

Forest Carbon Partnership Facility (FCPF) Carbon Fund

ER Monitoring Report (ER-MR)

ER Program Name and Country:	East Kalimantan - Jurisdictional Emission Reductions (EK-JER) Program, INDONESIA
Reporting Period covered in this report:	<i>01-07-2019 to 31-12-2020</i>
Number of FCPF ERs:	<i>30,850,798 tonCO_{2e}</i>
Quantity of ERs allocated to the Uncertainty Buffer:	<i>0 tonCO_{2e}</i>
Quantity of ERs to allocated to the Reversal Buffer:	<i>1,713,933 tonCO_{2e}</i>
Quantity of ERs to allocated to the Reversal Pooled Reversal buffer:	<i>1,713,933 tonCO_{2e}</i>
Date of Submission:	<i>v. 29/07/2022</i>

Notice

This ER Monitoring Report is made public for validation and verification purposes. Annex 1, 2, and 3 are not included in this version since they are being completed by the Program Entity. The full Report will be made available as soon as Annex 1, 2, and 3 are completed and the validation/verification are concluded as outlined in the FCPF Process Guidelines.

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1 IMPLEMENTATION AND OPERATION OF THE ER PROGRAM DURING THE REPORTING PERIOD

1.1 Implementation status of the ER Program and changes compared to the ER-PD

Implementation of ER (emission reduction) program under this reporting period is reported from July 2019 – December 2020.

The implementation of ER Program compared to ER-PD (Emission Reduction Program Document) is summarized per component as follows:

1) Component 1: Forest and Land Governance

1.1.Strengthening the licensing regime

- Licenses processes related mining and forestry are improved for efficiency and effectiveness, that are integrated into one single system (OSS). The system is under management of Provincial Investment and Licensing Integrated Service (DPMPTSP). The number of permits decreased after verification (clean and clear) was conducted during the reporting period. In 2019, the total mining permits were 386 permits. Up to December 2020, there are 272 mining permits that passed the assessment. The number of social forestry permits increased. Up to December 2020, there are 75 social forestry permits that have been issued to communities in East Kalimantan with the total of 193k ha. East Kalimantan Government issued High Conservation Value (HCV) Policy on Sustainable Estate Crops (No.7/2018¹). The regulation emphasises restoration of high conservation value (HCV) areas. The implementation of this regulation was followed up by Berau Bupati's decree² no 287/2020 about designation of HCV area inside an oil palm plantation for 83,000ha. Development partners involved in supporting designation of High Conservation Value (HCV) area are *Yayasan Konservasi Alam Nusantara* (YKAN), German Sustainable and Climate-Friendly Palm Oil Production and Procurement (GIZ SCPOPP), German Low-Emissions Oil Palm Development (GIZ LEOPALD), *Dewan Daerah Perubahan Iklim* (DDPI) Kaltim, Kalimantan Forest United National Development Program (Kalfor-UNDP), *Forum Perkebunan* (Estate Crops Multi-stakeholders Forum), Mulawarman University, private companies and others government institutions. Another efficiency for license issuance is the development of spatial databases, in which the licensing process is through a web-platform system that can be previewed. This web platform can assess whether the area is overlapped or not. If the area is overlapped then the license must be postponed until the issue is solved.

1.2.Dispute Settlement

- Dispute settlement has been addressed. At national level, a national policy under National Agrarian Reform Program (TORA) on the change of forest boundary area has

¹ [PERDA Prov. Kalimantan Timur No. 7 Tahun 2018 tentang Pembangunan Perkebunan Berkelanjutan \[JDIH BPK RI\]](#)

² [https://mrv.kaltimprov.go.id/storage/guest/ERMRI/Regulation/SK Bupati Berau 287 2020 ttg Peta Indikatif ANKT.pdf](https://mrv.kaltimprov.go.id/storage/guest/ERMRI/Regulation/SK%20Bupati%20Berau%20287%2020%20ttg%20Peta%20Indikatif%20ANKT.pdf)

been issued (S.698/Menlhk/Setjen/Pla.2/9/2021 on 10 September 2021)³. The revision of forest boundary area in the province between private lands and social forestry areas has been conducted with the size of 119.4 ha and 142.8ha respectively. The revision is still on-going in several districts (Paser Penajam Utara, East Kutai, Berau, and Kutai Kartanegara). The partner is directly from Ministry of Environment and Forestry (MoEF). Due to Covid-19, field activities are limited. The budget allocation for field surveys were transferred to combatting Covid-19. In order to minimise conflict within stakeholders, the provincial government has developed standard operation procedure (SOP) for conflict resolution in forestry sector. The standard operational procedure (SOP) provides guidance for EK Forestry Agency staff to implement conflict resolution and to ensure the State's rights, individual or group rights, customary community rights, concession holders rights, and to protect forest and its resources. Fifteen (15) disputes have been addressed using this SOP up to July 2020. Most of disputes were about tenurial rights. The disputes have been decreased from 27 cases in 2019 to 5 cases in 2020. Parties who supported conflict resolution are as follows: the Forest Management Unit (FMU), MoEF Social Forestry and Environmental Partnership (*Balai Perhutanan Sosial dan Kemitraan Lingkungan/BPSKL*), MoEF Regional Forest Gazettement Agency (*Balai Pemantapan Kawasan Hutan/BPKH*), local government, village government, concession holders and local or customary community. The EK government has developed the grievance system called "Aspirasi Etam" through Governor Regulation No 69/2019⁴. The "Aspirasi Etam" (meaning our aspirations) is an online portal for the community to report the complaints issued in East Kalimantan (EK). For FCPF, this "Aspirasi Etam" is used by the community/public to give feedback and grievances related to FCPF activities.

1.3 Support for the recognition of adat land

- The designated areas for customary forests that cover 23,867ha have been approved by the Central Government, whereas indicative areas for customary forests that have complied with regulations cover 554,552ha. As one of efforts to support the recognition of adat land from district government, validation of Customary Forest for Muluy and Muara Ande in Paser District has been conducted (under Bupati's Paser Decree No. 4/2019)⁵. However, up to 2020, there are only two customary forests that have been acknowledged by both MoEF and District Governments, namely 1) Muluy - Swan Slutung Village, Paser District and 2) Hemaq Beniung - Kampung Juaq Village, Kutai Barat respectively. Total area for both customary forests are 7,770ha.

