EMISSION REDUCTION REPORT

FOR THE INDONESIA-NORWAY PARTNERSHIP

(Revised Version)

DIRECTORATE GENERAL OF CLIMATE CHANGE
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Preface

Indonesia have committed to a new International climate agreement through the ratification of Paris Agreement in 2016. To achieve this commitment, Indonesia and the Kingdom of Norway agree to continue the partnership to further promote the implementation of REDD+ and to protect the remaining natural forests as well as the carbon-rich peatlands in Indonesia, which are part of the Letter of Intent (LoI) between the Government of Indonesia and the Government of Kingdom of Norway that has been signed in 2010.

Since the commencement of the LoI, both countries show strong commitments in addressing issue of climate change mitigation action and in particular supporting the preparedness of REDD+ implementation in Indonesia. Various supports from the government of Norway has been granted to support initiatives in improving capacities and developing systems for implementation of REDD+ and peatland management in Indonesia. Indonesia, as the REDD+ implementing countries, continue to meet the reporting requirement to the UNFCCC. The 1st Forest Reference Emision Level (FREL) has been submitted to and approved by the UNFCCC in 2016. Furthermore, in 2018 Indonesia submitted the Technical Annex of BUR to UNFCCC, which presents the emission reduction results by Indonesia. In paralel, the Indonesia REDD+ Performance report is also upload at Lima REDD+ Hub Website.

As part of the 3rd phase of Indonesia-Norway LoI, both countries have developed the agreed MRV Protocol outlining further mechanism of the result-based payment specifically for the implementation of Indonesia-Norway REDD+ Partnership. The protocol was developed under mutual relationship and common goals to contribute to the international climate agreement through reduction of emissions from tropical deforestation, forest degradation and peatland management.

As the next steps, Indonesia develops the baseline for the result-based payment, as agreed in the MRV Protocol and submits the emission reduction report from the avoided deforestation and forest degradation for the Indonesia-Norway Partnership. We acknowledge the contributions of relevant institutions and team of experts during preparation and development of the RBP baseline and Emission Reduction Report for The Indonesia-Norway Partnership.

Jakarta, February 2020

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1. Introduction

Government of Indonesia and Government of Kingdom of Norway have been officially agreed to work together in protecting the remaining natural forest in Indonesia, through the "Cooperation on reducing green house gas emissions from deforestation and forest degradation". The Cooperation was well explained on the Letter of Intent between the Government of Indonesia and the Government of Kingdom of Norway which has been signed on May 26th, 2010. In general, the Government of Kingdom of Norway will provide payment to Government of Indonesia, based on the performance of reducing green house gas emissions from deforestation and forest degradation.

One of the products that should be developed in this Cooperation is Emission Reduction Report that provides information on the reference emission level which will be defined as Result Based Payment (RBP) baseline, and the performance of emission reduction in 2017. This report is developed by refering to MRV protocol for the Indonesia-Norway partnership on climate, forests and peat.

This report is an independent document specifically used for Indonesia-Norway Cooperation on reducing green house gas emissions from deforestation and forest degradation. The RBP baseline in this report is different to Indonesia Forest Reference Emission Level (FREL) that has been submitted to UNFCCC, and passed the technical assessment in 2016. The main different between RBP baseline and FREL is its reference period, where the RBP Baseline used the period of 2006-2016, while FREL used period of 1990-2012.

The Ministry of Environment and Forestry (MoEF) is responsible to develop the emission reduction report and submit it to the Government of Kingdom of Norway. This report will be used as a basis of payments from Government of Kingdom of Norway to the performance or achivement of Government of Indonesia in reducing the green house gas emission from deforestation and forest degradation during 2017-2020.

In addition, based on the document annex for MRV protocol, Indonesia also reported reducing emissions from peatlands. Reports on reducing emissions on peatland include emissions from peat decomposition and emissions from peat fires. Reports for peatlands are presented in Annex 2 and 3 of this report.

2. Result Based Payment Baseline Indonesia-Norway Partnership

2.1 Definitions Used

The definitions used in this document are consistent with those in first FREL. The definitions restated in this document include, among others: definition of forest, deforestation, forest degradation and Baseline for Result Based Payment

2.1.1 Forest

The Government of Indonesia through the Minister of Forestry Decree No. 14/2004 regarding A/R CDM, has set up the definition of forest as "Land with a minimum area of 0.25 hectares that contains trees with canopy cover of at least 30 percent that are capable of reaching a minimum height of 5 meters at maturity" (MoFor, 2004).

Forests used in this document refers to the "working definition", defined as "a land area of more than 6.25 hectares with trees higher than 5 meters at maturity and a canopy cover of more than 30 percent". The area span is based on the land-cover maps produced through visual interpretation of satellite images at a scale of 1:50.000 where the minimum area for polygon delineation is 0.25 cm^2 which equals to 6.25 ha (minimum mapping unit).

Forests used as basis for calculation refer to natural forests, following the classification of Ministry of Environment and Forestry's land cover map (Table 1) and has been used in the Forest References Emissions Level. The natural forests included six classes, i.e. primary dry land forest, secondary dry land forest, primary swamp forest, secondary swamp forest, primary mangrove forest, and secondary mangrove forest.

Table 1. Land cover classes used in the RBP baseline

No	Land-cover class	Abbreviation	Category	IPCC
1.	Primary dryland forest	PF	Natural forest	Forest
2.	Secondary dryland forest	SF	Natural forest	Forest
3.	Primary mangrove forest	PMF	Natural forest	Forest
4.	Secondary mangrove forest	SMF	Natural forest	Forest
5.	Primary swamp forest	PSF	Natural forest	Forest
6.	Secondary swamp forest	SSF	Natural forest	Forest
7.	Plantation forest	TP	Plantation	Forest
8.	Estate crop	EP	Non-forest	Crop land
9.	Pure dry agriculture	AUA	Non-forest	Crop land
10.	Mixed dry agriculture	MxUA	Non-forest	Crop land
11.	Dry shrub	Sr	Non-forest	Grassland
12.	Wet shrub	SSr	Non-forest	Grassland
13.	Savanna and Grasses	Sv	Non-forest	Grassland
14.	Paddy Field	Rc	Non-forest	Crop land
15.	Open swamp	Sw	Non-forest	Wetland
16.	Fish pond/aquaculture	Po	Non-forest	Wetland
17.	Transmigration areas	Tr	Non-forest	Settlement
18.	Settlement areas	Se	Non-forest	Settlement
19.	Port and harbor	Ai	Non-forest	Other land
20.	Mining areas	Mn	Non-forest	Other land
21.	Bare ground	Br	Non-forest	Other land
22.	Open water	WB	Non-forest	Wetland
23.	Clouds and no-data	Ot	Non-forest	No data

2.1.2 Deforestation

Deforestation is defined as one-time conversion of natural forest cover to other land-cover categories that occurred in the same area. This means that the deforestation occurred in regenerated forests, that previously deforested, are not included in the calculation. This includes conversion of natural forest cover into plantation forest or non-forested lands.

2.1.3 Forest Degradation

Forest degradation is defined as a transition of primary forest classes, which include primary dryland, primary mangrove and primary swamp forests, to secondary forest classes, which reduce the quantity of carbon stocks as a result of human activities. These represent secondary forests that were subject to selective logging or other disturbance events (e.g. fires and encroachment).

2.1.4 Baseline for Result Based Payment

Baseline for result based payment (RBP) is a benchmark for assessing Indonesia's performance in implementing REDD+ under the framework of Norway-Indonesia Partnership. The performance of emission reduction was expressed in tons of carbon dioxide equivalent per year. The technical definition of RBP baseline adopted in this report is a projection of CO_2 gross emissions that is used as a reference to compare against actual emissions at a given point of time in the future. In accordance with MRV protocol document, the RBP baseline will be updated periodically indicatively every 5 years, taking into account any updates of Indonesia's FREL that might be submitted to the UNFCCC. This RBP baseline was developed based on historical forest dynamics and serves as a benchmark for future performance evaluation of REDD+ activities.

To be aligned with the 1st national FREL, we used the definition of forests as stated in the 1st FREL[1] submitted to the UNFCCC (paragraph 34), which defined the forests as natural forests that limited to the forest extents in 1990.

2.2 Area, Activities and Pools Covered Results

2.2.1 Area Covered

RBP baseline calculation cover the whole natural forests in Indonesia, which includes dryland, mangrove, and swamp forests from both primary and secondary classes.

2.2.2 Activities Covered

RBP baseline calculation covers the activities related to deforestation and forest degradation. Other REDD+ activities such sustainable management of forest, role of conservation, and enhancement of forest carbon stock were not covered in the calculation. Emissions from peat decomposition was also excluded in the calculation, following the Annex of MRV Protocol for the Indonesia-Norway partnership on climate, forests and peat (see section "Activities, pools and gases included in the results-based payment).

[1] https://redd.unfccc.int/files/frel_submission_by__indonesia_final.pdf

2.2.3 Pools and Gases

RBP baseline calculation considers aboveground biomass (AGB) as the most significant carbon pool, and reports the greenhouse gas emissions of carbondioxide (CO_2).

2.3 Data

2.3.1 Activity Data

Activity data were generated from the series of land cover maps produced by the Ministry of Environment and Forestry (MoEF), which are the product of the National Forest Monitoring System (NFMS). The maps are accessible via the website (http://webgis.menlhk.go.id:8080/nfms_simontana/) or in the map services are accessible via https://geoportal.menlhk.go.id/arcgis/rest/services/KLHK/). The datasets of 2006, 2009, 2011, 2012, 2013, 2014, 2015, and 2016 land cover maps were used to analyse historical land cover changes, and calculate the emissions estimates. To make consistent with the definition used, datasets of 1990, 1996, 2000 and 2003 land cover map also were used.

2.3.2 Emission Factors

RBP baseline calculation uses the emission factors that identical to emission factors used in the 1st Indonesia's FREL. The primary data source used to derive the emission factors were the National Forest Inventory (NFI) - a national program initiated by the Ministry of Forestry in 1989 and supported by the Food and Agriculture Organization of the United Nations (FAO) and the World Bank through the NFI Project. Additionally, research and published data collected from Indonesian sites were used to fill critical data gap currently not available for analysis. Detail emission factor for deforestation and forest degradation see Table 2 and Table 3.

Table 2. Deforestation Emission Factor

Forest Classes	Emission Factors of Deforestation (tCO2-e -e.ha^{-1})						
	JAWA	KALIMANTAN	MALUKU	NUSA BALI	PAPUA	SULAWESI	SUMATERA
Primary Dryland Forest	458.8	464.7	519.9	473.3	412.4	474.7	463.3
Secondary Dryland Forest	294.1	350.7	383.1	280.6	311.2	356.2	314.3
Primary Mangrove Forest	455.2	455.2	455.2	455.2	455.2	455.2	455.2
Secondary Mangrove Forest	347.9	347.9	347.9	347.9	347.9	347.9	347.9
Primary Swamp Forest	332.4	474.0	332.4	332.4	308.4	369.8	380.9
Secondary Swamp Forest	274.8	294.1	274.8	274.8	251.3	221.3	261.1

Note : If data for the emission factor by island is not available, then National Average is used

Table 3. Forest Degradation Emission Factor

Forest Classes	Emission Factors of Forest Degradation (tCO2-e -e.ha^{-1})						
	JAWA	KALIMANTAN	MALUKU	NUSA BALI	PAPUA	SULAWESI	SUMATERA
Primary Dryland Forest	164.7	114.0	136.8	192.7	101.3	118.5	149.0
Primary Mangrove Forest	107.3	107.3	107.3	107.3	107.3	107.3	107.3
Primary Swamp Forest	57.6	179.9	57.6	57.6	57.1	148.5	119.7

**) If data for the emission factor by island is not available, then National Average is used*

2.4 Methodology and Procedures

2.4.1 Forest Cover Change Analysis

Annual forest cover change analysis was conducted by overlaying all of land cover maps from 1990-2017. Referring to the working definition, deforestation is the change of natural forests into other classes that occurred one time at any given location across the entire observation period (2006/2007 – 2015/2016).

Forest degradation is the change of primary forests to secondary forests classes in the subsequent year. As elaborated in Margono *et al* (2015), the land cover (LC) data set is a series (T_1 to T_{1+n}) of data, and the degraded forest was generated by comparing the LC of T_n (class of primary forests in the first observation period) to the LC of T_{n+1} (becoming class of secondary forests in the consecutive observation period). Detail information for the calculation proccess see Annex 1. The Calculation of Emission from Deforestation and Forest Degradation.

2.4.2 Reference Period

RBP baseline was calculated based on the period of 2006/2007 – 2015/2016 as the reference period.

2.4.3 RBP Baseline Calculation

RBP baseline calculation was calculated by using the average annual emissions from 2006/2007 to 2015/2016, i.e. from historical emissions from deforestation and forest degradation.

2.5 Results of the Construction of RBP Baseline

2.5.1 Estimates Emission from Deforestation

The averaged annual emission from deforestation in the period 2006/2007 – 2015/2016 is 236.9 $MtCO_2$-e.yr^{-1} (*see* Figure 1).

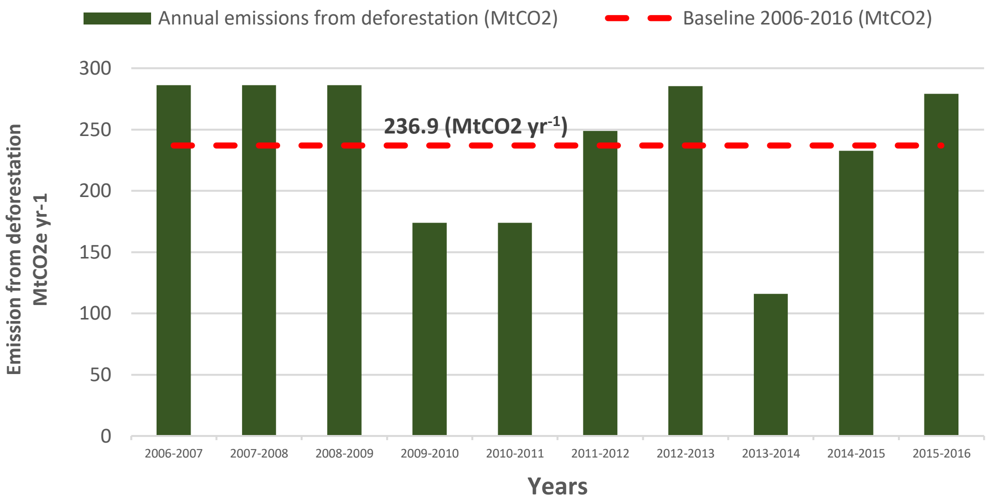

Figure 1. Average annual historical emissions from deforestation expressed in millions tCO2-e.

2.5.2 Estimates Emission from Forest Degradation

The annual emission from forest degradation in the period 2006/2007 – 2015/2016 is 41.0 $MtCO_2$-e.yr^{-1} (*see* Figure 2).

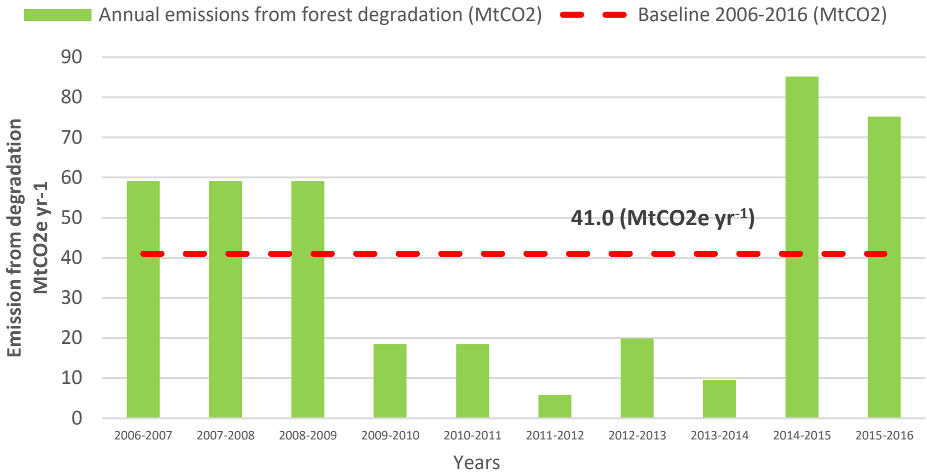

Figure 2. Average annual historical emissions from forest degradation expressed in millions tCO2-e.

2.6 Constructed and Projected RBP Baseline

The annual total emissions from deforestation and forest degradation in the period of 2006/2007 – 2015/2016 is 277.9 MtCO2-e.yr^{-1} (*see* Figure 3).

