happen due to the increased idle land use following the increase of food demand and job opportunities, as the result of Indonesia's population growth.

Level 2

Level 2 assumes the effective area of agricultural land in Indonesia in 2050 will increase ten percent (10%) as compared to the 2011 level. This may occur when the design of existing policies will encourage agricultural extensification.

Level 3

Level 3 assumes the effective area of agricultural land in Indonesia in 2050 is similar to the 2011 level. This can be achieved if future policies are developed to optimize the use of existing land.

Level 4

Level 4 assumes the effective area of agricultural land in Indonesia in 2050 will reduce ten percent (-10%) as compared to the 2011 level. This can be achieved if the policies are structured to support the optimization of land use and also reduce the demand for agricultural land. Improvement of zoning system and consistent implementation of spatial planning will be required to achieve the above target.

Indonesia's agricultural productivity is projected as follows:

Level 1

Level 1 assumes that Indonesia's agricultural productivity in 2050 will decrease ten percent (-10%) as compared to 2011. It can happen when there is no serious policy to reduce the vulnerability of the agricultural sector of Indonesia against the impacts of climate change.

Level 2

Level 2 assumes that Indonesia's agricultural productivity in 2050 will not change as compared to 2011. This is very likely to occur if all existing policies can only offset the negative impact of climate change in the agricultural sector in Indonesia.

Level 3

Level 3 assumes that Indonesia's agricultural productivity in 2050 will increase ten percent (10%) as compared to 2011. The level of productivity can be achieved through the design of policies that encourage investment in research and development on agricultural productivity.

Level 4

Level 4 assumes that Indonesia's agricultural productivity in 2050 will increase twenty percent (20%) as compared to 2011. This improvement can be achieved through the design of policies that encourage research and development as well as infrastructure investment for processing and distribution of agricultural products.

Meanwhile, a change in non-palm oil plantation area in Indonesia is projected as follows:

Level 1

Level 1 assumes the plantation area in Indonesia in 2050 will increase twenty percent (20%) as compared to 2011. This may occur due to increased demand for commodities and employment.

Level 2

Level 2 assumes the plantation area in Indonesia in 2050 will increase ten percent (10%) as compared to 2011. This may occur when the design of existing policies encourage the expansion of plantation area in Indonesia.

Level 3

Level 3 assumes the plantation area in Indonesia in 2050 will not change as compared to 2011. This can be achieved if policies developed in the future could optimize the use of existing land.

Level 4

Level 4 assumes the plantation area in Indonesia in 2050 will decrease ten percent (-10%) as compared to 2011. This can be achieved if policies are structured to support the optimization of land use and also reduce the demand for new land clearing. Implementation of zoning system and consistent implementation of spatial planning will be required to achieve the above target.

Change in the productivity of **non-palm oil plantations** can be modeled as follows:

Level 1

Level 1 assumes that Indonesia’s plantation productivity in 2050 will decrease ten percent (-10%) as compared to 2011. It can occur due to the impacts of climate change in the future.

Level 2

Level 2 assumes the productivity of Indonesia’s plantation in 2050 will not change as compared to 2011. This is very likely to occur if all existing policies can only offset the negative impact of climate change in Indonesia’s plantation sector.

Level 3

Level 3 assumes that Indonesia's plantation productivity in 2050 will increase ten percent (10%) as compared to 2011. The level of productivity can be achieved by expanding the distribution network agro-inputs such as certified seed and fertilizer produced by the research centers.

Level 4

Level 4 assumes that Indonesia's plantation productivity in 2050 will increase twenty percent (20%) as compared to 2011. This can be achieved by increasing the adoption of agricultural technology such as the use of certified seeds and fertilizer as well as the methods of soil and crop management.

4. Results

Based on the methodology explained above, there are 5 projections by 2050: food demand, agricultural land, agricultural productivity, non-palm oil plantation area, and the productivity of non-palm oil plantation. Since the projections of agricultural productivity and non-palm oil plantation productivity are given only as an index of food availability potential calculation, the user guide will focus on the graphs that have a greater impact such as the projected demand for calories, agricultural land area projection, and projection of the land area of non-palm oil plantation.