1.4 Strengthening village spatial planning

- In order to prevent overlapping land use, and to strengthen the village programs inside the village areas, the spatial land use plan was developed. Up to December 2020, 6 village spatial plans in peatland areas have been completed. In addition, 7 villages in Kombeng sub-district, with the support from GIZ-SCPOPP, have been finalised. So, total villages that have been mapped are 13 out of 150 villages. After the village spatial plan was completed, the process continued at the higher scale, sub-district/*kecamatan* and finally at the kabupaten/district level. At the kabupaten level, the village spatial plan will

³ <https://drive.google.com/file/d/1FMouIE2CBYxN5vakgxkB0O4HWM7ihXCt/view?usp=sharing>

⁴ https://mrv.kaltimprov.go.id/storage/guest/ERMRI/Regulation/PERGUB_69_2019-aspirasi etam.pdf

⁵ <https://mrv.kaltimprov.go.id/storage/guest/ERMRI/Regulation/Perda Paser 4 thn 2019 MHA Paser.pdf>

be synchronized with other sectors' spatial plans such as forestry, fishery and plantation. The development partners involved for village spatial plan are TNC/YKAN, GIZ -SCOPP, WWF Indonesia, Yasiwa, and Yayasan Bumi.

2) Component 2: Improving Forest Supervision and Administration

2.1 Strengthening management capacity within the State Forest Area: FMU development

- From a total of 19 Forest Management Unit (*Kesatuan Pemangkutan Hutan/KPH*) in East Kalimantan, up to December 2020 there were 10 out of 19 Long Term Forest Management Plans (RPHJPs) that have been ratified and approved by MoEF. To complete the other 9 RPHJPs, capacity building was conducted, such as strengthening KPH staff on development of KPH RPHJP (on 22-25 November 2020 in Samarinda). One of the activities is patrolling for Prevention and Suppression from Forest and Land fires in conservation and forest production areas (Kutai National Park for 53 times during the reporting period and 14 times with communities known as Community Partner Rangers/*Masyarakat Mitra Polhut*). KPH conducts forest patrolling every year. Twenty (20) cases of illegal logging were reported in East Kalimantan during the reporting period. Nine (9) Business plans of KPHs were developed with the support from development partners (GGGI, GIZ, WWF, TNC/YKAN, etc). In order to accelerate the development of business plans for other KPHs, a coaching clinic (capacity building) was conducted by Forestry Service of East Kalimantan. A baseline study on the application of environmental economic instruments and other incentive schemes was conducted as part of pre-assessment on sustainability of environmental services of Manggar Watershed in order to supply raw water for 79% of Balikpapan city residents.

2.2 Strengthening provincial and district governments to supervise and monitor the implementation of sustainable Estate Crops

- Strengthening provincial and district governments in monitoring implementation of sustainable estate crops were conducted through identification and development of HCV area maps. In early 2020 Bupati Berau signed a Decree on HCV indicative map No 287/2020⁶ covering 83,000ha.

3) Component 3: Reducing deforestation and forest degradation within licensed areas

3.1. Implementation of HCV policies for Oil Palm Estates

- Private sectors have a key role in reducing deforestation and forest degradation within their licensed areas such as implementation of HCV policies for oil palm estates. Commitments from district governments to implement HCV policies have been acknowledged. Meeting coordination within Estate Crops Services of East Kalimantan (Rakor Perkebunan) was conducted in Balikpapan on 18 October 2019. Seven (7) Regencies in East Kalimantan proposed HCV indicative maps within plantation businesses concessions or plantations. The HCV is designated areas by district

⁶ [https://mrv.kaltimprov.go.id/storage/guest/ERMRI/Regulation/SK Bupati Berau 287 2020 ttg Peta Indikatif ANKT.pdf](https://mrv.kaltimprov.go.id/storage/guest/ERMRI/Regulation/SK%20Bupati%20Berau%20287%202020%20ttg%20Peta%20Indikatif%20ANKT.pdf)

governments with total coverage of 417,505 ha. Up to December 2020, Berau district has put the committed areas of 83,876ha as HCV protection into Bupati's Decree on HCV indicative map No 287/2020⁷. Assistance to oil palm smallholders towards sustainability in order to gain Indonesia Sustainable Palm Oil (ISPO) & Roundtable Sustainable Palm Oil (RSPO) Certificates was conducted. Up to 2020, there are 60 companies that have obtained ISPO, whereas 12 companies obtained RSPO certificates. The area of the ISPO-certified is 520,605 ha, and the area of RSPO-certified is 87,070 ha.

3.2 Support for smallholders and Community Based Fire Management and Monitoring Systems (CBFMMS)

- In order to prevent forest and land fires, EK Estate Crops Service with the support of private companies established the Farmer Group on Fires Management and Prevention known as Fire Prevention Farmers Group (*Kelompok Tani Peduli Api/KTPA*). The total KTPA are 81 KTPAs. The KTPAs are key players in helping district government and private companies in combating forest and land fires. In the forestry sector, the private companies also contributed to the development of Community-based Fire Management and Prevention (MPA). The contribution includes training, gears and tools for firefighters, and patrol. Sinarmas Forestry and partners (PT. Surya Hutani Jaya, PT. Sumalindo Hutani Jaya II, PT. Acacia Andalan Utama, PT. Kelawit Wana Lestari) had 43 activities (patroli, training, and providing gears and tools to MPA) across six sub-districts in East Kalimantan until December 2020.

3.3 Implementation of HCV and RIL-C policies for Forestry Concessions

- The private sector implemented HCV and RIL policies inside their forest concession areas (IUPHHK-HA). The implementation was monitored by Production Forest Management Agency (BPHP) East Kalimantan region (MoEF's branch office in East Kalimantan). Up to 2019, three (3) out of 64 IUPHHK-HA have implemented reduced impact logging for carbon (RIL-C). The RIL-C training on the field site has been done for eight (8) companies. In terms SFM certification for timber plantation, it has reached 21 out of 42 timber plantation concession (IUPHHK-HT), whereas for natural forest has reached 53 out of 64 IUPHHK-HA.

4) Component 4: Sustainable Alternatives for Communities

4.1 Sustainable livelihoods

- Capacity building on strengthening village owned entrepreneurship (BUMDes) has been conducted in 45 out of 150 villages during July 2019 – December 2020. The contents of training included financial management and village assets, innovation, etc. Partnerships between government and communities in conserving wildlife have been conducted such as restoration of orangutan habitats in East Kutai district, conservation of sea turtle in Derawan islands, Berau district, conservation of black crocodile Siam (*Siamensis*) in Mesangat-Kenohan Suwi, East Kutai District, conservation of Sumatran Rhino in Kelian West Kutai district, and also conservation education that aims to increase awareness of the community on the importance of conservation in East Kalimantan.

⁷ <https://mrv.kaltimprov.go.id/storage/guest/ERMRI/Regulation/SK Bupati Berau 287 2020 ttg Peta Indikatif ANKT.pdf>

4.2 Conservation partnerships

- BKSDA Kaltim has implemented development of partnerships with communities for conservation of 100,000 hectares of Managed Traditional Zones and Community Empowerment in 10 Villages on Management of Conservation Areas and for livelihood development.