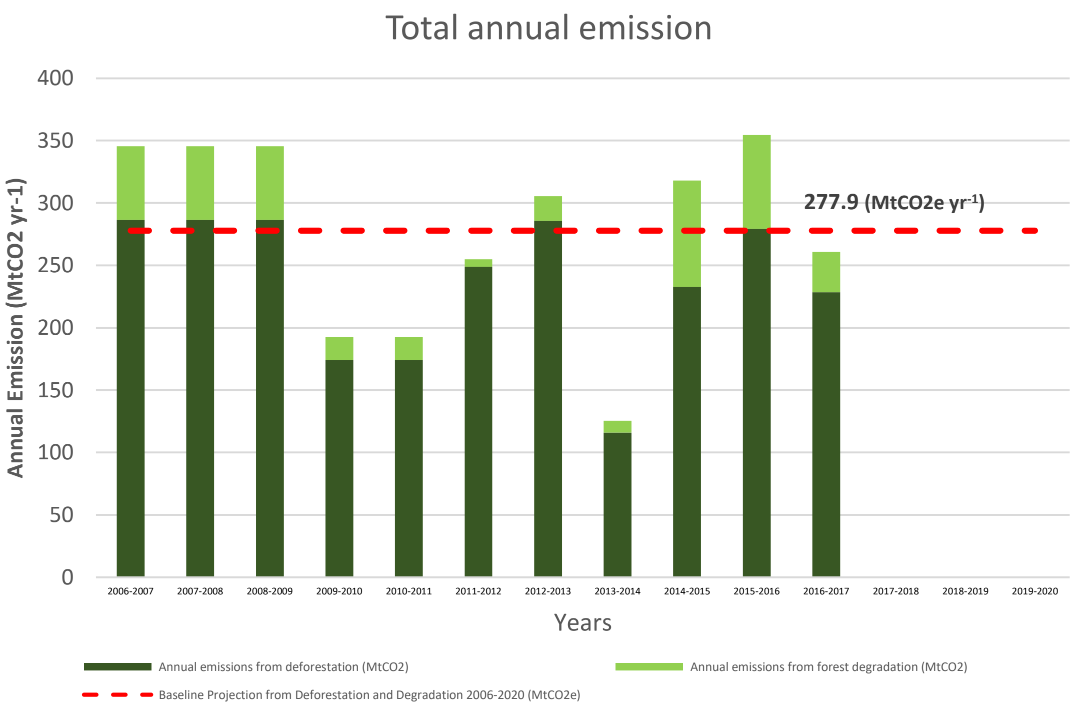

Figure 3. Annual and average annual historical emissions from deforestation and forest degradation (in MtCO2-e) in Indonesia from 2006/2007 to – 2015/2016 and projected emission from 2016/2017 – 2019/2020.

Baseline emissions from deforestation and forest degradation are generated based on annual emissions in the period of 2006/2007 to 2015/2016. Detailed annual emissions are shown in the *Table 4*.

Table 4. Historical (2006/2007 – 2015/2016) and projected (2016/2017 – 2019/2020) annual emission from deforestation and forest degradation (in tCO2-e), calculated using historical data of 2006/2007 – 2015/2016

Year	Deforestation	Forest Degradation	Total annual emission	
2006-2007	286,399,781	59,051,617	286,399,781	Historical
2007-2008	286,399,781	59,051,617	286,399,781	
2008-2009	286,399,781	59,051,617	286,399,781	
2009-2010	173,890,857	18,510,520	173,890,857	
2010-2011	173,890,857	18,510,520	173,890,857	
2011-2012	248,936,401	5,805,289	248,936,401	
2012-2013	285,586,539	19,833,885	285,586,539	
2013-2014	116,066,230	9,515,931	116,066,230	
2014-2015	232,677,053	85,190,736	232,677,053	
2015-2016	279,220,589	75,225,065	279,220,589	
2016-2017	236,946,787	40,974,680	277,921,466	Baseline
2017-2018	236,946,787	40,974,680	277,921,466	
2018-2019	236,946,787	40,974,680	277,921,466	
2019-2020	236,946,787	40,974,680	277,921,466	

3. Results

Emission reductions are calculated through deduction of baseline emision with actual annual emission. In this report, the baseline emissions were generated from the average emission of 2006/2007 – 2015/2016. The baseline for deforestation and forest degradation are 236,946,787 tCO2-e.year^{-1} and 40,974,680 tCO2-e.year^{-1}, respectively. While the 2016/2017 actual emission was derived from the current emission from deforestation (228,348,899 tCO2-e) and/or forest degradation (32,294,223 tCO_2-e).

Table 5. Emision reduction from avoided deforestation and forest degradation

Activity	Emission Reduction (tCO_2-e)	Percentage from Baseline (%)
Deforestation	8,597,888	3.6%
Forest Degradation	8,680,457	21.2%
Total Emision Reduction	17,278,345	24.8%

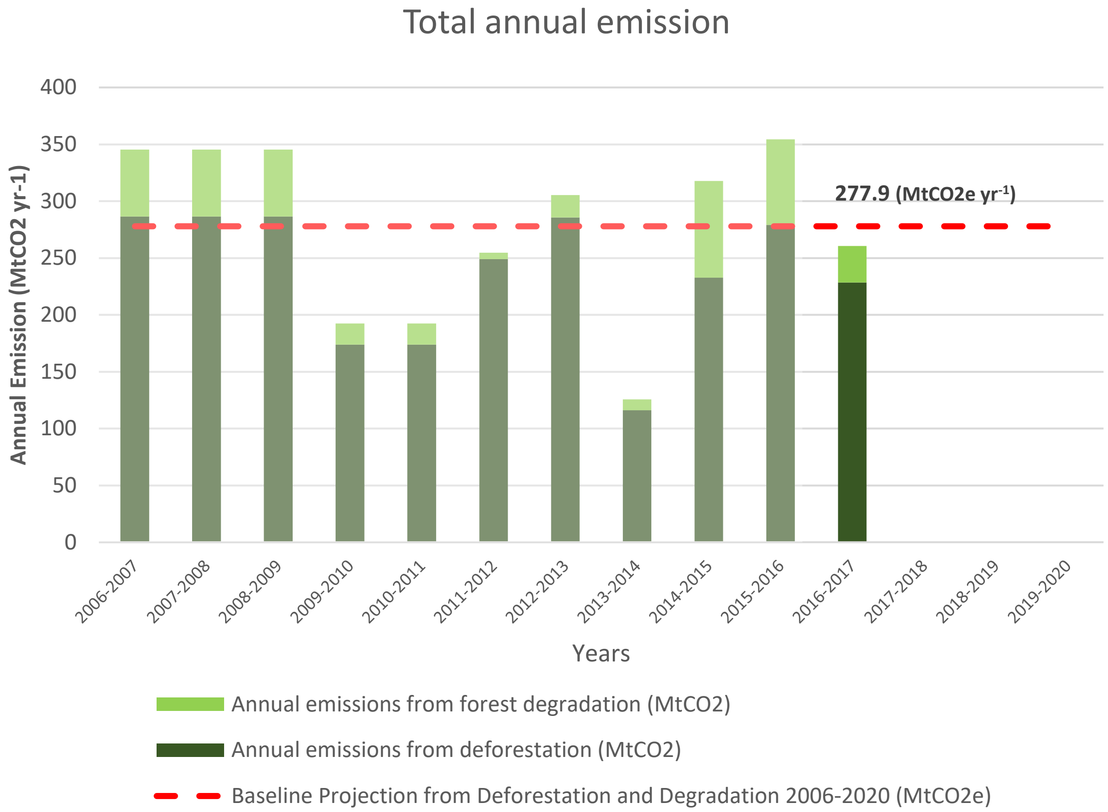

Figure 4. Annual emissions from deforestastion and forest degradation. Pale colours depict historical emissions and green colours depict 2016/2017 emissions

In 2017, Indonesia has reduced 17,278,345 tCO_2-e emission from both avoided deforestation and forest degradation (See Table 5 and Figure 4). Avoided emission from 2016/2017 deforestation is 8,597,888 tCO_2-e (3.6% from the baseline), while emission reduction from forest degradation is about 8,680,457 tCO2-e (21.2%).

4. Description of the National Forest Monitoring System (NFMS) and National Registry System (NRS/SRN)

4.1. National Forest Monitoring System

The Ministry of Forestry of Indonesia (MoF) developed forest resource monitoring through National Forest Inventory (NFI) project of Indonesia, established in 1989 (Margono et al., 2016). The NFI project was executed for years under collaboration of the Government of Indonesia (GOI) and Food and Agriculture Organization (FAO). The use of satellite imagery to produce land cover map, which was pre-dominantly Landsat data, was introduced during the periods of NFI. After termination of the NFI project at around 1997/1998, tasks for operationally mapping land cover were transferred into the Forestry Planning Agency/Directorate General (DG) of Forestry Planning of the Ministry of Forestry. The system is now named National Forest Monitoring System (NFMS), which is based on a regular production of land cover map of Indonesia generated in three years interval, and provided in 23 land cover classes including class of cloud cover and no-data (Figure 5). Example of the Indonesia's land cover map (Figure 6), and the National Forest Monitoring System is available online at http://webgis.menlhk.go.id:8080/nfms_simontana/ for data display, viewing and simple analysis.

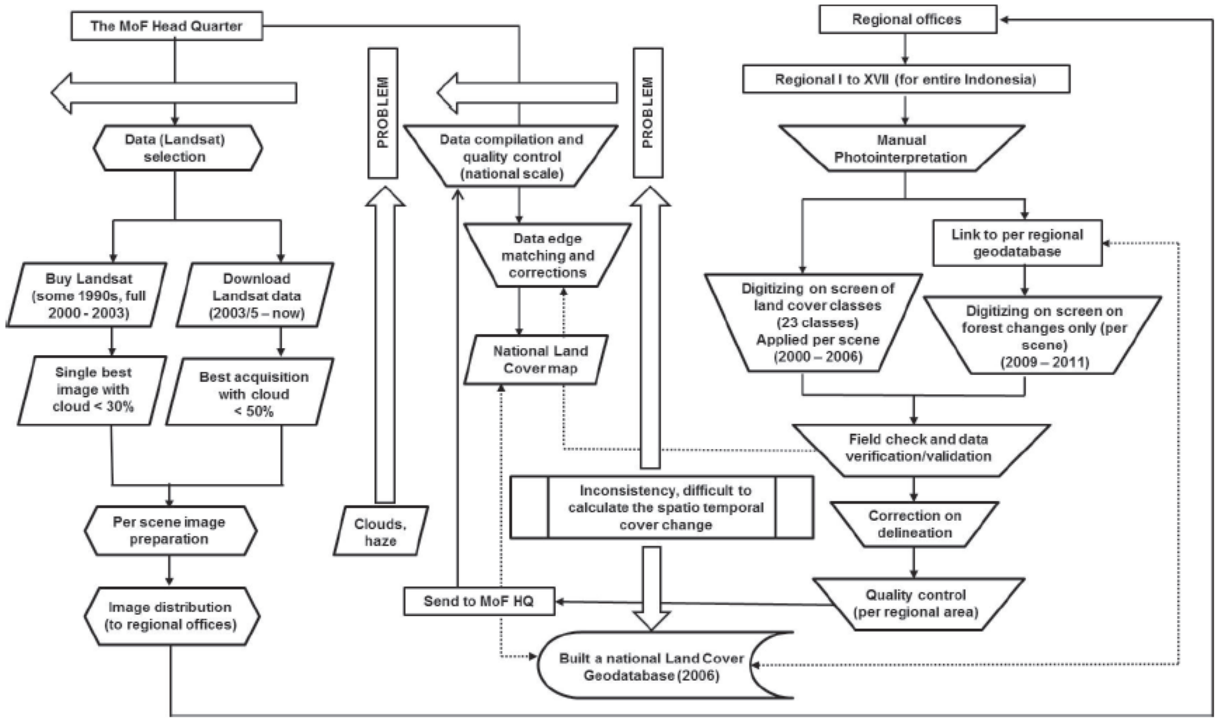

Figure 5. Workflow of forest and land cover mapping in Indonesia

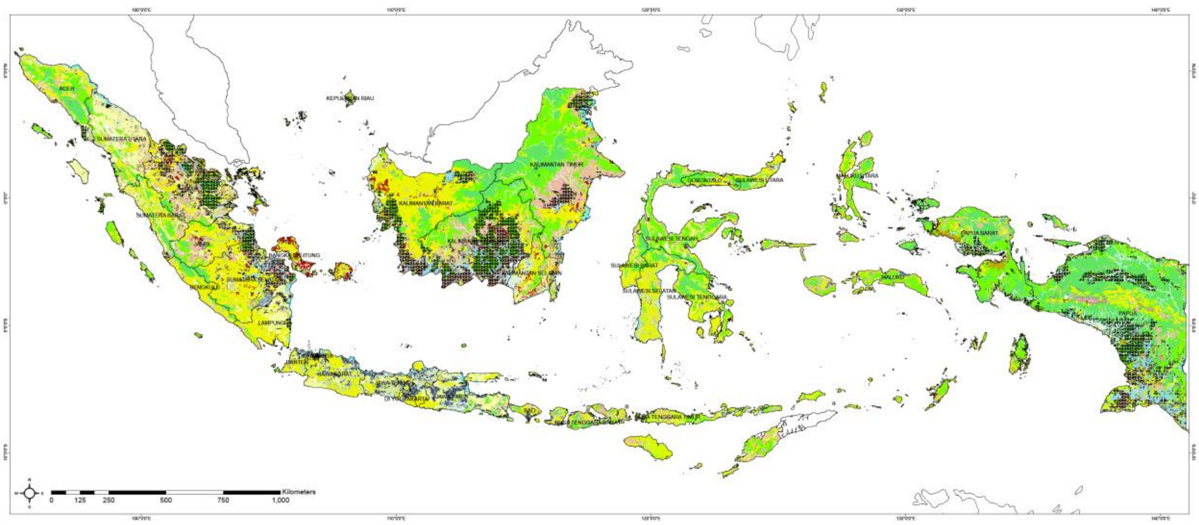

Figure 6. 2009 Forest and land cover map derived using visual interpretation of Landsat imageries.

Landsat 5 Thematic Mapper (TM) and Landsat 7 Enhanced Thematic Mapper Plus (ETM+) have been used as main data source since early 1990s (Margono et al., 2016). In the tropical region such as Indonesia, clouds and haze are major problems of using optical remotely sensed data, including Landsat. Unluckily, unlike Brazil, Indonesia has no seasonal cloud-free window that offering opportunity to capture clouds-free images [Broich et al 2011 in Margono et al., 2016].

The limited cloud-free image coverage and budget constraint restrict data availability for the system. However since 2008, given the change in Landsat data policy, the United States Geological Survey (USGS) has made Landsat data freely available over the internet [Wulder et al, 2012, Roy et al 2010]. Although most of data are available online at around 2009, the policy significantly gives Indonesia a chance and benefit to increase data available for the system. Total Landsat data to cover the entirety of Indonesia within selected year's interval were approximately 218 scenes.

At the end of 2014, the NFMS established MoU with National Space Agency (LAPAN), particularly in Landsat data provision for ensuring the data sustainability of the NFMS. From that point, LAPAN would automatically provide mosaic of Landsat covering Indonesia (mainly OLI and additional ETM+) on regular basis, which at first would be twice a year. The plan is implemented for 2015 onward.

The 23 land cover classes were generated based on physiognomy or appearance of bio-physical covers that visually distinguished by remote sensing data used: Landsat 30 meter spatial resolution. Detail land-cover category is described in Margono et al., 2016. Although in some extent names of land cover classes mixture to land uses, such as forest plantation or estate crops, object identification over the imagery is purely based on existing appearance, not probable cover or land uses. Several ancillary data sets were used for reference during the process of delineation, to catch as much as valuable information for classification.

Visual classification carried out by digitizing on screen technique using key elements of image/photointerpretation. Under standard GIS software, feature with distinctive existing appearance were visually taken, carefully and manually delineated on the screen to create closed polygons and assigned into designated classes (Figure 7**Error! Reference source not found.**). Recommended maximum scale for classification process is 1:100.000 for using only multispectral bands (e.g. band 5-4-3) and 1:50.000 for using panchromatic band for data registration. A minimum unit polygon is 6.25 hectares or equal to 2.5 cm x 2.5 cm at the maximum zoom screen of 1:50.000 scales or 25 hectares at 1:100.000 scales. Right now, the national land cover map of Indonesia is made available at the scale minimum of 1:250.000.

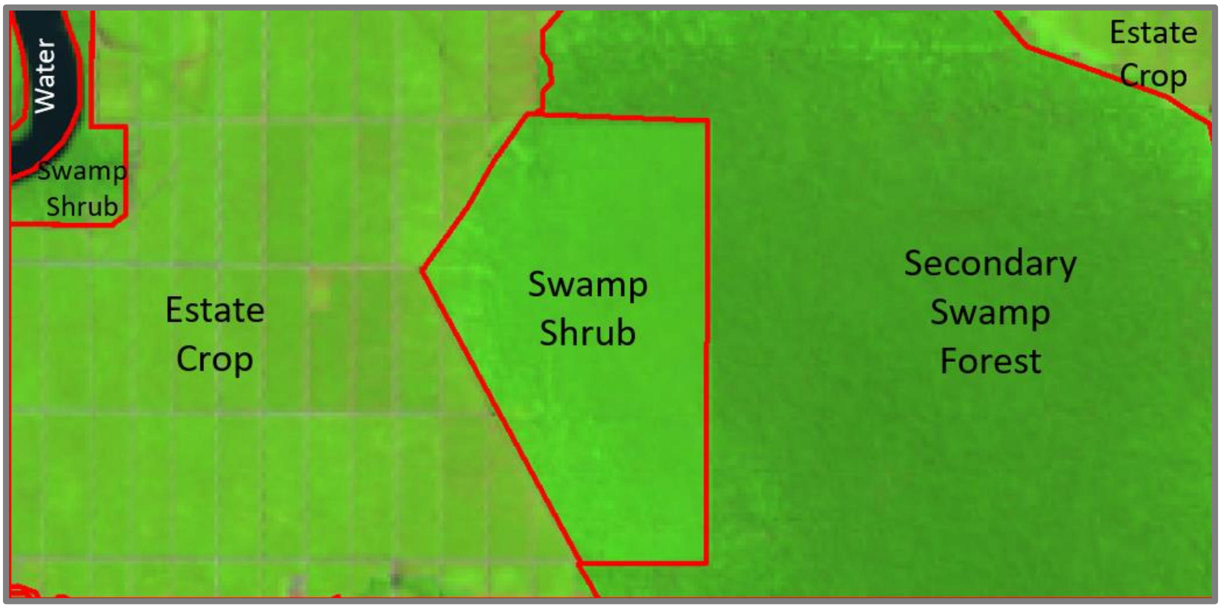

Figure 7. Sample of Landsat image interpretation and classification using visual delineation.