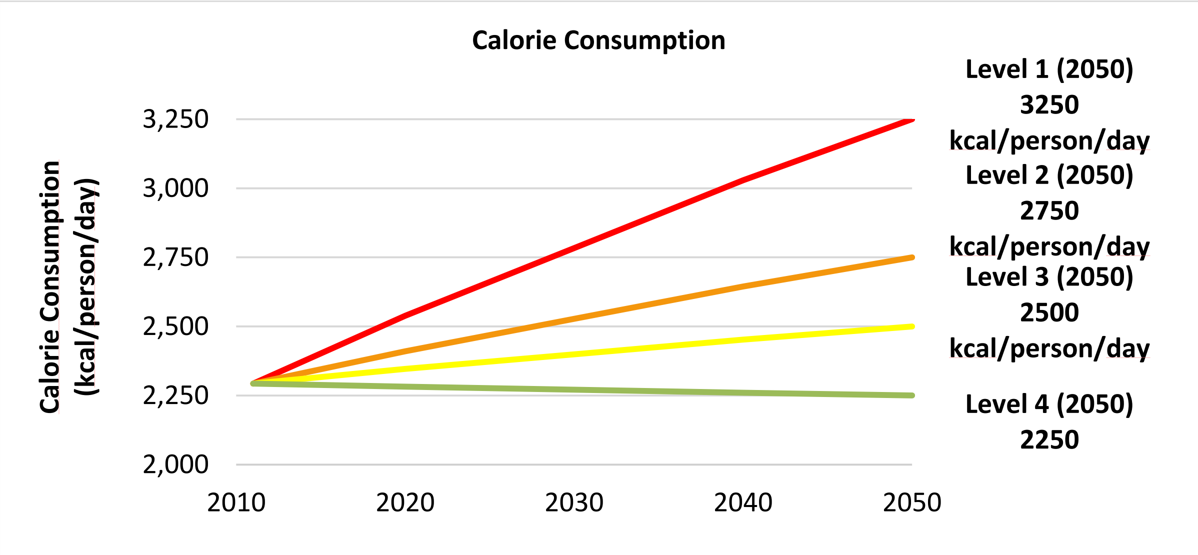

Figure 2. Projection of Indonesian's calorie consumption (source: Author)

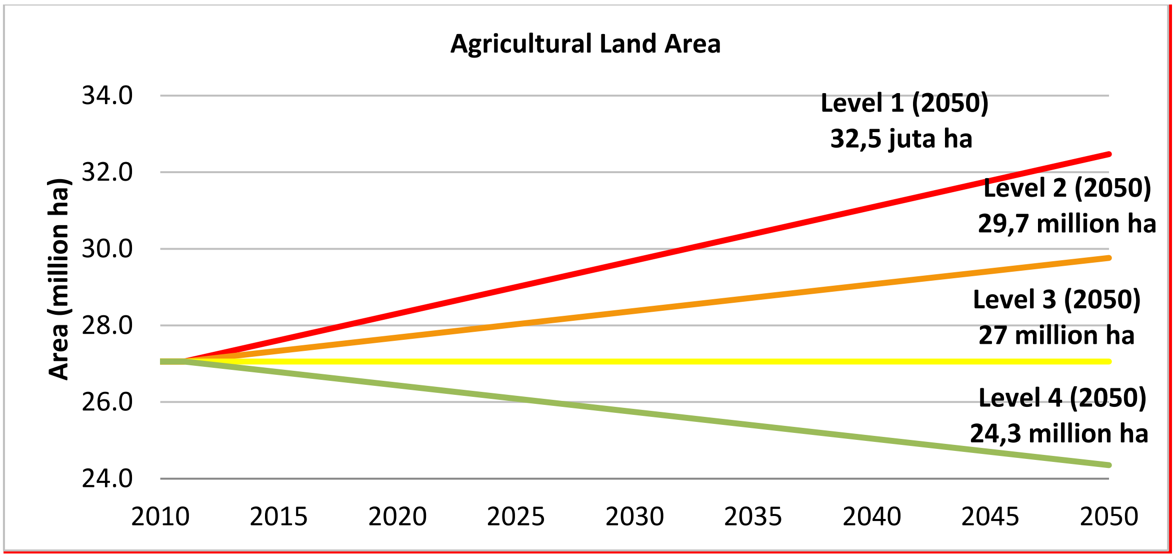

Figure 3. Projection of agricultural land area in Indonesia (source: Author)

Thus, the potential emission contribution of the **agricultural sector** can be predicted as follows:

Level 1

The land clearing for 32.5 million ha agricultural land will result in an increase in emissions of 1,020 billion tons of CO_2.eq.

Level 2

The land clearing for 28 million ha agricultural land will result in an increase in emissions of 500,6 million tons of CO_2.eq.

Level 3

The absence of new land clearing will result in the absence of emission fluxes in 2050 as compared to 2011 beyond the aggregate calculation of baseline emission for all land use sectors.

Level 4

The reduction of agricultural land area at two million hectares leads to emission reductions of 431.2 million tons of CO_2.eq.