4.3 Social forestry

- Up to December 2020, there are 75 social forestry (SF) permits that have been issued to communities in East Kalimantan with a total of 193k ha. The target area for SF is 250k ha. Most permits are issued for village forests (34 licenses - 165k ha), community-based timber plantation/HTR (15 licenses - 13k ha), community forestry/Hkm (13 licenses - 2.2k ha), forest partnerships (11 licenses - 5.4k ha), and customary forest/HA (2 licenses - 7.7k ha).

5) Component 5: Project Management and Monitoring

5.1 Project coordination and management

- Coordination meetings during July 2019 – December 2020 were hosted by different EK government services such as the EK Forestry Service for Safeguards issues, the Bureau Economy for BSM, and the EK Environmental Service for Measurement, Monitoring and Reporting (MMR) and Free, Prior and Informed Consent (FPIC). Coordination meetings were conducted with the purpose to strengthen and increase awareness of OPD (provincial government services) about their important roles in the implementation of ER Programs.
- Working Groups for Benefit Sharing, Safeguards, MMR, and Budget and Planning were established. These working groups are under Secretariat Office of Provincial Government East Kalimantan. Outputs are Draft Governor Regulation on Benefit Sharing, Draft SOP for Working Group Safeguards, MMR portal (website MMR), Technical correction on Emission Factor for FREL East Kalimantan, Data revision on Forest Cover for ER Calculation, and extrapolation of plot sample permanents (583 PSPs) under different 11 forest cover types.
- During the reporting period, the budget was mostly implemented according to the plan. However, since the Covid-19 pandemic in Indonesia started in March 2020, most of the field activities were limited. Social distancing was applied. As a result, meetings face to face were avoided. The budget plan for 2020 was revised and allocated to support combating Covid-19. For example, EK forestry Service had to revise its budget for facilitating RIL-C. The budget was reallocated to support the purchase of antigen detection rapid diagnostic test for Covid-19.

5.2 Monitoring and evaluation

- At the early stage of the reporting period most coordination between and within government agencies and partner agencies was conducted by *Sub National Program Namangemetn Unit (SN-PMU) under Economic Bureau of Provincial Secretariat.* At the end of the reporting period, the FCPF Readiness Fund was limited (the program was ended in December 2020). Most of the financial support for implementation of the ER program in the province was taken from the EK government budget and partly from the development partners. Since working groups (safeguards, benefit sharing, MMR, and

budgeting and planning) have been established, coordination of ER programs is led by the chairman of each working group. The Safeguards issue, for example, is led by EK Forestry Service, whereas MMR is led by EK Environment Service. The development partners are invited and actively participate in the issues related to the ER program.

5.3 Program communication

- The communication process is carried out by SN-PMU with the executor at the Provincial Secretariat Public Relations Bureau. Publication is carried out on the provincial website (www.kaltimprov.go.id), social media ([instagram.com/pemprov_kaltim](https://www.instagram.com/pemprov_kaltim)), as well as local newspapers, radio and television.

For further details of activities during the reporting period can be found in <https://mrv.kaltimprov.go.id/>.

1.2 Update on major drivers and lessons learned

Seven main drivers of deforestation and forest degradation in East Kalimantan were qualitatively identified through a series of consultative meetings with local stakeholders between October 2015 and March 2018. The main drivers are as follows:

1. Timber plantations
2. Estate crops
3. Mining
4. Subsistence agriculture
5. Unsustainable logging practices
6. Forest and land fires
7. Aquaculture

During the reporting period, those above drivers were then assessed through land cover changes from July 2019 – December 2020.

Land Cover changes July 2019 – December 2020

It was found that 19,310 ha of forest was lost during July 2019 – December 2020. The main drivers of deforestation for such period were caused by unlicensed land clearing (32,7%), oil palm (23.8%), Agriculture (15%), timber plantation (12.7%), unsustainable forest management (10.6%), mining (3%), and fishpond (2.2%).

Table 1. Area Deforested July 2019 - December 2020

Driver	Area deforested July 2019 – December 2020 (hectare)	Share of total deforestation (%)
Unlicensed Land clearing	6,310.37	32,7%
Estate crops - oil palm	4,597.77	23.8%
Agriculture	2,888.84	15.0%
Timber Plantation	2,450.48	12.7%
Unsustainable Forest Management	2,047.01	10.6%
Mining	587.85	3.0%

Driver	Area deforested July 2019 – December 2020 (hectare)	Share of total deforestation (%)
Fishpond	428.10	2.2%
Total Deforestation 2019-2020	19,310.41	100.0%

Comparing between the drivers from the baseline period (2006-2016) and reporting period (July 2019 – December 2020), unlicensed land clearing became the main driver of deforestation following up with the oil palm. However, the deforestation rate has sharply decreased compared to the baseline. The announcement and commitments from seven districts/regencies to provide areas for HCV protections (remaining natural forest inside concessions) contributed to the slowing down of land clearing in oil palm sector. Up to December 2020, one district, Berau, has put the committed areas of 83,876ha as HCV protection into Bupati's Decree on HCV indicative map No 287, year 2020. The other six districts will follow it in the following years. Policy or regulation on HCV management in oil palm has been formulated, and will be issued soon. Prior to commitments of the province and districts to protect HCV areas, the enforcement to manage HCV inside the oil palm concession was weak. As a result, forest conversion from natural forest to oil palm was dominant in deforestation. In the mining sector, deforestation was sharply down. During the reporting period, mining activity significantly decreased due to the low demand for coal in the international market. The mining policy (moratorium on coal mining license) issued by the Provincial Government to evaluate mining license seems effective to reduce the number of coal mining operations in the province.

1.2.1 Update on the strategy to mitigate and/or minimize potential Displacement

The progress of strategic actions to mitigate and minimize potential displacement are as follows:

1.	Conversion of forest to estate crops (oil palm)	
	Risk of displacement	Medium
	Progress of the strategy in Place	The issuance of the Provincial Regulation on Sustainable Plantations and the Governor's Regulation on the Identification of HCV areas, as well as the identification of HCVs in each district have been done and will be continued. The Plantation Office has also established a Sustainable Plantation Communication Forum (<i>Forum Komunikasi Perkebunan Berkelanjutan/FKPB</i>).
2.	Conversion of natural forest to industrial timber plantations	
	Risk of displacement	Low
	Progress of the strategy in Place	Accelerate the implementation of Sustainable Forest Management (<i>Pengelolaan Hutan Produksi Lestari/PHPL</i>) and SVLK in IUPHHK-HT, including the determination of HCV in concession areas. Cooperation between MoEF and the Forestry Agency, as well as KPHs has enhanced to supervise and monitor implementation. Up to December 2020, 21 out of 42 timber plantation concessions have been certified under PHPL certificates.
3.	Unsustainable Forest Management	
	Risk of displacement	Low