QC/QA for the land-cover data was performed at province level and national level. QC was conducted by BPKH[2]. The interpretation of landsat imageries was also verified using other supporting data, e.g. high-resolution imageries (SPOT) and existing land use maps. Interdependency with previous land cover map was ensured to reduce false classification. During the interpretation process, BPKH carried out ground thruthing for improving accuracy of image interpretation. SOPs on image classification and ground thruthing for operators were developed to ensure consistency and accuracy of the results.

At national level, the Directorate of IPSDH performs QA process using ground-truth points distributed throughout Indonesia. In addition, the assessment of land cover changes uncertainty uses reference data that was generated by using a set of 10,000 of 30x30m grids corresponding to time series of Landsat satellite image pixels (1985-2017). Based on the previous experience, the validation using 5,000 points is sufficient and therefore implemented since 2018 (Figure 8Figure 8). This reference data was selected throughout the country using a simple random sampling technique. The establishment of reference points were also corresponded to other data such as SPOT 6 and 7 satellites from 2013-2016, minimum and maximum values of NDVI, and very high-resolution satellite images from Google Earth.

[2] Balai Pemantapan Kawasan Hutan, the mapping agency at province level who carries out visual interpretation

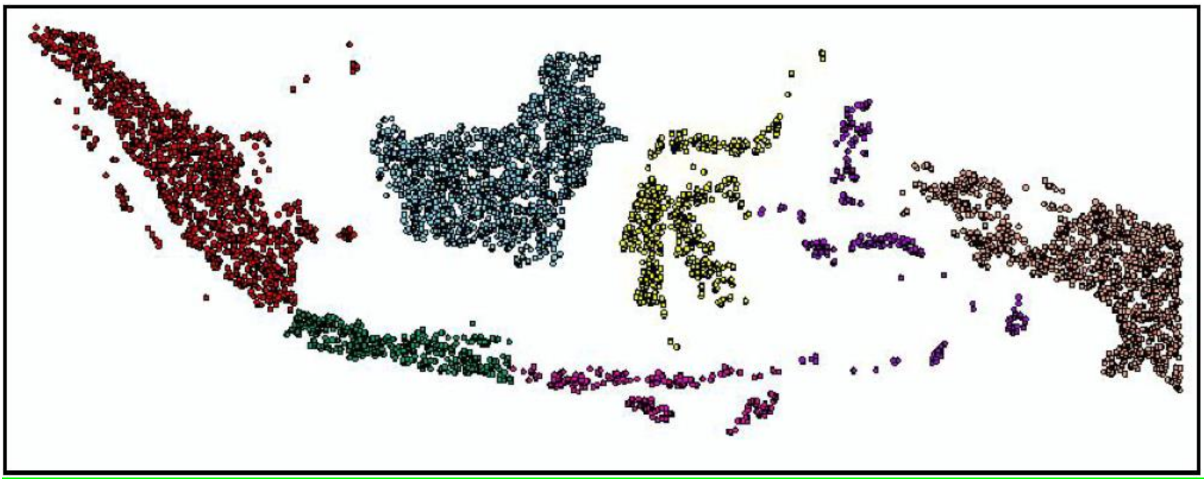

Figure 8. A random sample points were distributed across Indonesia for accuracy assessment

A contingency table or error matrix is a standard form for reporting the accuracy of the image interpretation result. Error matrixes were developed to assess the interpretation accuracy based on the agreement and disagreement between the interpretation results and the reference points for every mapping periods. Further explanation on the QA/QC method can be accessed through below document:

- Indonesian National Standard. 2014. Metode penghitungan perubahan tutupan hutan berdasarkan hasil penafsiran citra penginderaan jauh optik secara visual[3]
- MoEF. 2014. Klasifikasi Penutup Lahan – Bagian 1: Skala kecil dan menengah[4]
- Margono, B. A., Usman, A. B., Budiharto & Sugardiman, R. A. (2016). Indonesia's Forest Resource Monitoring. *The Indonesian Journal of Geography*, *48*(1), 7.[5]
- MoEF. Pedoman penjaminan dan pengendalian mutu (QA/QC) inventarisasi gas rumah kaca Indonesia[6]
- MoEF. 2018. Rekalkulasi Penutupan Lahan Indonesia[7]

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3 http://appgis.menlhk.go.id/appgis/download.aspx?status=view&filename=SNI_2014_8033_Metoda_Penghitungan_Perubahan_Tutupan_Hutan.pdf&fileFullName=E:\webgisapp\Download\Pemantauan%20Hutan%20Nasional\SNI_2014_8033_Metoda_Penghitungan_Perubahan_Tutupan_Hutan.pdf

4 http://appgis.menlhk.go.id/appgis/download.aspx?status=view&filename=SNI-7645-1-2014_Klasifikasi_Penutup_Llahan.pdf&fileFullName=E:\webgisapp\Download\Pemantauan%20Hutan%20Nasional\SNI-7645-1-2014_Klasifikasi_Penutup_Llahan.pdf

5 http://appgis.menlhk.go.id/appgis/download.aspx?status=view&filename=Indonesia%20Forest%20Resource%20Monitoring.pdf&fileFullName=E:\webgisapp\Download\Pemantauan%20Hutan%20Nasional\Indonesia%20Forest%20Resource%20Monitoring.pdf

6 http://ditjenppi.menlhk.go.id/reddplus/images/adminppi/dokumen/Pedoman_QA_QC_FULL_ISBN.pdf

7 http://appgis.menlhk.go.id/appgis/download.aspx?status=view&filename=Rekalkulasi%20Penutupan%20Lahan%2

Table 6. Error matrix for assessing interpretation accuracy of 2018 forest and non forest cover map

			Data Reference						
	No	Kelas Tutupan Lahan	Hutan	Non Hutan	Grand Total	Error of Commission Hutan	User Accuracy Hutan	Error of Commission Non Hutan	User Accuracy Non Hutan
PL Hasil Penafsiran	1	Hutan	2,315	103	2,418	**4.26**	**95.74**		
	2	Non Hutan	148	2,434	2,582			**5.73**	**94.27**
		Grand Total	2,463	2,537	5,000				
		Error of Omission Hutan	**6.01**						
		Producer Accuracy Hutan	**93.99**						
		Error of Omission Non Hutan		**4.06**					
		Producer Accuracy Non Hutan		**95.94**					
		Overall Accuracy	**94.98**						

Remarks: hutan *is forest,* non hutan *is non-forest*

User's and producer's accuracies were calculated for forest and non-forest classes based on the number of correctly interpretated sample points devided by total sample points for each corresponding class. The overall accuracy was calculated based on the total correctly interpreted sample points of all classess devided by total number of sample points (see 2018 sample calculation in Table 6). From table 6, the User's Accuracy for forest classes was calculated as 100* 2,315/2418 and Producer's Accuracy of forest classes was calculated as 100*2,315/2,463. The Overall Accuracy of 2018 forest cover map was calculated as 100*(2,315 + 2,434)/5000, which equals to 94.98%. The summary results of the accuracy assessment for each mappping period was presented in Table 7.

Table 7. Summary of assessment accuracy of activity data

Year	User's Accuracy		Producer's Accuracy		Overall Accuracy
	Forest	Non Forest	Forest	Non Forest	
2006-2007	91.31%	85.36%	86.85%	90.26%	88.42%
2007-2008	91.31%	85.36%	86.85%	90.26%	88.42%
2008-2009	91.31%	85.36%	86.85%	90.26%	88.42%
2009-2010	91.48%	86.35%	86.91%	91.17%	88.94%
2010-2011	91.48%	86.35%	86.91%	91.17%	88.94%
2011-2012	91.33%	87.12%	87.32%	91.26%	89.23%
2012-2013	91.18%	87.68%	87.63%	91.29%	89.43%
2013-2014	91.23%	88.01%	87.76%	91.50%	89.61%
2014-2015	91.03%	88.44%	88.04%	91.42%	89.73%
2015-2016	90.65%	89.06%	88.42%	91.26%	89.86%
2016-2017	90.30%	89.79%	89.00%	91.08%	90.07%

In general, three main problems exist within existing NFMS. Those are (a) presence of persistent clouds cover, (b) inconsistency within the mapping processes, and (c) inability to give near-real time information to match the dynamic recovery of vegetation disturbances. Problems exist due to complex and sometimes conflicting definitions for land cover classification, including

02018.pdf&fileFullName=E:\webgisapp\Download\1.1.%20Buku%20REKALKULASI%20PENUTUPAN%20LAHAN%20INDONESIA\Rekalkulasi%20Penutupan%20Lahan%202018.pdf

forest and deforestation definition. Technically, problems occurred due to lack of adequate data, robust methodologies, and insufficient infrastructure to perform work at a national scale. Adequate data includes timing for data gathering and sufficient pre-processing. Robust methods are linking to rapid needs for supporting carbon monitoring objectives.

The NFMS in a portal is designated to integrate internet ability and forest resource information system in reciprocal (two ways) media information sharing: a step toward the good forest governance, through transparency. As such, information uploaded on NFMS should be maintained, in term of real/near-real time, completeness, and correctness. The current NFMS provides a facility to benefit public participation in updating, correcting, or just commenting the uploaded land cover map. Although currently it might not work as intended, the two ways communication was expected to increase values of correctness, which collected from community in the field as well as from broader users.

4.2. National Registry System on Climate Change (NRS-CC/SRN)

As part of implementation of transparency framework of the Paris Agreement and its translation into the national context, the Ministry of Environment and Forestry of Indonesia through the Directorate General of Climate Change, the NFP of UNFCCC has built “National Registry System on Climate Change” (NRS CC or *Sistem Registri Nasional/SRN*), for collecting action and support on adaptation and mitigation that follows the rules of clarity, transparency and understanding. The development of NRS of CC formed the government recognition to the country contribution in combating climate change in Indonesia, and as efforts to prevent duplication, overlap, double reporting and double counting, as well as prevent the un-synchronization between actions (for adaptation and mitigation). The system intended to register all actions and related supports in order to acknowledge and identify each action related to climate change mitigation and adaptation (Figure 9).

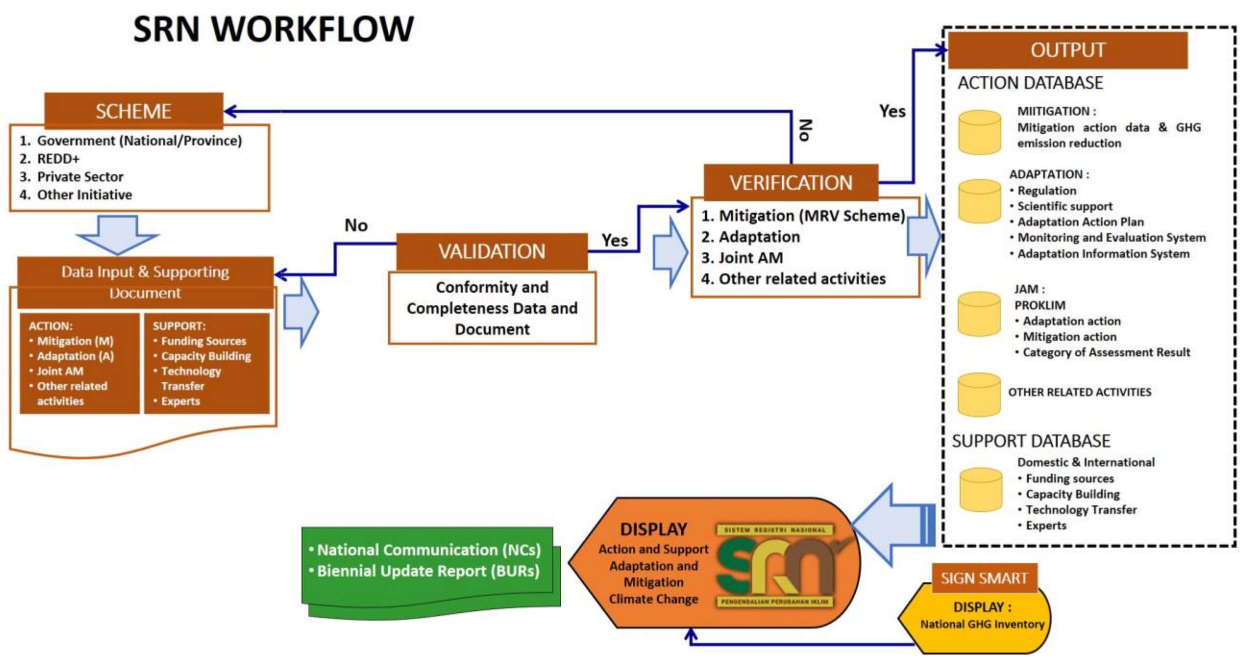

Figure 9. Workflow of the National Registry System of Indonesia.

NRS/SRN is developed to ensure that implementation of climate change mitigation actions at sub-national level, including under the REDD+ scheme, follow the TACCC principals and avoiding double acccounting as part of the implementation Clarity Transparency and Understanding (CTU) principal. NRS/SRN is used as part of requirement to access REDD+ financing through result-based payment at national and sub-national levels. The current NRS/SRN is developed in a way that the project level and sub national implementers are encouraged to register their actions related to emission reduction. This approach has several limitations, including the integration of various field-level initiatives to achieve province level goals in reducing emissions without double accounting and addressing leakages. In accordance with the Law 23/2014, provincial level plays a crucial role in the planning, implementation and ensuring the integration of the regional development. Therefore, SRN will be reviewed and improved in the future as a step-wise approach to match the progressing needs and requirements. Regardless several technical improvements that may still be required, the legal umbrella of the NRS/SRN is Ministerial Regulation 71/2017.

5. Demonstration that Methodologies are Consistent with RBP Baseline

This report used a consistent method as in the Chapter 2 on the development of RBP Baseline. This includes consistency in the methodologies used for generating activity data, emission factors, assumptions, definitions, and procedures for estimating CO_2-e emissions from deforestation and forest degradation.

Below are specific components used for the emission reduction report that are consistent with the methodologies used for generating the RBP baseline:

- The REDD+ activities included in this report were consistent with the RBP Baseline, i.e. the REDD+ activities with most significant emissions (deforestation and forest degradation).
- The activity data used in this report is the annual land cover map that is generated by the NFMS, which is inline with decision 4/CP 15. This land cover map is produced using the same method as in the RBP Baseline.
- The emission factors used in this report source from the same data used from the RBP Baseline and Indonesia 1st FREL.
- The carbon pools presented in this report were above-ground biomass, maintaining the consistency of the same pools as the RBP Baseline.

6. Necessary Information That Allows For The Reconstruction of The Results

For reconstruction of the results, sources of data needed for the reconstruction of the RBP Baseline and the REDD+ results are provided in the following sites:

1. The data of forest cover, deforestation and degradation that were produced from land cover maps (derived from Landsat imageries) through NFMS for 1990, 1996, 2000, 2003, 2006, 2009, 2011, 2012, 2013, 2014, 2015, 2016 & 2017, are accessible online at http://webgis.menlhk.go.id:8080/nfms_simontana/ or http://geoportal.menlhk.go.id/arcgis/rest/services/KLHK
2. Other information related the also can access online at https://geoportal.menlhk.go.id/arcgis/home/
3. Complete information (spatial data and tables) for the provision of data that allows for the reconstruction of the RBP Baseline and results of the REDD+ can be accessed by request.

Detail information related the reconstruction the RBP baseline and result see annex 1.

7. Uncertainty and Plan of Improvement

7.1. Uncertainty Analysis

Uncertainty (U) was calculated following the IPCC 2006 Guidelines, volume 1. Chapter 3. If EA is uncertainty from Activity Data and EE is uncertainty from emission factor from activity j, the combined uncertainty (Uj) is calculated using equation:

$$Uij = \sqrt{EAj^2 + EEj^2} \qquad \text{(Equation 1)}$$

Uncertainties from activity data of forest degradation and deforestation were derived from the overall accuracy assessment of land cover map.