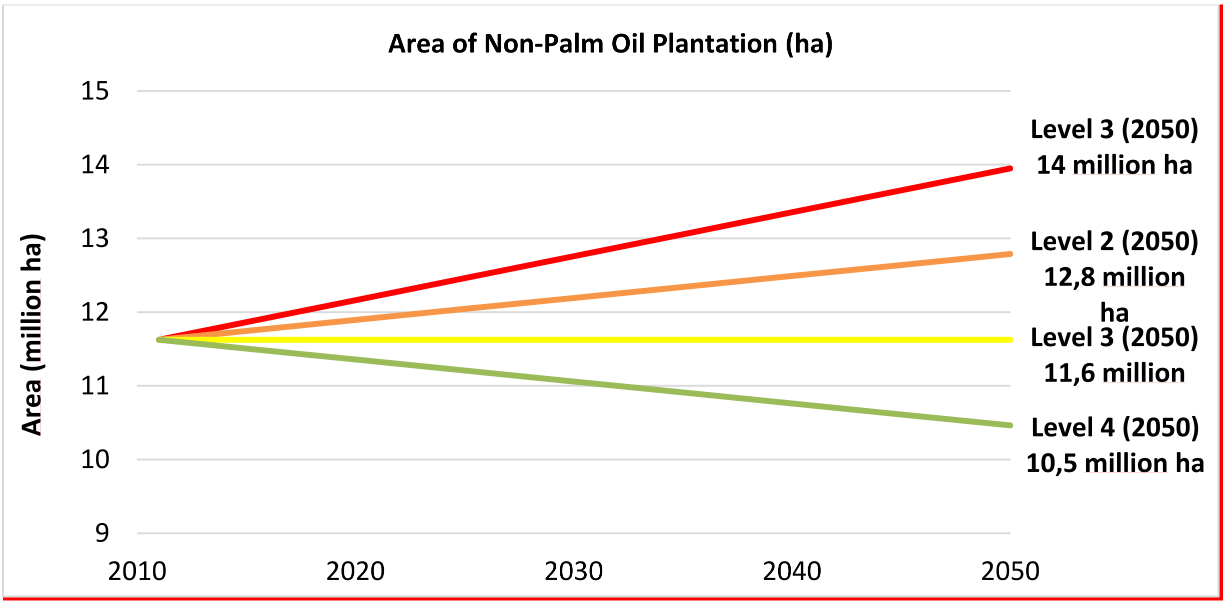

Figure 4. Projection of non-palm oil plantation area in Indonesia (source: Author)

Meanwhile, the potential emission contribution of **non-palm oil plantations** can be calculated as follows:

Level 1

The land clearing for 2.32 million ha plantation area will result in an increase in emissions of 307.2 million tons of $CO_{2.}$eq.

Level 2

The land clearing for 1,16 j million ha plantation area will result in an increase in emissions of 153,6 million tons of $CO_{2.}$eq.

Level 3

The absence of new land clearing will result in the absence of emission fluxes in 2050 as compared to 2011 beyond the aggregate calculation of baseline emission for all land use sectors.

Level 4

The reduction of plantation area at 1.16 million hectares leads to emission reductions of 123,8 million tons of $CO_{2.}$eq.

5. References

Agus, F, Henson, IE, Sahardjo, BH, Haris, N, van Noordwijk, M & Killeen, TJ 2013, "Review of Emission Factors for Assessment of CO_2 Emission From Land Use Change to Oil Palm in Southeast Asia", *Reports from the Technical Panels of the 2nd Greenhouse Gas Working Group of the Roundtable on Sustainable Palm Oil*, hal. 7-28.

Alexandratos, N & Bruinsma, J 2012, *"World Agriculture Towards 2030/2050 – The 2012 Revision"*, Agricultural Development Economics Division, UN-FAO, ESA Working Paper No. 12-03.

BAPPENAS (Kementerian Perencanaan Pembangunan Nasional) 2015, *"Pembentukan BAU Baseline Bidang Berbasis Lahan"*, Sekretariat RAN-GRK, diunduh 30 Maret 2015, <http://www.sekretariat-rangrk.org/english/home/9-uncategorised/173-baulahan>.

BKP (Badan Ketahanan Pangan) 2011, *Revisi Rencana Strategis Badan Ketahanan Pangan Tahun 2010-2014*, Badan Ketahanan Pangan, Jakarta.

BPPP (Badan Penelitian dan Pengembangan Pertanian) 2011, *"Outlook Pertanian 2010-2025"*, Kementerian Pertanian, Pemerintahan Republik Indonesia, Jakarta.

BPS (Badan Pusat Statistik) 2011, *"Konsumsi Kalori dan Protein Penduduk Indonesia dan Provinsi 2011"*, BPS, Pemerintahan Republik Indonesia, Jakarta.

— 2015, "*Rata-rata Konsumsi Kalori dan Protein per Kapita per Hari Menurut Provinsi 2007-2013*", BPS, diunduh 12 April 2015, < http://www.bps.go.id/linkTabelStatis/view/id/951>.

Carre, F, Hiederer, R, Blujdea, V & Koeble, R 2010, *Background Guide for the Calculation of Land Carbon Stocks in the Biofuels Sustainability Scheme – Drawing on the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Office for Official Publications of the European Communities, Luxembourg.

PUSDATIN (Pusat Data dan Sistem Informasi Pertanian) 2013, *"Statistik Lahan Pertanian Tahun 2008-2012"*, Sekretariat Jenderal Kementerian Pertanian, Pemerintahan Republik Indonesia, Jakarta.