	Progress of the strategy in Place	Accelerate the implementation of PHPL and SVLK in IUPHHK-HA, including the determination of HCV and implementation of RIL in concession areas. Cooperation between MoEF and the Forestry Agency, as well as KPHs is enhanced to supervise and monitor implementation. Up to December 2020, there are 53 out of 64 natural forest concessions having PHPL certificates.
4.	Forest clearing for subsistence agriculture	
	Risk of displacement	Medium
	Progress of the strategy in Place	Social forestry program aims to reduce the pressure of natural forests from the expansion of subsistence agriculture. The program has been included into Provincial Mid Term Development Plan (<i>Rencana Pembangunan Jangka Menengah Daerah/RPJMD</i>) 2019-2023 and Provincial Strategic Development Plan (<i>Rencana strategis Pembangunan/Renstra</i>). The annual target for SF in RPJMD is 32,000ha. Up to December 2020, there are 75 SF licenses that have been issued by MoEF with the total size of SF area for 193k ha.
5.	Forest clearing for mining	
	Risk of displacement	Medium
	Progress of the strategy in Place	Mining licenses have been assessed and integrated into one single system (OSS). There is a significant decrease of licenses from 386 to 272. With the new Job Creation Act 2020, the authority of issuing licenses is now controlled under Ministry of Energy and Minerals (National Government Ministry).
6.	Destruction of mangroves for aquaculture	
	Risk of displacement	Low
	Progress of the strategy in Place	The dispute settlement in coastal area that potentially accelerate mangrove conversion to fishponds has been decreasing since the national agrarian reform program (TORA) was launched in East Kalimantan in 2021.

2 SYSTEM FOR MEASUREMENT, MONITORING AND REPORTING EMISSIONS AND REMOVALS OCCURRING WITHIN THE MONITORING PERIOD

2.1 Forest Monitoring System

The ER Program has two sets of organizational structures for measurement, monitoring and reporting of emissions estimates as presented in Figure 1.

Figure 1. Organizational Structure for measurement, monitoring and reporting of the implementation of ER Program

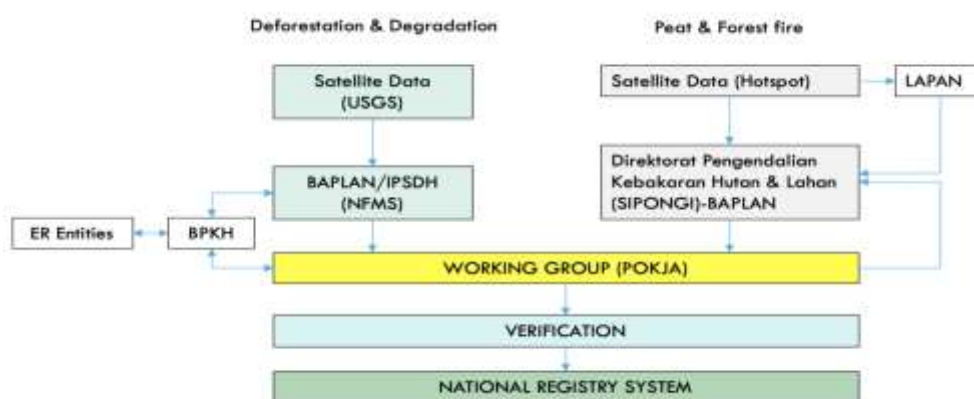


Figure 1 above shows the institutional bodies that responsible for producing annual national land cover (LC) map (scale 250.000). Indonesian national space agency (LAPAN = *Lembaga Penerbangan dan Antariksa Nasional*) provides satellite imageries from various sources and various spatial resolution to MoEF as main input for LC map production. In order to maintain the consistency with earliest LC map year 1990, the image sources used is Landsat products. SPOT 6/7 also provides by LAPAN and often used for validation and accuracy assessment of LC map as well as accuracy assesment Land Cover Change between 2 different LC maps. LAPAN was established on 27 November 1963 and responsible for development and utilization of aerospace technology and research including remote sensing data utilization and production.

BAPLAN (now changed to PKTL - *Forestry Planning and Environmental Management*) as one of DG of MoEF, produces LC map annually since 2011. BAPLAN has several directorate and Forest Resource Inventory and Monitoring Directorate (IPSDH = *Inventarisasi dan Pemantauan Sumber Daya Hutan*) is resonsible for producing national LC assisted by 22 Regional Office for the Management of Forest Area (BPKH = *Balai Pemantapan Kawasan Hutan*) spread from Sumatera to Papua including one office in EK. Most staff of IPSDH dan BPKH have adequate GIS and Remote Sensing knowledge and skills needed for LC production. BPKH did visual interpretation of Landsat imageries and conducting ground check for accuracy assessment (Figure 2). IPSDH will conducting quality control and quality assurance (QC/QA) of BPKH LC map. During the process of LC map production, BPKH may receives input from various institution (ER entities) for ensuring the map is more accurate. Meanwhile, another directorate under BAPLAN named PKHL is responsible to produce annual burn area map based on hotspot information provides by LAPAN. LC and burn area map is used as main input for monitoring and reporting of ER program

implementation in Indonesia and EK. The EK working group of MMR has responsible to analysed LC and burn area map data to calculate various sources of emission from deforestation, forest deradation, fire, soil mangrove and peats at certain period. In EK, Enviroment Service (DLH = *Dinas Lingkungan Hidup*) was appointed as coordinator for working group of MMR. DLH is provincial government body that responsible for environmental management including waste and pollutant management, prevention and controlling environmental degradation. In ER program, EK DLH facilitates MMR working group meeting and resonsible for any administration work as well as submission of emission calculation reports. The MMR system of the ER Program is also integrated with the national forest monitoring system (NFMS) as described in Regulation of Director General of Forest Planning Number P.1/VII- IPSDH/2015.

Data Process at National Level

The BPKH receives satellite data from Forest Resource Inventory and Monitoring (IPSDH). The satellite data is first acquired by LAPAN, which also does pre-processing of data up to mosaicking before sending the data to the respective institutions (including IPSDH). The visual interpretation is conducted by the BPKH using a standard methodology for land cover mapping (Margono *et al*, 2014, 2016). Results of the processing and ground check by BPKHs are sent back to IPSDH for validation by IPSDH including some necessary edge-matching as appropriate, as part of the QA/QC process. Finally, the accuracy of the interpretation is assessed by comparing the land cover maps to field data from the ground check using a contingency matrix (MoFor, 2012, Margono *et al.*, 2012). There are about 300 points for ground checking in East Kalimantan (MoEF, 2017), which are determined randomly by land cover classes. All the data from the BPKH are then consolidated to generate data on forest cover change.