A proportion of accuracy contribution (C_j) was calculated from activity j, by involving the uncertainty (U_j), total emissions occurred in the corresponding activities (E_j) and total emission from the corresponding year (E).

$$C_j = (E_j * U_j)^2 / E \qquad \text{(Equation 2)}$$

$$TU = \sqrt{\sum C_j} \qquad \text{(Equation 3)}$$

Total uncertainty of each year (TU), was derived from a square root of sum C_j.

The uncertainties of emission factor were generated from the standard error of carbon stock values from every forest type/class in each major island/group of islands. The carbon stock was estimated from the NFI plots that have been established in seven major island/group of islands.

The uncertainty for the parameter "activity data" (land cover) is around 9.9% - 11.6%, derived from overall accuracy of forest and land cover mapping. While the uncertainty for the parameter "emission factor" varies from 12.6% - 32.3 % depending on island/group of islands and forest classes. Uncertainty of emission factors from deforestation and forest degradation are generated from the sampling errors of the National Forest Inventory (NFI) from each forest cover class in each island (Annex 4). The detailed results of the uncertainty analysis for each assessment period are shown in the *Table 8* below.

Table 8. Uncertainty calculation for emission from deforestation and forest degradation

Component		Unit	Year										
			2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
Emissions	Deforestation	MtCO2	286.40	286.40	286.40	173.89	173.89	248.94	285.59	116.07	232.68	279.22	228.35
	Forest Degradation	MtCO2	59.23	59.23	59.23	18.51	18.51	5.92	20.40	9.84	85.99	78.66	42.74
	Total emissions	MtCO2	345.63	345.63	345.63	192.40	192.40	254.86	305.98	125.91	318.67	357.89	271.09
Uncertainty of Deforestation	AD uncertainty	%	11.58	11.58	11.58	11.06	11.06	10.77	10.57	10.39	10.27	10.14	9.93
	EF uncertainty	%	17.97	17.97	17.97	17.97	17.97	17.97	17.97	17.97	17.97	17.97	17.97
	Combined uncertainty	%	21.38	21.38	21.38	21.10	21.10	20.95	20.85	20.76	20.70	20.63	20.53
	Contribution to Variance by Category in Year *Base Year*	%	313.84	313.84	313.84	363.73	363.73	418.80	378.67	366.18	228.41	259.17	299.11
	Percentage uncertainty in total inventory:	%	17.72	17.72	17.72	19.07	19.07	20.46	19.46	19.14	15.11	16.10	17.29
Uncertainty of Forest Degradation	AD uncertainty	%	11.58	11.58	11.58	11.06	11.06	10.77	10.57	10.39	10.27	10.14	9.93
	EF uncertainty	%	25.41	25.41	25.41	25.41	25.41	25.41	25.41	25.41	25.41	25.41	25.41
	Combined uncertainty	%	27.93	27.93	27.93	27.72	27.72	27.60	27.53	27.46	27.41	27.36	27.29
	Contribution to Variance by Category in Year *Base Year*	%	22.90	22.90	22.90	7.11	7.11	0.41	3.37	4.60	54.71	36.17	18.51
	Percentage uncertainty in total inventory:	%	4.79	4.79	4.79	2.67	2.67	0.64	1.83	2.15	7.40	6.01	4.30
Total Uncertainty	Percentage uncertainty in total inventory:	**%**	**18.35**	**18.35**	**18.35**	**19.26**	**19.26**	**20.47**	**19.55**	**19.26**	**16.83**	**17.19**	**17.82**
	Uncertainty	MtCO2	63.43	63.43	63.43	37.05	37.05	52.18	59.81	24.24	53.62	61.50	48.31

The uncertainties from 2006 to 2017 were improving from 18.35% in 2006 to 17.82% in 2017, due to the improvement of accuracy of activity data. Uncertainty from the activity data could be from the misinterpretation of satellite imageries by the operators who deliniate the forest and land cover maps. However, this error should be minimized through regular training and coordination and QA/QC process, including development of specific SOP for standardization.

The uncertainties from the emission factors were remained constant because we use all the NFI plot data (1990 – 2014) for estimating carbon stocks of all periods. The uncertanty from emision factors were generated from the sampling error of the NFI, but not incorported the error from allometric equation used for converting NFI measurement data to carbon stock values.

7.2. Plan of improvement

Current analysis, we only include aboveground biomass as the carbon pool, due to the data availability. In the next reporting, it is expected to include other significant carbon pool, such as organic soils from peat fires, peatland degradation and mangrove conversion. This will involve generation of activity data for peat fires, peatland degradation and mangrove conversion. The last two activity data are already available for the baseline periods and will be produce regularly. The peat fire activity data, however, is produced and verified only since 2015. To develop the baseline of peat fires, the activity data started from 2006 are required. As consequences, generating peat fires from 2006 to 2014 is crutial for the imporvement of the GHG accounting and reporting. In addition, the emission factors for those activities are also required, either through compilation of existing research and encouraging more research to fill the gaps.

Potential bias could come from an inapropriate sampling design, which tend to be tendencious and purposive and do not consider the variations of the sub populations. However, the NFI used a systematic sampling approach for plot distribution which avoid purposive sampling. One of the limitations of simple systematic sampling is the potential of small forest and land cover classes to be under representated or not representated at all. This is the case for the mangrove classes and other forest classes in some islands, where none of NFI plots are located. The smaller the number of sample plots, the higher the uncertainty and thus the higher confidence interval of the emissions and emission reduction estimation. Therefore, it is crucial to develop sampling design that represent better all forest classes and all non-forest classes, eventually.

Current uncertainty analysis for the emission factor for deforestation and forest degradation are still using the sampling error of the NFI data only, not include the error from the use of allometric equation. Therefore, the inclusion of error originated from the use of allometric equation should be one of potential activity on comprehensive uncertainty analysis in the future.

The uncertainty analysis of activity data is still using the overal accuracy of forest and land cover interpretation, which doesnt fully represent the actual uncertainty of deforestation and forest degradation. In the future, the uncertainty of activity data of deforestation and forest degradation should be assessed from the forest cover changes related to deforestation and forest degradation.

Improvement of MRV system is crucial to ensure avoiding of double counting and double reporting of emission reduction. The national registry system has been constructed for this purpose. However, technical improvement and infrastructure enhancement are stil required to ensure smooth implementation of the system. In addition, a web-based emission calculation monitoring system is also under construction. This will allow a robust, comprehensive and consistent monitoring system of emission and emission reduction at all level.

8. Proposed Result Based Payment

The result based payment baseline for this first reporting period is based on the annual historical average level of each of the following performance indicators: emissions from deforestation and forest degradation. The results based payment baseline for first reporting period is developed using reference period from 2006/2007 – 2015/2016 and valid up to 2019/2020.

Based on MRV Protocol of Norway and Indonesia Partnership, both Parties has agreed terms to treat statistical uncertainty, reversal risk, and possibly other risk factors inclusion of Indonesia's ambition. This treatment term later simplify called set-asides/deductions has been stated in Annex of MRV Protocol that agreed at final meeting between Indonesia and Norway representatives at 7 February 2019. From the reported emission reduction results, the following set-asides/deductions used to determine the maximum number of emission reductions Indonesia can be rewarded for by Norway. The term of set asides/deductions consist of following detail:

a. From the reported emission reduction results, set-aside/deduction of 20% to reflect the risk of uncertainty in estimates;
b. In terms of deduction to reflect risk of leakage, Indonesia – Norway agreed to not include this deduction due to the baseline and performance of REDD+ in Indonesia – Norway partnership is counted in national level accounting. Therefor, 0% deduction to reflect risk of leakage is set. The 0% deduction from leakage also consistently used in Indonesia

National FREL and REDD+ Performance in 2nd BUR that has been submitted to the UNFCCC as Indonesia approach for implementation REDD+ is in National Level;

c. In terms of to reflect Indonesia's ambition to reduce national GHG emissions, Indonesia and Norway agreed to deduct 15%.

As systems are developed over time and policies and strategies are put in place to reduce uncertainty risk, risk of leakage, and reflection of Indonesia's ambition, the set aside factor can be reduced. For the first reporting period under the Indonesia – Norway agreement, the total set aside factor of 35% will be applied.

As mentioned on Chapter Results, Indonesia has reduced the emission from deforestation and forest degradation in total amounted to 17,278,345 tCO_2-e. It comprises of 8,597,888 tCO_2-e from reduce deforestation and 8,680,457 tCO_2-e from forest degradation. The emission reduction results later deducted 35%. Therefor, Indonesia propose Net results amounted to 11,230,924 tCO_2-e shall be rewarded by Norway for first RBP.

References

Ballhorn, U., Siegert, F., Mason, M. and Limin, S. 2009 Derivation of burn scar depths and estimation of carbon emissions with LIDAR in Indonesian peatlands. *Proceedings of the National Academy of Sciences of the United States of America*, 106 (50), 21213-21218.

IPCC. 2014. 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands, Hiraishi, T., Krug, T., Tanabe, K., Srivastava, N., Baasansuren, J., Fukuda, M. and Troxler, T.G. (eds). Published: IPCC, Switzerland.

Konecny, K., Ballhorn, U., Navratil, P., Jubanski, J., Page, S.E., Tansey, K., Hooijer, A., Vernimmen, R. and Siegert, F. 2016. *Variable carbon losses from recurrent fires in drained tropical peatlands*. Global Change Biology 22, pp. 1469–1480.

Margono, B.A., Usman, A.B., Budiharto, Sugardiman, R.A. 2016. Indonesia's Forest Resource Monitoring. Indonesian Journal of Geography 48, 7. https://doi.org/10.22146/ijg.12496.

MoEF. 2018. Indonesia Second Biennial Report - Under UNFCCC. http://ditjenppi.menlhk.go.id/reddplus/images/adminppi/dokumen/Indonesia-2nd_BUR_web.pdf.

MoEF. 2018. MRV Protocol for The Indonesia-Norway Partnership on Climate, Forests and Peat. http://ditjenppi.menlhk.go.id/reddplus/images/adminppi/dokumen/MRV-protocol_final.pdf.

MoEF. 2016. National Forest Reference Emission Level For Deforestation And Forest Degradation. http://ditjenppi.menlhk.go.id/reddplus/images/resources/frel/FREL-Submission-by-Indonesia-2016.pdf.

MoFor. 2004. *Peraturan Menteri Kehutanan Nomor: P.14/Menhut-II/2004 Tentang Tata Cara Aforestasi dan Reforestasi Dalam Kerangka Mekanisme Pembangunan Bersih*. (p. 1. article 1). Ministry of Forestry. Jakarta.

MRI 2013. *Green House Gas Reduction Project through Forest Conservation in Peat land in Central Kalimantan*: Mitsubishi Research Institute, Inc.

Mulyani, et al. 2012. *Basis Data Karakteristik Tanah Gambut Di Indonesia*. Prosiding Seminar Nasional Pengelolaan Lahan Gambut Berkelanjutan 4 Mei 2012: From http://balittanah.litbang.deptan.go.id

Annex 1. The Calculation of Emission from Deforestation and Forest Degradation

Deforestation and forest degradation emission was calculated using the following equation:

$$GE_{ij} = A_{ij} \times EF_j \quad (1)$$

Where GE_{ij} = CO_2 emissions from deforested or forest degraded area-i at forest change class-j, in tCO2-e e. A_{ij} = deforested or forest degradation area-i in forest change class j, in hectares (ha). EF_j = Emission Factor from the loss of carbon stock due to change of forest class-j, owing to deforestation or forest degradation; in tons carbon per ha (tC ha^{-1}). Emission factor from deforestation and forest degradatiaon see table annex 1.1 and table annex 1.2 respectivly.
Emission from deforestation and forest degradation at period t (GE_t) was estimated using the following equation:

$$GE_t = \sum_{i=1}^{N} \sum_{j=1}^{P} GE_{ij} \quad (2)$$

Where, GE_t written in tCO2-e , GE_{ij} is emission from deforested or degraded forest area-i in forest class j expressed in tCO2-e . N is the number of deforested or degraded forest area unit at period t (from t_0 to t_1), expressed without unit. P is the number of forest classes, which meet natural forest criterion.

Table Annex 1.1. Deforestation Emission Factor

Forest Classes	Emission Factors of Deforestation (tCO2-e -e)						
	JAWA	KALIMANTAN	MALUKU	NUSA BALI	PAPUA	SULAWESI	SUMATERA
Primary Dryland Forest	458.8	464.7	519.9	473.3	412.4	474.7	463.3
Secondary Dryland Forest	294.1	350.7	383.1	280.6	311.2	356.2	314.3
Primary Mangrove Forest	455.2	455.2	455.2	455.2	455.2	455.2	455.2
Secondary Mangrove Forest	348.0	348.0	348.0	348.0	348.0	348.0	348.0
Primary Swamp Forest	332.5	474.0	332.5	332.5	308.4	369.8	380.9
Secondary Swamp Forest	274.8	294.1	274.8	274.8	251.3	221.3	261.1

*) If not avaialable data for the emission factor by island, used National Average

Table Annex 1.2. Forest Degradation Emission Factor

Forest Classes	Emission Factors of Forest Degradation (tCO2-e -e)						
	JAWA	KALIMANTAN	MALUKU	NUSA BALI	PAPUA	SULAWESI	SUMATERA
Primary Dryland Forest	164.7	114.0	136.8	192.7	101.3	118.5	149.0
Primary Mangrove Forest	107.3	107.3	107.3	107.3	107.3	107.3	107.3
Primay Swamp Forest	57.6	179.9	57.6	57.6	57.1	148.5	119.7

*) If not avaialable data for the emission factor by island, used National Average

The estimation of emission from deforestation and forest degradation from the loss of above-ground biomass between two years used the land use transition matrix (LUTM). LUTM derived from the spatial analysis of series of land cover maps, for example series years : 2012 - 2013. Table annex 1.4 provides an example of LUTM transition matrix for the period 2012 - 2013. The emissions from the change of forest change class-j to non-forest classes were calculated using the equation (1). For example, to calculate the emissions from deforestation from primary dryland forest (class code 2001) (GE_{2001}) in tCO2-e e, we used the equation (3). Detail class code for the land cover data see table annex 1.3.

$$GE_{2001} = AD * EF \quad (3)$$

Where *AD* is the change of primary dryland forests (code 2001) to non-forests in the period in hectare; and *EF* is the emission factor for deforestation of the corresponding class in ton CO_2e/ha (see Table annex 1.4 and 1.5 presents the example of the emission matrix from deforestation of all forest classes in 2012-2013).

Table Annex 1.3. Land cover classes used in the Forest Reference Emission Level

No	Land-cover class	Class Code	Abbreviation
1.	Primary dryland forest	2001	PF
2.	Secondary dryland forest	2002	SF
3.	Primary mangrove forest	2004	PMF
4.	Secondary mangrove forest	20041	SMF
5.	Primary swamp forest	2005	PSF
6.	Secondary swamp forest	20051	SSF
7.	Plantation forest	2006	TP
8.	Estate crop	2010	EP
9.	Pure dry agriculture	2009	AUA
10.	Mixed dry agriculture	20091	MxUA
11.	Dry shrub	2007	Sr
12.	Wet shrub	20071	SSr
13.	Savanna and Grasses	3000	Sv
14.	Paddy Field	20093	Rc
15.	Open swamp	50011	Sw
16.	Fish pond/aquaculture	20094	Po
17.	Transmigration areas	20122	Tr
18.	Settlement areas	2012	Se
19.	Port and harbor	20121	Ai
20.	Mining areas	20141	Mn
21.	Bare ground	2014	Br
22.	Open water	5001	WB
23.	Clouds and no-data	2500	Ot

Emissions from the deforestation of other forest classes use similar equation with corresponding emission factors. Therefore the total emission from deforestation of all different forest classes is estimated using the equation (4):

$$GE_t = GE_{2001}+GE_{2002}+ GE_{2004}+GE_{2005}+ GE_{20041}+GE_{20051} \quad (4)$$

Table Annex 1.4. An example of land use transition matrix of deforestation in the period of 2012-2013 in Kalimantan (in hectares).

LC Class		LC 2012 (ha)						
		2001	2002	2004	20041	2005	20051	Grand Total
LC 2013 (ha)	2006		697				11,729	12,426
	2007	2,034	118,209		23		1,390	121,656
	2010		17,445		495		26,903	44,842
	2012		192					192
	2014	999	44,711		1,298	2,632	99,371	149,011
	20071		48	590	2,778	2,047	60,049	65,511
	20091	188	1,653		580		1,602	4,023
	20092	7,868	80,696				1,015	89,579
	20094				735		1,454	2,189
	20122		330					330
	20141		2,852	3	41		1,321	4,217
	50011						104	104
	Grand Total	**11,088**	**266,834**	**593**	**5,949**	**4,678**	**204,939**	**494,080**

Table Annex 1.5. An example of CO2 emission matrix from deforestation due to loss of above-ground biomass in the period 2012-2013 in Kalimantan (in tCO2-e e).