Data Process at sub-national level

The ER Program (through the Working Group⁸ of MMR) analyses the data from the IPSDH/BPKH to calculate emissions from deforestation and degradation, peat decomposition, fire, and loss of mangrove soil from the conversion of mangrove to aquaculture using 2 LCLU maps (T_0 and T_1). Results of the estimation are then submitted to the EK Environmental Service (*Dinas Lingkungan Hidup*/DLH) for internal validation. The DLH then submits the results of the validated calculation to the national registry system.

To facilitate the work of the Working Group, the Government of East Kalimantan has developed a web portal for the Sub-national MMR System for managing all the processed data from the national and also from local governments. The system is operated by the Provincial Environmental Office (DLH) as Coordinator of the East Kalimantan MMR Working Group. The menu on the web portal (<http://mrv.kaltimprov.go.id>) consists of Measurement (data input pages) and Reporting section. In order to access and input data into those sections, it needs a user account that has to be registered to DLH. On the other hand, data related to Emission Factor (*Faktor Emisi*), Activity Data (*Data Aktivitas*) and Emission include Reference Emission Level (*Tingkat Emisi Rujukan*), Actual Emission after reference period (*Emisi Aktual*) and Performance of Emission Reduction (*Kinerja Penurunan Emisi*) are publicly available.

⁸ The Working Group of MMR is led by Provincial Environmental Service. The members are from Bureau Economy of Governor Office, Forestry Service, Estate Crop Service, Dipteropa Agency – MoEF, Forest Ecocsytem Wregion IV – MoEF, Climate Change Regional Council/Dewan Daerah Perubahan Iklim/DDPI, Mulawarman University, Bioma Foundation, Yasiwa Foundation, Planet Urgence, Conservation Foundation, GGGI, GiZ, and YKAN)

The MMR web portal has been tested using national data. The infrastructure for the server has been ready and installed in Samarinda, East Kalimantan. This MMR web portal increases public participation of Government Services to village communities or indigenous people to update their ER activities and participate in monitoring the condition of forests and changes in the forest/land that occurs.

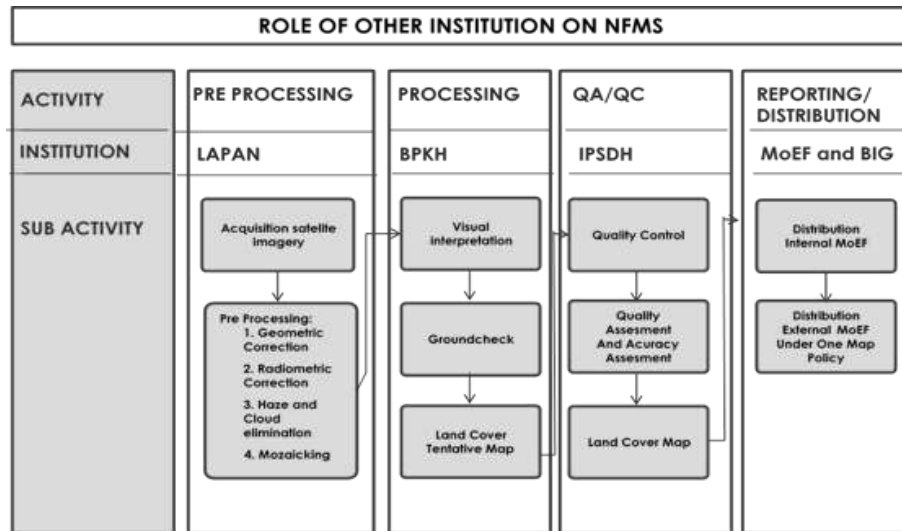


Figure 2. Related institutions on NFMS management (MoEF, 2017)

The process of the production of land cover maps will be on an annual basis as defined in the Regulation of the Director General of Forest Planology Number P.1/VII- IPSDH/2015⁹. The timeline of the process is shown in **Error! Reference source not found..** The collection of the LANDSAT images is conducted throughout the year by LAPAN and the pre-processing of the image is conducted as the data becomes available for producing the mosaic. The mosaic will be available by June to be distributed to IPSDH and to BPKH.

Design and maintenance of the Forest Monitoring System

The design of Indonesia forest monitoring system is formally regulated using MoEF regulation No. P7/2021¹⁰. Indonesia forest monitoring system includes two main components which is forest inventory and land cover mapping. National forest inventory is conducted by MoEF at least once in a five year period using more than 4000 sample plots distributed systematically (20 km × 20 km) across Indonesia. The national forest inventory started for the first time in 1989 as supported by FAO and WB. The sample plots is set as rectangle shape with size 100 m × 100 m (for non mangrove forest) and 50 m × 50 m (for mangrove forest). Approximately 74% of these sample plots were used for calculating Indonesia FREL. One of the pivotal result from national forest inventory is emission factor (biomass stock) for each land cover classes after calculated using allometric equations by Manuri *et.al* (2017)¹¹ and Chave (2014)¹².

⁹ <https://mrv.kaltimprov.go.id/storage/guest/ERMRI/Guidance/PERDIRJEN Planologi Kehutanan No P.1-VII-IPSDH-2015 Tentang Pedoman Pemantauan Penutupan Lahan.pdf>

¹⁰ https://mrv.kaltimprov.go.id/storage/guest/ERMRI/Regulation/2021pmlhk007_menlhk.pdf

¹¹ <https://link.springer.com/article/10.1007/s13595-017-0618-1>

¹² <https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.12629>

Complementing to national forest inventory is land cover mapping. Land cover mapping is not limited to forest area but to all land cover that appropriate to mapping product scale 250.000. Twenty three of land cover classes (including cloud class) has been mapped since 1990 for entire Indonesia mass land. Since 2011, MoEF has successfully produced annual land cover maps of Indonesia. The LC map is used for monitoring the forest coverage that can be further analysed for deforestation and forest degradation by comparing two set of LC map data. Interpretation of satellite image is conducted by trained and skilled personel in BPKH using visual method in GIS enviroment combine with ground checking. The budget for ground checking is always prepared by BPKH since it is necessary to calculate the accuracy.

The interpretation process is often conducted in July-October, while ground check is conducted in June-September. In October-December, all the results of the interpretation by BPKH will be compiled to the national by IPSDH for QA/QC and accuracy assessment. By February Y+1, the result of the interpretation is normally finalized and reported. Table below shows the LC map production under current national forest monitoring system (NFMS).

Table 2. Timeline of land cover map production under the current NFMS

No	Activity	Year (n-1)						Year (n)											
		J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
A	LAPAN																		
	Collecting Landsat Satelite Image																		
	Finalization of Mozaik (M)													M					
B	IPSDH																		
	Techncail evaluation																		
	Supervision																		
	Quality Control																		
	Data finalization (DF)																		
	Reporting *																		DF R
C	IPSDH/BPKH																		
	Data distribution (DD)																		
	Interpretation																		
	Ground Checking																		
	National Compilation of results (NC)																	NC	

For Measurement, Monitoring and Reporting (MMR) of peat and forest fire, as seen in Figure 2, estimation of peat and forest burnt area is based on Director General of Climage Change (DG-CC) MoEF Regulation No. P.11/PPI/PKHL/Kum.1/12/2018¹³. The interpretation of the burned area uses remote sensing data, such as Landsat, SPOT and others, and is supported by hotspot data obtained from monitoring satellite imagery of NOAA-AVHRR, SNPP-VIIRS, ATSR, Terra/Aqua MODIS, Himawari and others. It is also supported by information based on the results of ground check reports and forest fire extinguishing locations. Such data analysis was done by the Directorate for Forest and Land Fire Prevention, of the MoEF. The ER Program (through the Working Group) gets access to and analyses the burn scar data in order to estimate burnt area and greenhouse gas emissions. Results of the estimation are then submitted to IPSDH for internal verification.

¹³ [https://mrv.kaltimprov.go.id/storage/guest/ERMRI/Guidance/Perdirjen P. 11 Pedoman Teknis Penaksiran Luas Karhutla \(2\).pdf](https://mrv.kaltimprov.go.id/storage/guest/ERMRI/Guidance/Perdirjen P. 11 Pedoman Teknis Penaksiran Luas Karhutla (2).pdf)

Indonesia forest monitoring system continue to evolve and improve the method and tools for getting trustworthy data on land cover map and biomass stock by involving uncertainty analysis started in 2020. Other than land cover map and biomass stock, Indonesia forest monitoring system is currently producing burn scare map at montly period that pivotal for calculating emission from fire.

Systems and processes that support the Forest Monitoring System, including Standard Operating Procedures and QA/QC procedures

At national level, Indonesia forest monitoring system is supported by MoEF (IPSDH) and LAPAN as shown in Figure 1 and 2. At sub-national level (East Kalimantan province), the system is supported by DLH especially for emission calculation. LAPAN provides mozaics of Landsat imageries to be further interpreted by BPKH. LAPAN has two ground stations (located in Parepare, South Sulawesi and Rumpin, Bogor, West Java) for receiving and processing Landsat raw data sets (in daily basis) into L1 level (image scene was corrected using ground control points dan digital elevation model). Collection of L1 level imageries send to LAPAN office in Jakarta for further processing into L2 level or Analysis Ready Data (ARD). Analysis Ready Data (ARD) are pre-packaged and pre-processed bundles of Landsat data products that make the Landsat archive more accessible and easier to analyze, and reduce the amount of time users spend on data processing for time-series analysis. Collection of Landsat ARD image in a single year are then processed into RGB mosaics by LAPAN Jakarta office before distributed to end user (e.g. IPSDH). Further information on Landsat processing procedure by LAPAN see page 20 on this [link](#).

MoEF (IPSDH) has already provided procedure for interpreting medium resolution satellite images i.e. Landsat images from LAPAN ([click to see the document](#)). The procedure contains key interpretation of 23 land cover classes as guidance for operator GIS in BPKH during interpretation process. For calculating accuracy and uncertainty, another separate document is provided by IPSDH¹⁴. These 2 procedures ensure the quality and accuracy of LC data that will be used to calculate land cover change and emission from deforestation and forest degradation in ER program.

The ER Program in East Kalimantan uses the data generated by the above mentioned NFMS that consist of Forest inventory data and LC map. The system provides continuous information on activity data and emission factors that can ensure the sustainability of activity data supply needed for estimating emission reductions from the implementation of the ER Program, thus ensuring consistency. The ER Program will continue to apply these samples-based area estimation for ER purposes, and will consider whether this approach is also applicable to the NFMS for national reporting purposes.

In addition, the ER Program also includes ground checking activities, as mentioned above, to increase the number of points required for the accuracy assessment. At present, due to limited budget BPKH can only do ground checks in a small number of observation points. Through the ER Program, it is planned for ER Entities, as shown in Figure 2.

Role of communities and non-government in the forest monitoring system

¹⁴ https://mrv.kaltimprov.go.id/storage/guest/ERMRI/Guidance/SOP_AKURASI_ISI_EBOOK.pdf

The community and non-government parties can provide input to the MoEF through Directorate Forest Resource Inventory and Monitoring (IPSDH), if they find data that is not in accordance with field conditions. Reports are accompanied by field photo documentation, as well as GPS location points. Regarding forest fire information, based on real-time hotspot data, short messages are sent from the national to the provincial level, then forwarded to the district to the village head. The village then carried out a field check, and re-informed the actual situation on the ground.

We highlight a minor alteration of Indonesia national forest monitoring system (NFMS) URL (uniform resource locator) from http://webgis.menlhk.go.id:8080/nfms_simontana/ as it is mentioned in ERPD, to the new URL as <https://nfms.menlhk.go.id/>

2.2 Measurement, monitoring and reporting approach

2.2.1 Line Diagram

The ER Program applies methods for monitoring activity data and for estimating emission factors that are aligned with the approach used in developing Indonesia's FREL and that comply with established standards for the measurement of satellite imagery (LANDSAT) interpretation to estimate forest cover changes (SNI 8033:2014).¹⁵ These standards have been defined in the annex of the Regulation of the Director General of Forest Planology Number P.1/VII-IPSDH/2015¹⁶. Technical guidelines for field observation and ground check procedures for land cover accuracy assessment can be seen in Annex 9.1 ERPD and Annex 9.2 ERPD, respectively. In the implementation phase (June 2019-December 2024), activity data (AD) and emission factors (EF) are monitored in the Accounting Area to measure emissions from deforestation and forest degradation. Monitoring follows the procedures defined in the NFMS (national forest monitoring system) and in the East Kalimantan forest inventory. Parameters to be monitored include the same parameters used to develop the REL, specifically:

Activity Data

- Forest cover change resulting in deforestation or forest degradation for all land that was forested in 2006.
- Areas of burned forest land in stable secondary forest and peat land starting in 2006.