LC Class		LC 2012 (tCO2.e)						
		2001	2002	2004	20041	2005	20051	Grand Total
LC 2013 (tCO2.e)	2006	-	244,449	-	-	-	3,449,418	3,693,867
	2007	944,955	41,452,653	-	7,901	-	408,842	42,814,351
	2010	-	6,117,329	-	172,360	-	7,911,904	14,201,592
	2012	-	67,489	-	-	-	-	67,489
	2014	464,345	15,679,014	-	451,519	1,247,344	29,224,561	47,066,784
	20071	-	16,839	268,511	966,443	970,080	17,660,033	19,881,905
	20091	87,173	579,770	-	201,775	-	471,260	1,339,978
	20092	3,656,008	28,297,707	-	-	-	298,588	32,252,304
	20094	-	-	-	255,731	-	427,677	683,408
	20122	-	115,716	-	-	-	-	115,716
	20141	-	1,000,177	1,201	14,160	-	388,615	1,404,153
	50011	-	-	-	-	-	30,615	30,615
	Grand Total	**5,152,481**	**93,571,144**	**269,711**	**2,069,890**	**2,217,425**	**60,271,513**	**163,552,163**

For the calculation purposes LUTM as shown in table annex 1.3 summarized by islands, land cover classes and by year period. Detail information for emission from deforestation and forest degradation calculation see table annex 1.6 – 1.9

Table annex 1.6. Activity Data for Deforestation

Island/Soil/ Land Cover	Deforestation (ha)							
	2006-2009	2009-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
SUMATERA	**1,420,549**	**502,062**	**367,706**	**307,579**	**151,461**	**210,212**	**213,258**	**152,982**
PEAT	**433,076**	**204,652**	**108,510**	**82,362**	**65,608**	**90,962**	**32,841**	**28,392**
Primary Dryland Forest							613	24
Secondary Dryland Forest	14,920	2,708	3,691	512	314	986		228
Primary Mangrove Forest	0					10	15	1
Secondary Mangrove Forest	751	1,087	547	50	38	421	654	262
Primary Swamp Forest	37,901	10,757	5,678	5,163	1,110	9,949	10,712	703
Secondary Swamp Forest	379,503	190,100	98,595	76,637	64,146	79,596	20,846	27,174
MINERAL	**987,473**	**297,410**	**259,195**	**225,217**	**85,854**	**119,250**	**180,417**	**124,591**
Primary Dryland Forest	8,063	7,871	7,300	7,479	8,628	2,429	22,229	14,231
Secondary Dryland Forest	752,153	181,813	202,431	188,383	57,801	83,576	128,923	91,871
Primary Mangrove Forest	1,043	110	715	145	4	1,400	1,316	901
Secondary Mangrove Forest	24,441	2,906	5,485	1,894	1,508	4,865	11,195	6,893
Primary Swamp Forest	5,001	236	134	492	23	1,044	3,983	155
Secondary Swamp Forest	196,772	104,473	43,130	26,823	17,889	25,935	12,771	10,539
KALIMANTAN	**1,021,058**	**458,046**	**292,796**	**494,080**	**154,089**	**348,008**	**423,404**	**315,302**
PEAT	**234,606**	**99,684**	**52,164**	**127,764**	**23,146**	**172,957**	**90,678**	**24,439**
Primary Dryland Forest					16		367	
Secondary Dryland Forest	5,580	1,407	2,054	3,973	184	322		415
Primary Mangrove Forest		213					0	
Secondary Mangrove Forest	341	19	66	159	20	106	19	210
Primary Swamp Forest	3,837	2,058	339	4,556	503	3,446	9	333
Secondary Swamp Forest	224,847	95,987	49,704	119,076	22,423	169,082	90,282	23,480
MINERAL	**786,452**	**358,362**	**240,632**	**366,317**	**130,944**	**175,051**	**332,726**	**290,863**
Primary Dryland Forest	2,968	362	6,968	11,088	1,967	1,870	5,504	1,632
Secondary Dryland Forest	584,102	273,274	194,914	262,861	106,896	113,193	241,082	256,555
Primary Mangrove Forest	493	133	164	593	10	116	452	244
Secondary Mangrove Forest	22,061	3,608	8,768	5,791	3,828	5,674	11,547	7,608
Primary Swamp Forest	3,237	7	600	122	28	516	577	170
Secondary Swamp Forest	173,591	80,977	29,219	85,863	18,214	53,682	73,563	24,654
PAPUA	**115,232**	**31,876**	**43,003**	**23,880**	**22,309**	**81,321**	**17,323**	**51,129**
PEAT	**11,987**	**1,729**	**1,039**	**590**	**1,556**	**4,201**	**1,459**	**2,240**
Primary Dryland Forest	48	229	590		75	254	98	364
Secondary Dryland Forest	1,848	1,359	298	304	473	1,490	740	1,006
Primary Mangrove Forest	52		37	22		18	0	42
Secondary Mangrove Forest	212	10	49			0	0	40
Primary Swamp Forest	4,911	105	66	264	642	1,309	271	788
Secondary Swamp Forest	4,916	25			366	1,130	350	
MINERAL	**103,246**	**30,147**	**41,964**	**23,290**	**20,753**	**77,121**	**15,863**	**48,889**
Primary Dryland Forest	17,442	14,118	9,116	3,892	5,654	19,268	4,820	14,659
Secondary Dryland Forest	69,499	9,952	22,597	16,312	11,243	34,274	9,438	32,327
Primary Mangrove Forest	49	88	173		599	1,276	0	134
Secondary Mangrove Forest	372	339	238	106	31	165	0	201
Primary Swamp Forest	8,403	4,974	1,532	1,931	1,129	4,859	1,422	1,513
Secondary Swamp Forest	7,481	677	8,308	1,049	2,097	17,279	183	56
SULAWESI	**140,533**	**74,658**	**19,448**	**46,192**	**16,950**	**56,839**	**91,981**	**77,842**
MINERAL	**140,533**	**74,658**	**19,448**	**46,192**	**16,950**	**56,839**	**91,981**	**77,842**
Primary Dryland Forest	4,327	18,996	1,892	6,782	1,729	6,727	17,285	6,417
Secondary Dryland Forest	121,052	54,885	17,268	38,410	14,080	47,488	68,042	65,222
Primary Mangrove Forest	193	116		60	200	60	619	270
Secondary Mangrove Forest	3,722	556	223	860	708	2,221	5,131	4,247
Primary Swamp Forest						91		3
Secondary Swamp Forest	11,239	105	65	80	233	251	904	1,683
JAWA	**13,244**	**6,100**	**1,294**	**4,349**	**12,976**	**4,495**	**5,015**	**29,863**
MINERAL	**13,244**	**6,100**	**1,294**	**4,349**	**12,976**	**4,495**	**5,015**	**29,863**
Primary Dryland Forest	84	150				81		7
Secondary Dryland Forest	6,377	5,943	1,294	3,068	12,950	4,414	5,008	29,812
Primary Mangrove Forest							8	
Secondary Mangrove Forest	6,783	7		1,280	26		0	43
Primary Swamp Forest								
Secondary Swamp Forest								
BALI NUSA	**4,877**	**3,612**	**55,092**	**906**	**1,308**	**18,630**	**30,394**	**9,332**
MINERAL	**4,877**	**3,612**	**55,092**	**906**	**1,308**	**18,630**	**30,394**	**9,332**
Primary Dryland Forest	190	146	1,409		12	729	3,437	623
Secondary Dryland Forest	4,687	3,194	52,111	864	1,288	17,512	24,493	8,664
Primary Mangrove Forest		157	1,569			302	779	10
Secondary Mangrove Forest		115	3	42	9	87	1,684	34
Primary Swamp Forest								
Secondary Swamp Forest								
MALUKU	**25,965**	**24,687**	**6,713**	**7,001**	**3,962**	**16,780**	**44,391**	**37,388**
MINERAL	**25,965**	**24,687**	**6,713**	**7,001**	**3,962**	**16,780**	**44,391**	**37,388**
Primary Dryland Forest	309	1,732	10	10	0	599	4,476	1,033
Secondary Dryland Forest	25,371	21,911	6,590	6,607	3,864	15,903	36,478	33,612
Primary Mangrove Forest	188	1	112	60	75	11	782	650
Secondary Mangrove Forest	48	22		324	22	225	2,522	1,449
Primary Swamp Forest						41	63	23
Secondary Swamp Forest	50	1,021					70	622
Grand Total	**2,741,459**	**1,101,040**	**786,052**	**883,986**	**363,056**	**736,285**	**825,766**	**673,838**
Annual Rate	**913,820**	**550,520**	**786,052**	**883,986**	**363,056**	**736,285**	**825,766**	**673,838**

Table annex 1.7. Emission from Deforestation

Island/Soil/ Land Cover	2006-2009	2009-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
SUMATERA	**420,882,182**	**144,191,518**	**109,810,531**	**92,745,264**	**44,656,358**	**61,928,920**	**70,204,885**	**48,624,595**
PEAT	**118,492,743**	**54,970,845**	**29,260,718**	**22,158,417**	**17,286,313**	**25,036,717**	**10,042,386**	**7,538,496**
Primary Dryland Forest	-	-	-	-	-	-	284,071	11,246
Secondary Dryland Forest	4,689,089	851,204	1,159,915	160,932	98,741	309,837	-	71,661
Primary Mangrove Forest	39	-	-	-	-	4,745	7,015	357
Secondary Mangrove Forest	261,406	378,024	190,143	17,394	13,235	146,370	227,532	91,083
Primary Swamp Forest	14,434,966	4,097,021	2,162,697	1,966,415	422,655	3,789,269	4,079,744	267,610
Secondary Swamp Forest	99,107,243	49,644,596	25,747,962	20,013,676	16,751,682	20,786,496	5,444,024	7,096,538
MINERAL	**302,389,438**	**89,220,674**	**80,549,813**	**70,586,846**	**27,370,045**	**36,892,202**	**60,162,499**	**41,086,099**
Primary Dryland Forest	3,735,588	3,646,567	3,382,225	3,465,079	3,997,422	1,125,595	10,298,983	6,593,370
Secondary Dryland Forest	236,384,152	57,139,657	63,619,388	59,204,427	18,165,666	26,265,891	40,517,552	28,873,039
Primary Mangrove Forest	474,688	50,142	325,256	66,047	1,841	637,500	598,946	410,252
Secondary Mangrove Forest	8,503,364	1,011,110	1,908,429	659,099	524,605	1,692,583	3,894,736	2,398,092
Primary Swamp Forest	1,904,686	90,033	51,183	187,292	8,709	397,743	1,517,033	59,002
Secondary Swamp Forest	51,386,961	27,283,165	11,263,332	7,004,902	4,671,802	6,772,889	3,335,249	2,752,345
KALIMANTAN	**336,714,580**	**150,933,959**	**99,113,242**	**163,552,163**	**52,017,855**	**110,131,295**	**139,963,547**	**108,096,256**
PEAT	**70,020,849**	**29,801,783**	**15,521,872**	**38,627,658**	**6,911,762**	**51,509,668**	**26,733,427**	**7,281,983**
Primary Dryland Forest	-	-	-	-	7,352	-	170,762	-
Secondary Dryland Forest	1,956,875	493,569	720,310	1,393,281	64,510	113,016	-	145,684
Primary Mangrove Forest	-	96,788	-	-	-	-	0	-
Secondary Mangrove Forest	118,793	6,584	22,872	55,243	6,915	36,931	6,676	73,156
Primary Swamp Forest	1,818,590	975,570	160,870	2,159,536	238,517	1,633,405	4,475	157,742
Secondary Swamp Forest	66,126,590	28,229,273	14,617,820	35,019,598	6,594,467	49,726,316	26,551,513	6,905,401
MINERAL	**266,693,731**	**121,132,175**	**83,591,369**	**124,924,505**	**45,106,093**	**58,621,626**	**113,230,120**	**100,814,272**
Primary Dryland Forest	1,379,197	168,346	3,237,846	5,152,481	914,135	868,794	2,557,852	758,506
Secondary Dryland Forest	204,828,256	95,829,702	68,350,879	92,177,862	37,485,591	39,693,652	84,540,815	89,966,547
Primary Mangrove Forest	224,379	60,734	74,550	269,711	4,741	52,851	205,909	111,066
Secondary Mangrove Forest	7,675,249	1,255,133	3,050,467	2,014,647	1,331,642	1,974,199	4,017,414	2,646,952
Primary Swamp Forest	1,534,207	3,290	284,575	57,889	13,289	244,571	273,593	80,496
Secondary Swamp Forest	51,052,443	23,814,970	8,593,053	25,251,915	5,356,695	15,787,558	21,634,538	7,250,706
PAPUA	**36,885,172**	**11,340,989**	**13,903,291**	**7,763,040**	**7,456,990**	**26,355,226**	**5,851,738**	**17,455,455**
PEAT	**3,442,138**	**559,776**	**390,042**	**186,171**	**467,894**	**1,264,206**	**442,373**	**739,074**
Primary Dryland Forest	19,763	94,536	243,141	-	30,771	104,686	40,496	149,924
Secondary Dryland Forest	575,023	423,014	92,586	94,537	147,045	463,563	230,388	313,153
Primary Mangrove Forest	23,506	-	16,751	10,182	-	8,241	0	18,957
Secondary Mangrove Forest	73,773	3,527	17,207	-	-	1	0	14,058
Primary Swamp Forest	1,514,477	32,378	20,357	81,452	198,043	403,850	83,632	242,983
Secondary Swamp Forest	1,235,595	6,322	-	-	92,036	283,865	87,857	-
MINERAL	**33,443,034**	**10,781,212**	**13,513,250**	**7,576,869**	**6,989,095**	**25,091,020**	**5,409,366**	**16,716,380**
Primary Dryland Forest	7,193,579	5,822,406	3,759,747	1,605,167	2,331,955	7,946,769	1,987,875	6,045,666
Secondary Dryland Forest	21,626,292	3,096,742	7,031,483	5,075,787	3,498,439	10,665,161	2,936,697	10,059,389
Primary Mangrove Forest	22,237	39,936	78,800	-	272,711	580,803	49	60,950
Secondary Mangrove Forest	129,410	118,113	82,816	36,715	10,637	57,317	0	69,838
Primary Swamp Forest	2,591,521	1,533,952	472,547	595,489	348,343	1,498,536	438,648	466,502
Secondary Swamp Forest	1,879,994	170,062	2,087,856	263,710	527,011	4,342,434	46,096	14,034
SULAWESI	**49,041,911**	**28,836,236**	**7,141,021**	**17,244,815**	**6,224,807**	**20,997,633**	**34,707,808**	**28,251,709**
MINERAL	**49,041,911**	**28,836,236**	**7,141,021**	**17,244,815**	**6,224,807**	**20,997,633**	**34,707,808**	**28,251,709**
Primary Dryland Forest	2,054,188	9,017,254	898,220	3,219,442	820,936	3,193,482	8,204,968	3,046,245
Secondary Dryland Forest	43,117,649	19,549,660	6,150,751	13,681,195	5,015,265	16,914,895	24,235,884	23,231,447
Primary Mangrove Forest	88,022	52,618	-	27,197	90,937	27,260	281,605	122,898
Secondary Mangrove Forest	1,294,770	193,432	77,749	299,243	246,171	772,849	1,785,221	1,477,498
Primary Swamp Forest	-	-	-	-	-	33,663	-	1,073
Secondary Swamp Forest	2,487,282	23,271	14,302	17,738	51,498	55,485	200,130	372,547
JAWA	**4,274,082**	**1,819,026**	**380,515**	**1,347,847**	**3,817,678**	**1,335,354**	**1,476,122**	**8,785,953**
MINERAL	**4,274,082**	**1,819,026**	**380,515**	**1,347,847**	**3,817,678**	**1,335,354**	**1,476,122**	**8,785,953**
Primary Dryland Forest	38,730	68,806	-	-	-	37,155	-	3,440
Secondary Dryland Forest	1,875,450	1,747,742	380,515	902,375	3,808,571	1,298,199	1,472,697	8,767,708
Primary Mangrove Forest	-	-	-	-	-	-	3,416	-
Secondary Mangrove Forest	2,359,902	2,477	-	445,472	9,106	-	9	14,805
Primary Swamp Forest	-	-	-	-	-	-	-	-
Secondary Swamp Forest	-	-	-	-	-	-	-	-
BALI NUSA	**1,405,503**	**1,076,959**	**16,006,617**	**257,241**	**370,065**	**5,427,462**	**9,441,214**	**2,742,924**
MINERAL	**1,405,503**	**1,076,959**	**16,006,617**	**257,241**	**370,065**	**5,427,462**	**9,441,214**	**2,742,924**
Primary Dryland Forest	90,165	68,980	666,880	-	5,528	345,190	1,626,904	294,696
Secondary Dryland Forest	1,315,338	896,307	14,624,485	242,544	361,353	4,914,636	6,873,880	2,431,600
Primary Mangrove Forest	-	71,681	714,117	-	-	137,269	354,402	4,641
Secondary Mangrove Forest	-	39,991	1,134	14,697	3,184	30,367	586,028	11,987
Primary Swamp Forest	-	-	-	-	-	-	-	-
Secondary Swamp Forest	-	-	-	-	-	-	-	-
MALUKU	**9,995,913**	**9,583,027**	**2,581,184**	**2,676,169**	**1,522,479**	**6,501,164**	**17,575,275**	**14,392,008**
MINERAL	**9,995,913**	**9,583,027**	**2,581,184**	**2,676,169**	**1,522,479**	**6,501,164**	**17,575,275**	**14,392,008**
Primary Dryland Forest	160,574	900,288	5,386	5,101	0	311,499	2,326,890	536,952
Secondary Dryland Forest	9,719,546	8,394,018	2,524,810	2,531,081	1,480,491	6,092,518	13,974,744	12,876,639
Primary Mangrove Forest	85,622	465	50,988	27,130	34,367	5,072	356,021	295,933
Secondary Mangrove Forest	16,528	7,625	-	112,858	7,622	78,379	877,365	504,171
Primary Swamp Forest	-	-	-	-	-	13,696	20,904	7,483
Secondary Swamp Forest	13,643	280,630	-	-	-	-	19,351	170,831
Grand Total	**859,199,342**	**347,781,714**	**248,936,401**	**285,586,539**	**116,066,230**	**232,677,053**	**279,220,589**	**228,348,899**
Annual Rate	**286,399,781**	**173,890,857**	**248,936,401**	**285,586,539**	**116,066,230**	**232,677,053**	**279,220,589**	**228,348,899**