Emission Factors

- Emission factors for live biomass by land cover classes (forested and non forested)
- Emission factors for peat and mangrove soils
- Emission factors for fires

Table 3. Characterization of forest and non-forests in Indonesia used in national land cover mapping

No	Land cover type	Code	Description
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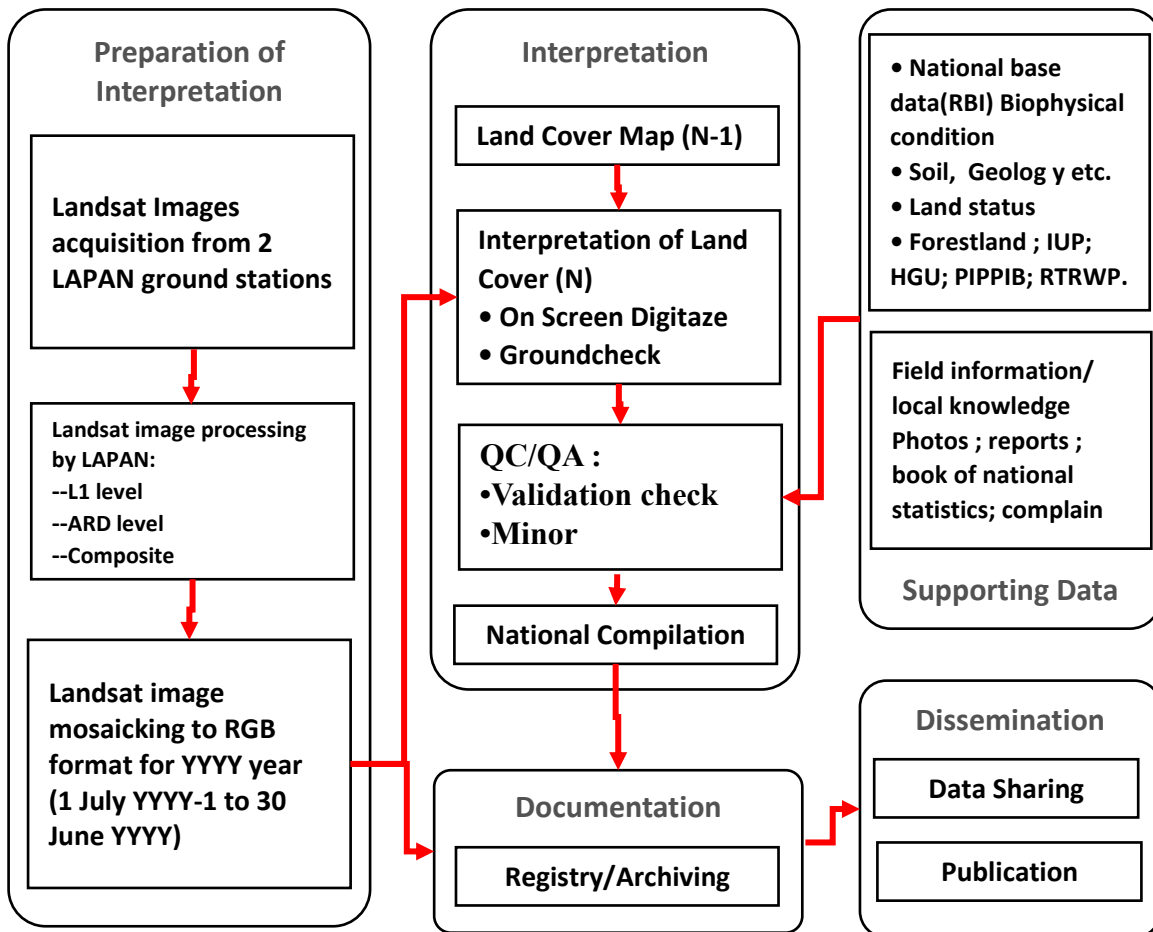
¹⁵ Standar Nasional Indonesia (Indonesia National Standard) No. 8033 year 2014 regarding Method for Estimation of Forest Cover Changes based on Result of Visual Interpretation of Optical Remote Sensing Imagery.

¹⁶ Perdirjen Planologi (2015). Pedoman pemantauan penutupan lahan (guidance for monitoring land cover change). http://appgis.dephut.go.id/appgis/download/Pemantauan%20Hutan%20Nasional/Perdirjen_Plano_2015_01_Pedoman_PSDH.pdf

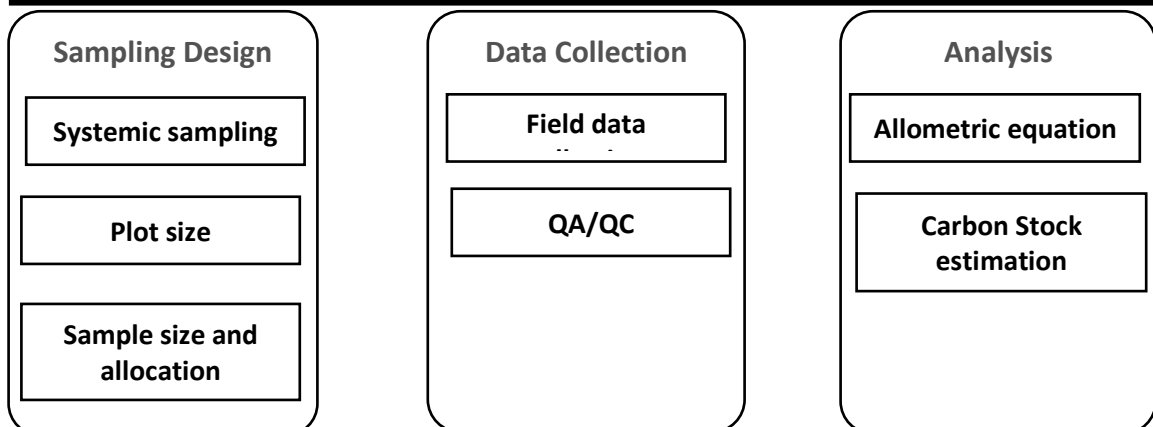
No	Land cover type	Code	Description
Forests			
1	Primary dry land forest	2001	Natural tropical forests growing on non-wet habitat including lowland, upland, and montane forests with no signs of logging activities. The forest includes heath forest and forest on ultramafic and lime-stone, as well as coniferous, deciduous and mist or cloud forest, which shows no, or little, influence from human activities such as logging.
2	Secondary dry land forest	2002	Natural tropical forests growing on non-wet habitat including lowland, upland, and montane forests that exhibit signs of logging activities indicated by patterns and signs of logging (appearance roads and patches of logged-over area). The forest includes heath forest and forest on ultramafic and lime-stone, as well as coniferous, deciduous and mist or cloud forest.
3	Primary swamp forest	2005 biics2020test	Natural tropical forests growing on wet habitat in swamp form, including, brackish swamp, marshes, sago and peat swamp, which shows no, or little, influence from human activities such as logging.
4	Secondary swamp forest / logged forest	20051	Natural tropical forests growing on wet habitat in swamp form, including brackish swamp, marshes, sago and peat swamp that exhibit signs of logging activities indicated by patterns and signs of logging (appearance roads and logged-over patches).
5	Primary mangrove forest	2004	Wetland forests in coastal areas such as plains that are still influenced by the tides, muddy and brackish water and dominated by species of mangrove including Nipa (<i>Nipafrutescens</i>), which shows no, or little, influence from human activities such as logging.
6	Secondary mangrove forest / logged forest	20041	Wetland forests in coastal areas such as plains that are still influenced by the tides, muddy and brackish water and dominated by species of mangrove and Nipa (<i>Nipa frutescens</i>), and exhibit signs of logging activities, indicated by patterns and signs of logging activities.
7	Plantation forest	2006	The appearance of the structural composition of the forest vegetation in large areas, dominated by homogeneous trees species, and planted for specific purposes. Planted forests include areas of reforestation, industrial plantation forest and community plantation forest.
Non-Forests			
8	Dry shrub	2007	Highly degraded logged over areas on non-wet habitat that are ongoing process of succession but not yet reach stable forest ecosystem, having natural