Table annex 1.8. Activity Data for Forest Degradation

Island/Soil/ Land Cover	Forest Degradation (ha)							
	2006-2009	2009-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
SUMATERA	**70,409**	**45,449**	**2,346**	**14,795**	**1,166**	**39,162**	**227,384**	**36,232**
PEAT	**33,571**	**15,421**	**2,228**	**2,551**	**248**	**529**	**23,427**	**70**
Primary Dryland Forest								
Primary Mangrove Forest	258					381	81	7
Primary Swamp Forest	33,313	15,421	2,228	2,551	248	149	23,346	63
MINERAL	**36,838**	**30,028**	**118**	**12,244**	**917**	**38,633**	**203,957**	**36,162**
Primary Dryland Forest	3,595	24,465	26	1,230	774	26,598	185,991	33,951
Primary Mangrove Forest	28,134	2,939		600		11,494	3,536	1,965
Primary Swamp Forest	5,109	2,624	93	10,414	144	541	14,431	246
KALIMANTAN	**70,608**	**18,019**	**10,210**	**4,720**	**37,644**	**163,874**	**74,153**	**88,301**
PEAT	**740**	**166**	**10,210**	**434**	**1,209**	**9,064**	**1,569**	**3,223**
Primary Dryland Forest			10,210			37		
Primary Mangrove Forest					75			1,330
Primary Swamp Forest	740	166		434	1,135	9,027	1,569	1,893
MINERAL	**69,868**	**17,853**		**4,285**	**36,434**	**154,810**	**72,584**	**85,078**
Primary Dryland Forest	67,975	17,713		3,126	35,782	145,534	70,604	81,100
Primary Mangrove Forest	1,887			284	442	238	1,288	3,649
Primary Swamp Forest	7	140		875	209	9,038	691	329
PAPUA	**992,217**	**62,177**	**6,165**	**168,199**	**51,369**	**263,141**	**162,406**	**74,317**
PEAT	**47,726**	**5,941**	**710**	**14,287**	**3,116**	**8,739**	**5,965**	**2,506**
Primary Dryland Forest	14,533	535		4,573	330	8,108	2,199	1,793
Primary Mangrove Forest	3,205	255		3,887	4	325	1,084	7
Primary Swamp Forest	29,988	5,151	710	5,828	2,782	306	2,682	706
MINERAL	**944,491**	**56,236**	**5,455**	**153,912**	**48,253**	**254,402**	**156,442**	**71,810**
Primary Dryland Forest	817,699	37,989	1,009	138,898	29,573	249,465	135,226	64,686
Primary Mangrove Forest	5,547	53		2,642	2,769	568	2,354	363
Primary Swamp Forest	121,244	18,194	4,445	12,372	15,911	4,369	18,862	6,761
SULAWESI	**93,256**	**186,799**	**9,487**	**9,113**	**4,637**	**112,472**	**63,205**	**20,054**
MINERAL	**93,256**	**186,799**	**9,487**	**9,113**	**4,637**	**112,472**	**63,205**	**20,054**
Primary Dryland Forest	91,312	186,707	9,487	9,113	3,180	111,273	62,916	19,537
Primary Mangrove Forest	1,944	92			1,457	850	282	517
Primary Swamp Forest						349	7	
JAWA	**267,460**				**43**	**1,021**	**242**	**303**
MINERAL	**267,460**				**43**	**1,021**	**242**	**303**
Primary Dryland Forest	266,518				43	1,021	107	26
Primary Mangrove Forest	942						87	277
Primary Swamp Forest							48	
BALI NUSA	**59,491**	**2,107**	**15,010**	**255**		**71,062**	**29,379**	**37,041**
MINERAL	**59,491**	**2,107**	**15,010**	**255**		**71,062**	**29,379**	**37,041**
Primary Dryland Forest	59,457	2,107	14,387	255		69,946	28,310	35,947
Primary Mangrove Forest	33		624			1,117	1,069	1,094
Primary Swamp Forest								
MALUKU	**5,266**	**7,460**		**153**	**398**	**48,005**	**39,764**	**1,434**
MINERAL	**5,266**	**7,460**		**153**	**398**	**48,005**	**39,764**	**1,434**
Primary Dryland Forest	56	7,375			41	45,665	38,719	531
Primary Mangrove Forest	5,210	85		153	357	1,618	928	714
Primary Swamp Forest						722	117	189
Grand Total	**1,558,707**	**322,009**	**43,218**	**197,235**	**95,256**	**698,738**	**596,533**	**257,682**
Annual Rate	**519,569**	**161,005**	**43,218**	**197,235**	**95,256**	**698,738**	**596,533**	**257,682**

Table annex 1.9. Emission from Forest Degradation

Island/Soil/ Land Cover	Emisi Degradasi Hutan (t CO2e/Periode)							
	2006-2009	2009-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
SUMATERA	**8,181,356**	**6,121,462**	**281,552**	**1,799,670**	**162,207**	**5,320,510**	**32,628,700**	**5,308,346**
PEAT	**4,015,542**	**1,845,991**	**266,654**	**305,319**	**29,720**	**58,615**	**2,803,393**	**8,292**
Primary Dryland Forest	-	-	-	-	-	-	-	-
Primary Mangrove Forest	27,720	-	-	-	-	40,834	8,684	739
Primary Swamp Forest	3,987,823	1,845,991	266,654	305,319	29,720	17,781	2,794,710	7,553
MINERAL	**4,165,814**	**4,275,471**	**14,898**	**1,494,350**	**132,487**	**5,261,895**	**29,825,307**	**5,300,054**
Primary Dryland Forest	535,760	3,646,066	3,819	183,317	115,301	3,963,940	27,718,485	5,059,807
Primary Mangrove Forest	3,018,437	315,321	-	64,416	-	1,233,202	379,372	210,834
Primary Swamp Forest	611,617	314,083	11,078	1,246,617	17,186	64,753	1,727,450	29,414
KALIMANTAN	**8,086,973**	**2,074,535**	**1,164,151**	**622,504**	**4,377,050**	**19,872,956**	**8,594,868**	**10,180,646**
PEAT	**133,138**	**29,841**	**1,164,151**	**78,140**	**212,147**	**1,628,240**	**282,251**	**483,240**
Primary Dryland Forest	-	-	1,164,151	-	-	4,262	-	-
Primary Mangrove Forest	-	-	-	-	8,038	-	-	142,699
Primary Swamp Forest	133,138	29,841	-	78,140	204,109	1,623,978	282,251	340,541
MINERAL	**7,953,835**	**2,044,694**	**-**	**544,364**	**4,164,903**	**18,244,716**	**8,312,617**	**9,697,405**
Primary Dryland Forest	7,750,208	2,019,584	-	356,367	4,079,749	16,593,227	8,050,008	9,246,687
Primary Mangrove Forest	202,400	-	-	30,506	47,475	25,576	138,214	391,466
Primary Swamp Forest	1,227	25,110	-	157,491	37,680	1,625,913	124,395	59,253
PAPUA	**93,838,355**	**5,266,503**	**396,533**	**16,266,198**	**4,392,490**	**26,442,417**	**15,513,342**	**7,197,188**
PEAT	**3,527,501**	**375,592**	**40,539**	**1,212,743**	**192,663**	**873,279**	**492,067**	**222,642**
Primary Dryland Forest	1,471,483	54,155	-	463,009	33,453	820,951	222,620	181,574
Primary Mangrove Forest	343,864	27,369	-	417,003	383	34,853	116,332	766
Primary Swamp Forest	1,712,154	294,067	40,539	332,731	158,827	17,476	153,115	40,302
MINERAL	**90,310,854**	**4,890,911**	**355,994**	**15,053,455**	**4,199,827**	**25,569,137**	**15,021,275**	**6,974,546**
Primary Dryland Forest	82,793,340	3,846,429	102,203	14,063,626	2,994,316	25,258,734	13,691,810	6,549,600
Primary Mangrove Forest	595,164	5,717	-	283,437	297,083	60,964	252,544	38,909
Primary Swamp Forest	6,922,350	1,038,765	253,791	706,391	908,427	249,439	1,076,921	386,037
SULAWESI	-	-	-	-	-	-	-	-
MINERAL	**11,029,105**	**22,134,778**	**1,124,242**	**1,079,892**	**533,168**	**13,328,948**	**7,486,829**	**2,370,641**
Primary Dryland Forest	10,820,550	22,124,946	1,124,242	1,079,892	376,876	13,185,941	7,455,557	2,315,160
Primary Mangrove Forest	208,555	9,832	-	-	156,292	91,171	30,255	55,481
Primary Swamp Forest	-	-	-	-	-	51,837	1,018	-
JAWA	-	-	-	-	-	-	-	-
MINERAL	**43,993,108**	**-**	**-**	**-**	**7,153**	**168,090**	**29,675**	**33,961**
Primary Dryland Forest	43,892,065	-	-	-	7,153	168,090	17,554	4,245
Primary Mangrove Forest	101,043	-	-	-	-	-	9,345	29,716
Primary Swamp Forest	-	-	-	-	-	-	2,777	-
BALI NUSA	-	-	-	-	-	-	-	-
MINERAL	**11,459,327**	**405,877**	**2,838,811**	**49,185**	**-**	**13,596,350**	**5,569,179**	**7,043,336**
Primary Dryland Forest	11,455,750	405,877	2,771,894	49,185	-	13,476,552	5,454,481	6,925,976
Primary Mangrove Forest	3,577	-	66,917	-	-	119,798	114,698	117,359
Primary Swamp Forest	-	-	-	-	-	-	-	-
MALUKU	-	-	-	-	-	-	-	-
MINERAL	**566,627**	**1,017,884**	**-**	**16,436**	**43,864**	**6,461,465**	**5,402,471**	**160,105**
Primary Dryland Forest	7,654	1,008,801	-	-	5,550	6,246,289	5,296,195	72,655
Primary Mangrove Forest	558,972	9,082	-	16,436	38,314	173,638	99,562	76,552
Primary Swamp Forest	-	-	-	-	-	41,538	6,714	10,898
Grand Total	**177,154,851**	**37,021,039**	**5,805,289**	**19,833,885**	**9,515,931**	**85,190,736**	**75,225,065**	**32,294,223**
Annual Rate	**59,051,617**	**18,510,520**	**5,805,289**	**19,833,885**	**9,515,931**	**85,190,736**	**75,225,065**	**32,294,223**

Annex 2. Emissions from Peat Decomposition

Emissions from peat decomposition have been reported in technical annex BUR until 2017. Explanation of the calculation has also been stated in the technical annex of the BUR. The following article is only to clarify the calculation process to obtain the achievement figures in 2017.
Peat decomposition: Changing process of peat form as a result of a decline in water levels caused by deforestation and degradation activities, and land utilization.

Inherited emissions: Emission of peat decomposition will continuously occur after peatland is drained due to peat forest land conversions or land utilizations. The emissions will only stop when the peatland is completely decomposed or completely rewetted. Thus, emissions are inherited from one to another after the initial disturbance and the total emission from peat decomposition is the accumulation of peat emissions from 1990 onwards.

Emission factor for peat decomposition emission calculation: The emission factors used in the calculation are derived from the document "2013 supplement to the IPCC 2006 Guidelines for National GHG Inventory: Wetlands (2014)".

These emission factors are used with the assumption that all utilized areas are drained. For instance, if there is a transition from primary swamp forest to secondary swamp forest, we will use the mean emission factor of the two land cover types, (0+19)/2 = 9.5 t CO2 $ha^{-1}yr^{-1}$. Because it was assumed that the transition occurs gradually within the transition period, rather than abruptly in the first or the last year of the period.

There are activities needed to be seriously and continuously done for reducing the emission from peat decomposition. Those mitigation action include peat land rewetting, establishing water management systems for peat land, reducing deforestation and degradation and preventing fires on peat land.

Calculation of emissions from peat decomposition in particular year at the time of deforestation and forest degradation used the same basis as the one used in calculation of emissions from deforestation and forest degradation with the inclusion of inherited emission. As mentioned above, this is because once deforestation and forest degradation occurred in peat forests, there would be emissions from the loss of ABG at the time of conversion as described above, and additional subsequent emissions from peat decomposition at the time of deforestation and forest degradation. In addition, the deforested and degraded peat forests will release further CO_2 emissions in the following years, known as inherited emissions from peat decomposition. The emission from peat decomposition is calculated using Equation follows :

$$PDE_{ijt} = A_{ijt} \; x \; EF_j$$

Where: PDE_{ijt} is Peat Decomposition Emission (PDE), i.e. CO_2 emission (tCO2-e yr^{-1}) from peat decomposition occurring in peat forest area-*i* that changed into land-cover type-*j* within time period-*t*; A_{ijt} is area-*i* of peat forest that changed into land-cover type-*j* within time period-*t*; EF_j is the emission factor from peat decomposition of peat forest that changed into land-cover class-*j* (tCO2-e ha^{-1} yr^{-1}).
Consistent with deforestation and forest degradation activities, the emission from peat decomposition was calculated from 2013 to 2017. The base calculation for peatland emission is the area located on forested peatland in 1990. The emission baseline of peat decomposition for FREL was estimated using a linear equation approach. This estimate will be improved gradually through a stepwise process to produce a more accurate estimate for future implementation.
The decomposition process in organic soil will produce significant carbon emissions when organic soils are drained. The soils will be exposed to the aerobic condition, being oxidised and emit CO_2. In another

hand, when forested peatland being converted to other land uses, the organic soils will continuously decompose for years. These emissions are inherited for years after the initial disturbance. Therefore, emissions from peat decomposition will always increase with an additional peatland being deforested. Regarding consistency, the data, methodologies, and procedures used for calculating the results presented in this report are similar to those used when establishing the FREL.

For example, in the land cover transition matrix of peatlands in the 2012-2013 period, the change of primary swamp forest (PSF) to swamp shrubs (SSr) was 3,379 ha (see Table Annex 2.1 at column 5, line 10), which was considered as the activity data. The emission factor used for this land cover transition (Table annex 2.2 at column 5, line 10), was the mean of emissions factor of the two land cover types, in this case (0+19)/2 or equals to 9.5 tCO2-e /year. Thus, the emission from the peat decomposition of this deforestation was 3,379 × 9.5 equals to 32,102 ton CO_2 (see table annex 2.3. at column 5, line 10). In the following years, the emission of peat decomposition from the swamp shrubs continues as inherited emission at a rate of 19 ton CO_2/year. This rate will change if the shrubs are converted to other land use that has different emission factor.

Table Annex 2.1. Land cover transition matrix of peatlands in 2012-2013 period (in hectares)

LC		2012																							Grand Total
		PF	SF	PMF	SMF	PSF	SSF	TP	Sr	EP	SSr	AUA	MxUA	Rc	Sv	Po	Sw	Se	Ai	Tr	Br	Mn	WB	Ot	
2013	PF	372,446			1		16																		372,463
	SF	4,573	292,000				19																		296,592
	PMF			232,928																					232,928
	SMF			3,887	89,838																				93,724
	PSF		2			2,124,918																			2,124,920
	SSF		1,145		37	10,206	3,368,605	755	329	115	10,881		224									429			3,392,726
	TP		31		50	585	27,950	517,985	4,548	1,420	19,059	115	518									46,389			618,650
	Sr		1,121				1,068		106,438				13												108,641
	EP		105		10	15	19,188	2,226	2,092	992,893	42,555	89	35	6,467								26,090			1,091,765
	SSr		342	22	137	3,379	57,595	276	206	515	1,791,213						5,131					97			1,858,913
	AUA		8,890				1,186			598	1,884	87,988										238			100,784
	MxUA		2,103				490		55,956		4,378	2,787	120,391												186,105
	Rc										33			51,552											51,585
	Sv														31,703										31,703
	Po															1,555									1,555
	Sw																95,234								95,234
	Se																	5,014							5,014
	Ai																		72						72
	Tr																			669					669
	Br		959		33	6,104	93,206	28,124	1,077	4,153	11,531	5	86	109								320,660			466,046
	Mn		28				554				3										1,823				2,408
	WB																						824		824
	Ot																								-
Grand Total		377,019	306,726	236,837	90,106	2,145,207	3,569,878	549,366	170,647	999,694	1,881,538	90,983	121,267	58,128	31,703	1,555	100,365	5,014	72	669	1,823	393,902	824	-	11,133,321

Table Annex 2.2. Matrix of emission factors for peat decomposition (in tCO2-e /ha)

LC		T1																						
		PF	SF	PMF	SMF	PSF	SSF	TP	Sr	EP	SSr	AUA	MxUA	Rc	Sv	Po	Sw	Se	Ai	Tr	Br	Mn	WB	Ot
T0	PF	-	9.5	-	9.5	-	9.5	36.5	9.5	20.0	9.5	25.5	25.5	17.5	17.5	-	-	17.5	-		25.5	25.5	-	-
	SF	9.5	19.0	9.5	19.0	9.5	19.0	46.0	19.0	29.5	19.0	35.0	35.0	27.0	27.0	9.5	9.5	27.0	9.5	35.0	35.0	35.0	9.5	9.5
	PMF	-	9.5	-	9.5	-	9.5	36.5	9.5	20.0	9.5	25.5	25.5	17.5	17.5	-	-	17.5	-	25.5	25.5	25.5	-	-
	SMF	9.5	19.0	9.5	19.0	9.5	19.0	46.0	19.0	29.5	19.0	35.0	35.0	27.0	27.0	9.5	9.5	27.0	9.5	35.0	35.0	35.0	9.5	9.5
	PSF	-	9.5	-	9.5	-	9.5	36.5	9.5	20.0	9.5	25.5	25.5	17.5	17.5	-	-	17.5	-	25.5	25.5	25.5	-	-
	SSF	9.5	19.0	9.5	19.0	9.5	19.0	46.0	19.0	29.5	19.0	35.0	35.0	27.0	27.0	9.5	9.5	27.0	9.5	35.0	35.0	35.0	9.5	9.5
	TP	36.5	46.0	36.5	46.0	36.5		73.0	46.0	56.5	46.0	62.0	62.0	54.0	54.0	36.5	36.5	54.0	36.5	62.0	62.0	62.0	36.5	36.5
	Sr	9.5	19.0	9.5	19.0	9.5	19.0	46.0	19.0	29.5	19.0	35.0	35.0	27.0	27.0	9.5	9.5	27.0	9.5	35.0	35.0	35.0	9.5	9.5
	EP	20.0	29.5	20.0	29.5	20.0	29.5	56.5	29.5	40.0	29.5	45.5	45.5	37.5	37.5	20.0	20.0	37.5	20.0	45.5	45.5	45.5	20.0	20.0
	SSr	9.5	19.0	9.5	19.0	9.5	19.0	46.0	19.0	29.5	19.0	35.0	35.0	27.0	27.0	9.5	9.5	27.0	9.5	35.0	35.0	35.0	9.5	9.5
	AUA	25.5	35.0	25.5	35.0	25.5	35.0	62.0	35.0	45.5	35.0	51.0	51.0	43.0	43.0	25.5	25.5	43.0	25.5	51.0	51.0	51.0	25.5	25.5
	MxUA	25.5	35.0	25.5	35.0	25.5	35.0	62.0	35.0	45.5	35.0	51.0	51.0	43.0	43.0	25.5	25.5	43.0	25.5	51.0	51.0	51.0	25.5	25.5
	Rc	17.5	27.0	17.5	27.0	17.5	27.0	54.0	27.0	37.5	27.0	43.0	43.0	35.0	35.0	17.5	17.5	35.0	17.5	43.0	43.0	43.0	17.5	17.5
	Sv	17.5	27.0	17.5	27.0	17.5	27.0	54.0	27.0	37.5	27.0	43.0	43.0	35.0	35.0	17.5	17.5	35.0	17.5	43.0	43.0	43.0	17.5	17.5
	Po	-	9.5	-	9.5	-	9.5	36.5	9.5	20.0	9.5	25.5	25.5	17.5	17.5	-	-	17.5	-	25.5	25.5	25.5	-	-
	Sw	-	9.5	-	9.5	-	9.5	36.5	9.5	20.0	9.5	25.5	25.5	17.5	17.5	-	-	17.5	-	25.5	25.5	25.5	-	-
	Se	17.5	27.0	17.5	27.0	17.5	27.0	54.0	27.0	37.5	27.0	43.0	43.0	35.0	35.0	17.5	17.5	35.0	17.5	43.0	43.0	43.0	17.5	17.5
	Ai	-	9.5	-	9.5	-	9.5	36.5	9.5	20.0	9.5	25.5	25.5	17.5	17.5	-	-	17.5	-	25.5	25.5	25.5	-	-
	Tr	25.5	35.0	25.5	35.0	25.5	35.0	62.0	35.0	45.5	35.0	51.0	51.0	43.0	43.0	25.5	25.5	43.0	25.5	51.0	51.0	51.0	25.5	25.5
	Br	25.5	35.0	25.5	35.0	25.5	35.0	62.0	35.0	45.5	35.0	51.0	51.0	43.0	43.0	25.5	25.5	43.0	25.5	51.0	51.0	51.0	25.5	25.5
	Mn	25.5	35.0	25.5	35.0	25.5	35.0	62.0	35.0	45.5	35.0	51.0	51.0	43.0	43.0	25.5	25.5	43.0	25.5	51.0	51.0	51.0	25.5	25.5
	WB	-	9.5	-	9.5	-	9.5	36.5	9.5	20.0	9.5	25.5	25.5	17.5	17.5	-	-	17.5	-	25.5	25.5	25.5	-	-
	Ot	-	9.5	-	9.5	-	9.5	36.5	9.5	20.0	9.5	25.5	25.5	17.5	17.5	-	-	17.5	-	25.5	25.5	25.5	-	-

Table Annex 2.3. Matrix of CO2 emissions from peat decomposition (in tC02e)

LC		2012																							Grand Total
		PF	SF	PMF	SMF	PSF	SSF	TP	Sr	EP	SSr	AUA	MxUA	Rc	Sv	Po	Sw	Se	Ai	Tr	Br	Mn	WB	Ot	
2013	PF	-	-	-	5	-	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	155
	SF	43,442	5,548,000	-	-	-	358	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,591,800
	PMF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	SMF	-	-	36,924	1,706,913	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,743,837
	PSF	-	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16
	SSF	-	21,750	-	703	96,952	64,003,498	34,747	6,260	3,388	206,744	-	7,832	-	-	-	-	-	-	-	-	15,001	-	-	64,396,876
	TP	-	1,434	-	2,300	21,343	-	37,812,876	209,190	80,255	876,716	7,108	32,137	-	-	-	-	-	-	-	-	2,876,095	-	-	41,919,455
	Sr	-	21,306	-	-	-	20,297	-	2,022,327	-	-	-	447	-	-	-	-	-	-	-	-	-	-	-	2,064,376
	EP	-	3,094	-	308	306	566,045	125,761	61,716	39,715,730	1,255,384	4,051	1,592	242,497	-	-	-	-	-	-	-	1,187,080	-	-	43,163,564
	SSr	-	6,506	212	2,611	32,102	1,094,303	12,692	3,920	15,182	34,033,041	-	-	-	-	-	48,743	-	-	-	-	3,387	-	-	35,252,698
	AUA	-	311,140	-	-	-	41,523	-	-	27,222	65,957	4,487,368	-	-	-	-	-	-	-	-	-	12,127	-	-	4,945,338
	MxUA	-	73,599	-	-	-	17,159	-	1,958,469	-	153,225	142,115	6,139,945	-	-	-	-	-	-	-	-	-	-	-	8,484,512
	Rc	-	-	-	-	-	-	-	-	-	897	-	-	1,804,327	-	-	-	-	-	-	-	-	-	-	1,805,225
	Sv	-	-	-	-	-	-	-	-	-	-	-	-	-	1,109,621	-	-	-	-	-	-	-	-	-	1,109,621
	Po	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Sw	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Se	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	175,494	-	-	-	-	-	-	175,494
	Ai	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Tr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	34,130	-	-	-	-	34,130
	Br	-	33,552	-	1,147	155,650	3,262,211	1,743,714	37,684	188,941	403,577	267	4,373	4,688	-	-	-	-	-	-	-	16,353,669	-	-	22,189,474
	Mn	-	991	-	-	-	19,386	-	-	-	97	-	-	-	-	-	-	-	-	-	92,961	-	-	-	113,436
	WB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Ot	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Grand Total		43,442	6,021,388	37,137	1,713,987	306,353	69,024,931	39,729,791	4,299,566	40,030,718	36,995,639	4,640,910	6,186,325	2,051,513	1,109,621	-	48,743	175,494	-	34,130	92,961	20,447,359	-	-	232,990,006

Historical emission from peat decomposition

The emissions from peat decomposition is progressive, due to inherited emissions from previous degraded peatlands. The emissions from peat decomposition will never decrease unless the degraded peatlands are changed into forests, which is unlikely to happen in this period of assessment. In the first FREL document, we developed linear equations from regression analysis using annual peat emissions from historical data. The emissions from peat decomposition were estimated based on the land cover maps. In some years, instead of yearly land cover map, we only have multi-years land cover maps, i.e. 3-yearly (2006 – 2009, 2-yearly (2009-2011) and 1-yearly (2011-2016). We generated annual emission from the average values of the mapping period. Each year has an estimated emission value to be regressed against year.
For the construction of reference emission level 2017-2020, consistent with method in fisrt FREL document used linear projection with equetion y = 6.706.744,03x – 13.266.946.368,06 R^2 = 0,97 The reference period 2006/2007 – 2015/2016 (see table annex 2.4 and figure annex 2.1)

Table annex 2.4. Emission from peat decomposition

Year	Peat Decomposition	Actual Emission	
2006-2007	200,067,598		Historical
2007-2008	200,067,598		
2008-2009	200,067,598		
2009-2010	215,742,080		
2010-2011	215,742,080		
2011-2012	226,109,789		
2012-2013	234,152,020		
2013-2014	240,799,350		
2014-2015	248,530,578		
2015-2016	255,413,778		
2016-2017	260,556,280	256,694,322	Projection y = 6,706,744.03x – 13,266,946,368.06 R^2 = 0.97
2017-2018	267,263,024		
2018-2019	273,969,768		
2019-2020	280,676,512		

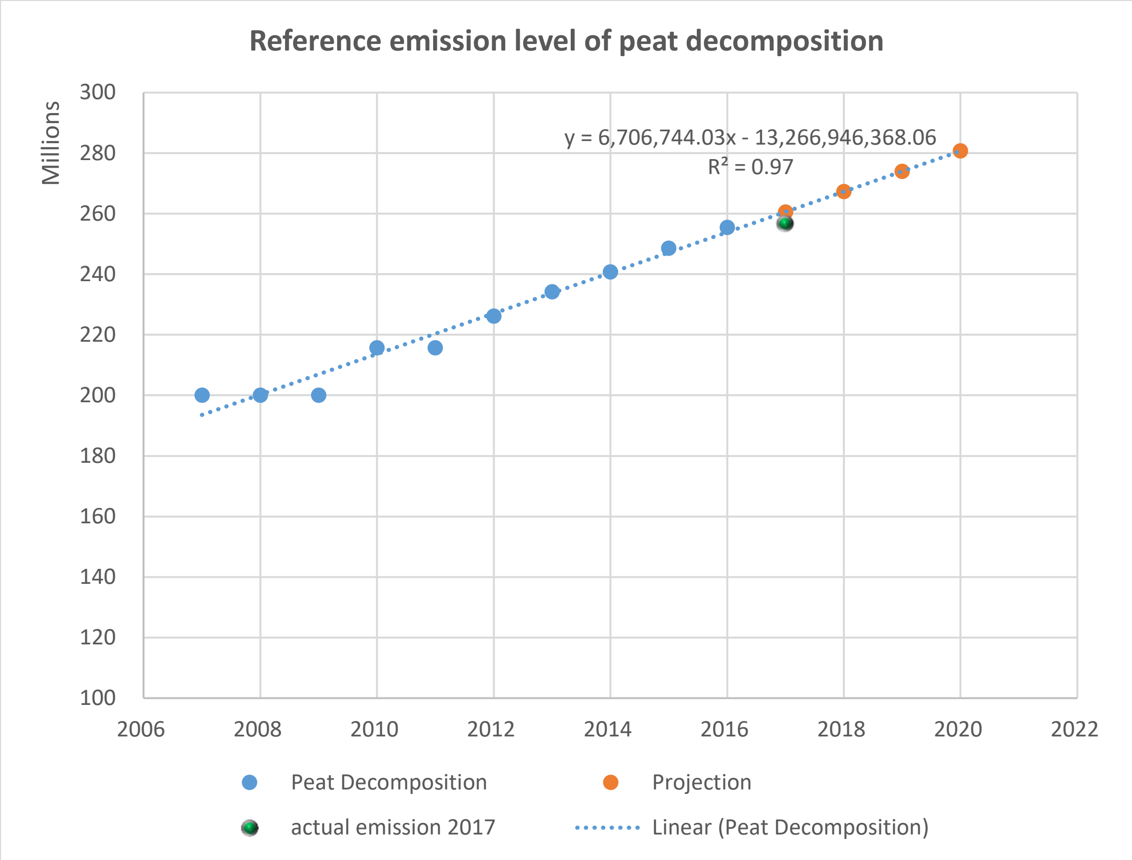

Figure Annex 2.1. The emissions from peat decomposition

<u>Emission Reduction from peat decomposition in 2017</u>

Peat decomposition emissions in 2017 (actual emission 256,694,322 tCO_2-e) , when compared to the historical emissions projections in the reference emission level 2006-2016 (projected in 2017 is 260,556,280 tCO_2-e) , then the **emission reduction in 2017 is 3,861,958 tCO_2-e**

Annex 3. Emissions from Peat Fires

Emissions from peat fires have not been included in Indonesia's first FREL calculation. Peat fire emission data is presented in the annex of the first FREL document. However, in the protocol MRV document, emissions from peat fires were also reported. Until now, no reference has been made for peat fires. Thus, the reference to peat fires will be made using peat fire data from 2006-2016. The method and data used for this report are consistent with the annex first FREL document regarding peat fire.

According to the IPCC Supplement for Wetland (IPCC, 2014), emissions from organic soil fires are calculated with the following formula:

$$L_{fire} = A \times MB \times CF \times G_{ef}$$

Where, L_{fire} is emission from peat fires, A is burned peat area, MB is mass of fuel available for combustion, CF is combustion factor (default factor = 1.0) and G_{ef} is emissions factor.

Fire activity data from 2006-2014 used a method developed by the Mitsubishi Research Institute (MRI) with a 1 x 1 km grid approach.

Tier 1 estimation of peat fire emission requires data on burn scar area. The currently available methods for determining burned scar area are based on low resolution MODIS images or hotspots analysis (MRI, 2013). However, the MODIS collection 5 of burned areas (MCD45A1) data had no observation over SE Asia regions, especially for major Islands of Indonesia.

The following is the method adapted from MRI (2013) to generate burn scar map in peatland based on hotspot analysis. The method was developed from a REDD+ demonstration activity project in Central Kalimantan. First, hotspots data are compiled annually from the baseline years (e.g. 1990, 1991, 1992, 1993, etc.). To improve certainty, only hotspots with confidence level of more than 80% are selected. As MODIS hotspots are not available for the period before 2000, NOAA hotspot might be used for to fill the gap. However, comparability and accuracy of NOAA hotspots need to be assessed, as they do not have the information on the confidence level. Second, a raster map with 1×1 km grid (pixel size) is generated and overlaid on top of the hotspot data. Pixels without hotspots are considered as not burned and excluded from the activity data. Each 1km ×1 km pixel with at least one hotspot is considered as burned but with the assumption that the burned area is 75% of the pixel area (7,500 ha). This rule applies for each pixel regardless the number of hotspots within a particular pixel (Figure Annex 4.1). Then, these burned areas were overlaid with the peat land map (produced by MoA) to estimate the burned peat land for each year.

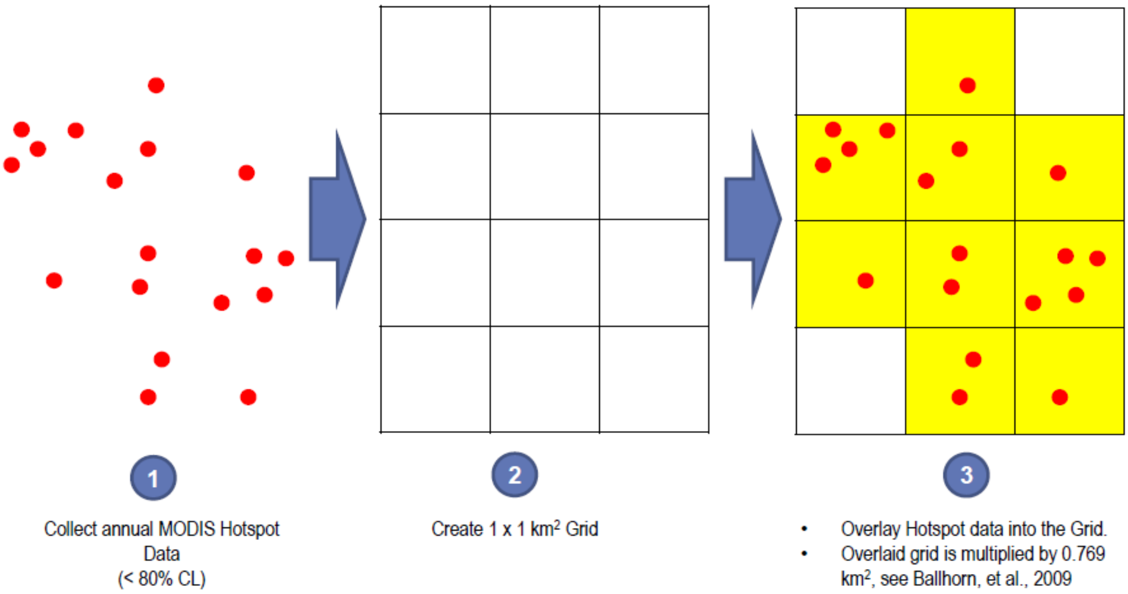

Figure Annex 3.1. Methodology to derive burned area (activity data)

While for 2015 - 2017 fire activity data uses visual interpretation methods, making it more accurate. Based on indications of hotspots with more than 80% confidence level, point density analysis was made. This is to make the initial polygon area burn. Furthermore Landsat with coverage dates after the fire (max. 14 days afterwards) is used as a reference to digitize actual burn scar. As an illustration see the picture ...

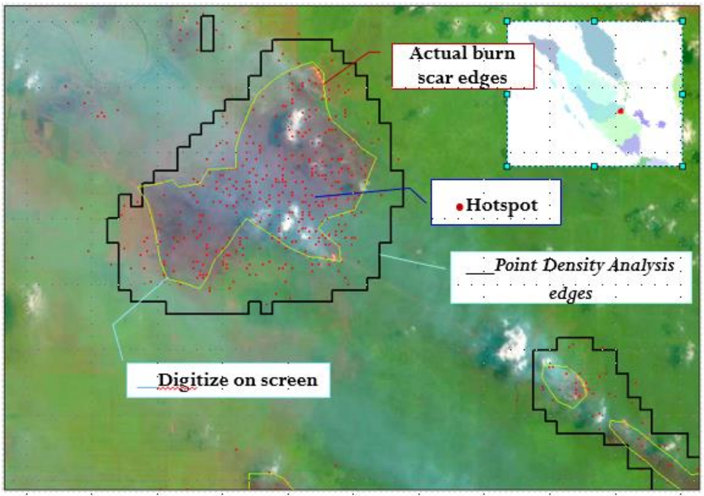

Figure Annex 3.2. Delineation of burn scar

<u>Mass of fuel available for combustion</u>

Mass of fuel available for combustion, MB, is estimated from multiplication of mean depth of burned peat (D) and bulk density (BD), assuming average peat depth burned by fire is 0.33 m (Ballhorn *et al*., 2009) and bulk density is 0.153 ton/m^3 (Mulyani *et al.*, 2012). Resulted mass available for combustion is 0.05049 ton/m2 or 504.9 ton/ha.

Emission factor

CO_2 emission factor (G_{ef}) can be indirectly estimated from organic carbon content (C_{org}, % of weight), which is equal to:

$$G_{ef} = C_{org} \times 3.67$$

C_{org} can be estimated by the following equation:

$$C_{org} = \frac{(1 - M_{ash}/M_s)}{1.724} \times 3.67$$

Where M_s is mass of soil solids, which is equal to accumulation mass of ash (M_{ash}) and mass of organic matters. Ratio of M_{ash} and M_s is 14.04%, which is the mean ash contents of three peat types; namely, Sapric (4.98%), Hemic (21.28%) and Fibric (15.85%) (*see* Mulyani *et al*., 2012).

Adjustment factor of 1/1.724 is used to convert organic matter estimate to organic carbon content. Estimated C_{org} is 49.86% (or kg/kg), which is equal to 498.6 C g/kg dry matter burnt.

If the value is converted to CO_2e, the value would be C_{org} x 3.67 = 1,828.2 CO_2 g/kg dry matter burnt or 1,828.2 CO_2 kg/ton. Assuming of 1 ha peat burning, CO_2 emissions released to the atmosphere is:

$$L_{fire} = A \times MB \times CF \times G_{ef}$$

= 1 ha × 504.9 t/ha × 1,828.2 kg/t

= 923,058.18 kg/ha

= 923.1 tCO2-e e/ha

This result is used as emission factor of burned peat. Emissions from peatlands that suffer more than one fire event are assumed to be reduced by half compared to that of the first burning, e.g. the first burning of 1 ha peat emits 923.1 tCO2-e (UKP4 and UNORCID, 2013), while the subsequent burning of exactly the same area will release 462 tCO2-e . The third burning of the same area will release again a lower amount of emissions than the second burning but further research is necessary to determine the amount of reduction. The above assumption is from a manuscript that resulted from Peat Emission Workshop held by UKP4 and UNORCID (6 November 2013) in Jakarta.

Historical emission from peat fire

For this report, historical emissions from peat fire have been calculated for the period 2006-2016.

It was found that the annual estimated burned peat areas varied greatly from 2006 to 2016 (Figure Annex 3.3). The highest rate occurred in 2015 accounting for 869,754 ha of burned peatland, while the lowest rate occurred in 2010 accounting for 55,664 ha of burned peat area. Using this historical data set, the average value used as activity data for proposed REL from burned peat accounts for 269,686 ha.

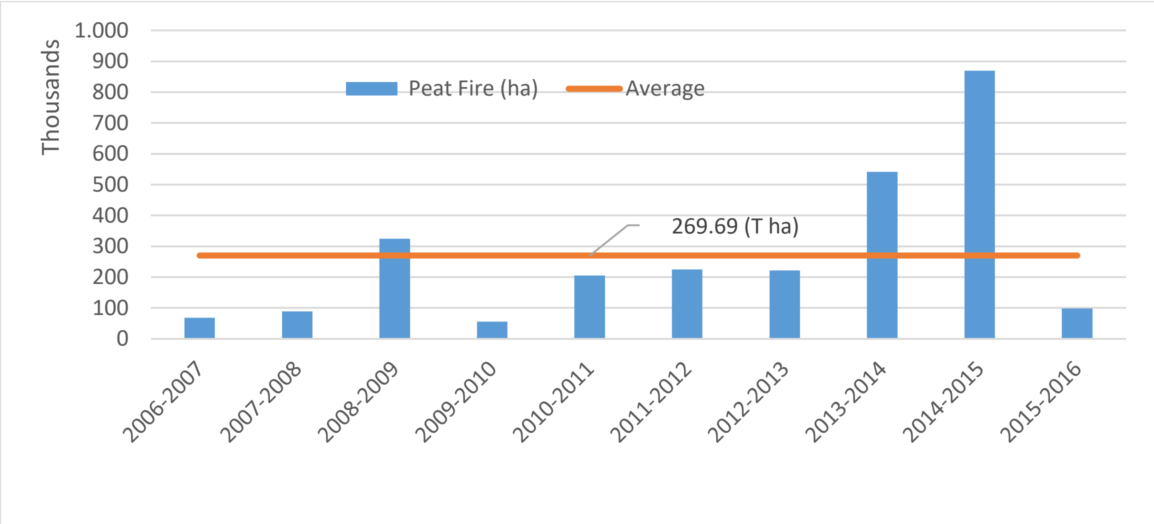

Figure Annex 3.3. Estimated burned peat area

The results of the calculation of emissions from burned peat are shown in Figure Annex 3.4. Average emission from peat fire from 2006 – 2016 is 248,947,149 tCO_2-e yr^{-1}. The derivation of the burned areas has not been verified using ground truthing or high-resolution satellite data. Therefore, the uncertainty level cannot be estimated.

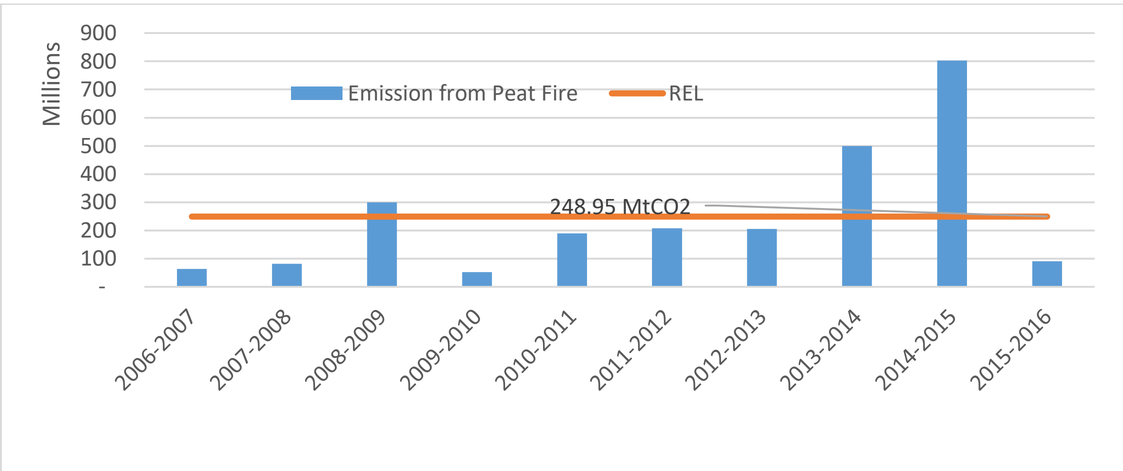

Figure Annex 3.4. Estimated historical emission from burned peat

Emission reduction from peat fire in 2017

Emissions from peat fires in 2017 have decreased dramatically, this was due to massive law enforcement and moratorium policies for new permits on peat and primary forests. The fire incident in peat in 2017 was 13,555 hectares. If it is converted to emissions, it will amount to 12,512,621 tCO_2-e. When compared to the reference emission level for peat fire (248,947,149 tCO_2-e), the **emission reduction in 2017 is 236,434,529 tCO_2-e**.

Constraints in measuring emissions from peat fires

Some critical issues on the accuracy of the burn scar lies in the assumptions used to estimate the size and intensity of the fires. Hotspots are just an indication of active fire existence through thermal differentiation with neighboring pixels. Thus, false detection is possible as a thermal anomaly can originate from other heat sources than fires. Selection of hotspot with high confidence level can reduce such error. However, smoke coverage is very common during fire season, which reduces the sensor's capability to detect fires covered by smokes. This can result in underestimation of the burned areas. In contrast, assuming that the burned area is 75% for each pixel with hotspot might lead to a severe overestimate of the burned area, especially in the border area between burned and unburned.

A further challenge lies in determining the peat depth consumed by fires. Relationship analyses between hotspot parameters (fire intensity, frequency etc.) with burned peat depth need to be carried out to better estimate the burned peat depth of the burned peatland and thus estimate the actual emissions from peat fires. Ballhorn *et al*. (2009) used airborne LIDAR for estimating burned peat depth with accuracy of less than 20 cm. Konecny *et al.* (2016) found that carbon loss varies significantly for recurrent fires in drained tropical peatlands. According to their research the relative burned area depth decreases over the first four fire events and is then constant for further successive fires. They estimate values for the dry mass of peat fuel consumed to be only 58–7% of the current IPCC Tier 1 default value for all fires. This indicates that accurate estimation of emissions from peat fires should also consider the frequency of fires in an area and employ accordingly adjusted emission factors.

Improvement of Peat Fire Data used the data burn area from Ministry of Environment and Forestry with the a new approach for estimating the burned area. This improved method has been applied for estimation of the burn scar, i.e. by combining the Landsat image (quick look original with composite band 645) with the hotspot data and verified with observed burnt area data on the ground. That is able to delineate the burn area. This new approach might be adopted in the future as this approach will have higher certainty.

With above conditions and high level of uncertainties of all involved parameters (hotspot detection, size of burned area estimation, fire frequency, burned peat depth, mass of fuel available for combustion), this FREL document did not include emissions from peat fires. Advancing technology in remote sensing to improve burned scar and peat depth mapping will increase the accuracy of peat fire emission calculation which can then be included as improvement in a future FREL.

Annex 4. The estimates of AGB stocks and their uncertainties in each forest class in Indonesia

Main Island	Forest Type	Mean AGB (Mg ha-1)	95% Confidence Interval (Mg ha-1)		N of plot measurement	U(%)	Emission Factor of Deforestation		Emission Factor of Forest Degradation	
							($t CO_2 ha^{-1}$)	U(%)	($t CO_2 ha^{-1}$)	U(%)
Bali Nusa Tenggara	Primer_dryland	274.4	247.4	301.3	52	10%	473.3	9.80%	192.7	16.80%
	Sekunder_dryland	162.7	140.6	184.9	69	14%	280.6	13.64%		
	Primer_swampforest									
	Sekunder_swampforest									
	Primer_mangrove	263.9	209.0	318.8	8	21%	455.2	20.79%	107.3	29.53%
	Sekunder_mangrove	201.7	134.5	244.0	12	21%	348.0	20.96%		
	Average	**191.6**	**174.2**	**209.0**	**121**	**17%**	330.5	**16.99%**	**192.7**	**24.02%**
Jawa	Primer_dryland									
	Sekunder_dryland	170.5			1					
	Primer_swampforest									
	Sekunder_swampforest									
	Primer_mangrove									
	Sekunder_mangrove									
	Average									
Kalimantan	Primer_dryland	269.4	258.2	280.6	333	4%	464.7	4.16%	114.0	5.40%
	Sekunder_dryland	203.3	196.3	210.3	608	3%	350.7	3.44%		
	Primer_swampforest	274.8	269.2	281.9	3	2%	474.0	2.32%	179.9	7.41%
	Sekunder_swampforest	170.5	158.6	182.5	166	7%	294.1	7.04%		
	Primer_mangrove	263.9	209.0	318.8	8	21%	455.2	20.79%	107.3	29.53%
	Sekunder_mangrove	201.7	134.5	244.0	12	21%	348.0	20.96%		
	Average	**225.4**	**219.7**	**231.2**	**1129**	**13%**	388.9	**12.62%**	**133.7**	**17.85%**
Maluku	Primer_dryland	301.4	220.3	382.5	14	27%	519.9	26.91%	136.8	28.06%
	Sekunder_dryland	222.1	204.5	239.8	99	8%	383.1	7.97%		
	Primer_swampforest						-			
	Sekunder_swampforest						-			
	Primer_mangrove	263.9	209.0	318.8	8	21%	455.2	20.79%	107.3	29.53%

Main Island	Forest Type	Mean AGB (Mg ha-1)	95% Confidence Interval (Mg ha-1)		N of plot measurement	U(%)	Emission Factor of Deforestation		Emission Factor of Forest Degradation	
							(t CO_2 ha^{-1})	U(%)	(t CO_2 ha^{-1})	U(%)
	Sekunder_mangrove	201.7	134.5	244.0	12	21%	348.0	20.96%		
	Average	**215.5**	**196.4**	**234.6**	**113**	**20%**	371.8	**20.37%**	**122.0**	**28.80%**
Papua	Primer_dryland	239.1	227.5	250.6	162	5%	412.4	4.81%	101.3	13.11%
	Sekunder_dryland	180.4	158.5	202.4	60	12%	311.2	12.20%		
	Primer_swampforest	178.8	160	197.5	67	10%	308.4	10.46%	57.1	28.74%
	Sekunder_swampforest	145.7	106.7	184.7	16	27%	251.3	26.77%		
	Primer_mangrove	263.9	209.0	318.8	8	21%	455.2	20.79%	107.3	29.53%
	Sekunder_mangrove	201.7	134.5	244.0	12	21%	348.0	20.96%		
	Average	**210.7**	**202.1**	**219.3**	**305**	**18%**	363.4	**17.65%**	**88.5**	**24.96%**
Sulawesi	Primer_dryland	275.2	262.4	288.1	221	5%	474.7	4.69%	118.5	7.54%
	Sekunder_dryland	206.5	194.3	218.7	197	6%	356.2	5.91%		
	Primer_swampforest	214.4	-256.4	685.2	3	21%	369.8	20.88%	148.5	46.84%
	Sekunder_swampforest	128.3	74.5	182.1	12	42%	221.3	41.93%		
	Primer_mangrove	263.9	209.0	318.8	8	21%	455.2	20.79%	107.3	29.53%
	Sekunder_mangrove	201.7	134.5	244.0	12	21%	348.0	20.96%		
	Average	**241.6**	**232.7**	**250.5**	**433**	**23%**	416.7	**22.81%**	**124.8**	**32.26%**
Sumatera	Primer_dryland	268.6	247.1	290.1	92	8%	463.3	8.00%	149.0	9.77%
	Sekunder_dryland	182.2	172.1	192.4	265	6%	314.3	5.60%		
	Primer_swampforest	220.8	174.7	266.9	22	21%	380.9	20.88%	119.7	22.15%
	Sekunder_swampforest	151.4	140.2	162.6	160	7%	261.1	7.40%		
	Primer_mangrove	263.9	209.0	318.8	8	21%	455.2	20.79%	107.3	29.53%
	Sekunder_mangrove	201.7	134.5	244.0	12	21%	348.0	20.96%		
	Average	**198.5**	**189.9**	**207.1**	**539**	**16%**	342.4	**15.59%**	**125.3**	**22.04%**
	Average all						368.9	**17.97%**		**25.41%**