No	Land cover type	Code	Description
			scattered trees or shrubs.
9	Wet shrub	20071	Highly degraded logged over areas on wet habitat that are ongoing process of succession but not yet reach stable forest ecosystem, having natural scattered trees or shrubs.
10	Savanna and Grasses	3000	Areas with grasses and scattered natural trees and shrubs. This is typical of natural ecosystem and appearance on Sulawesi Tenggara, Nusa Tenggara Timur, and south part of Papua island. This type of cover could be on wet or non-wet habitat.
11	Pure dry agriculture	20091	All land covers associated with agriculture activities on dry/non-wet land, such as tegalan (moor), mixed garden and ladang (agriculture fields).
12	Mixed dry agriculture	20092	All land covers associated with agriculture activities on dry/non-wet land that is mixed with shrubs, thickets, and log over forest. This cover type often results of shifting cultivation and its rotation, including on karts.
13	Estate crop	2010	Estate areas that has been planted, mostly with perennials crops or other agriculture trees commodities.
14	Paddy field	20093	Agriculture areas on wet habitat, especially for paddy, that typically exhibit dyke patterns (pola pematang). This cover type includes rainfed, seasonal paddy field, and irrigated paddy fields.
15	Transmigration areas	20122	Kind of unique settlement areas that exhibit association of houses and agroforestry and/or garden at surrounding.
16	Fish pond/aquaculture	20094	Areas exhibit aquaculture activities including fish ponds, shrimp ponds or salt ponds.
17	Bare ground	2014	Bare grounds and areas with no vegetation cover yet, including open exposure areas, craters, sandbanks, sediments, and areas post fire that has not yet exhibit regrowth.
18	Mining areas	20141	Mining areas exhibit open mining activities such as open-pit mining including tailing ground.
19	Settlement areas	2012	Settlement areas including rural, urban, industrial and other settlements with typical appearance.
20	Port and harbor	20121	Sighting of port and harbor that big enough to independently delineated as independent object.
21	Open water	5001	Sighting of open water including ocean, rivers, lakes, and ponds.
22	Open swamps	50011	Sighting of open swamp with few vegetation.
23	Clouds and no-data		Sighting of clouds and clouds shadow with size more than 4 cm2 at 100.000 scales display.

[1] ACTIVITY DATA



[2] EMISSION FACTOR



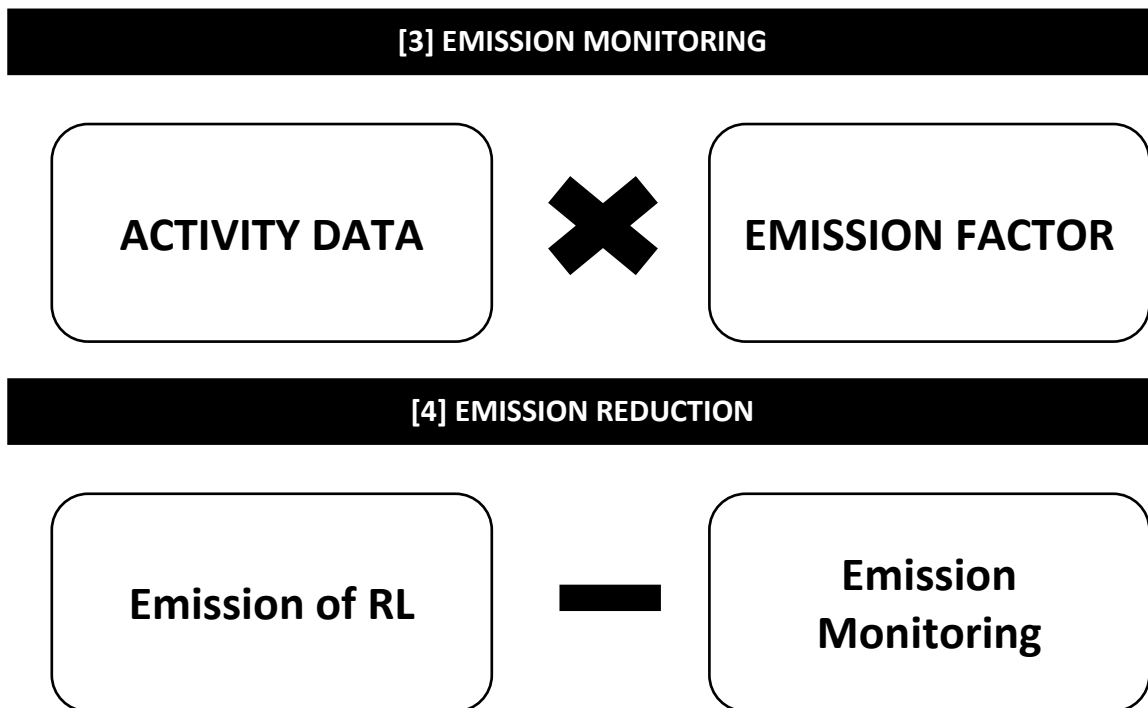


Figure 3. Flow chart for calculation of emissions from deforestation and forest degradation

2.2.2 Calculation

Emission reduction calculation

$$ER_{ERP,t} = RL_t - GHG_t \quad \text{Equation 1}$$

Where:

- ER_{ERP} = Emission Reductions under the ER Program in year t ; $tCO_2e \cdot year^{-1}$.
- RL_{RP} = Gross emissions of the RL from deforestation and forest degradation over the Reference Period; $tCO_2e \cdot year^{-1}$. This is sourced from Annex 4 to the ER Monitoring Report and equations are provided below.
- GHG_t = Monitored gross emissions from deforestation and forest degradation at year t ; $tCO_2e \cdot year^{-1}$;
- t = Number of years during the monitoring period; dimensionless.

Reference Level (RL_t)

Following the TAP assessment of the ERPD, Indonesia notified the FMT on the intention to apply technical corrections to the reference level for the ER-Program before the signing of the ERPA. The corrected RL estimation may be found in Annex 4, yet a description of the equations is provided below.

Gross emissions of the RL from deforestation over the Reference Period (RL_{RP}) are estimated as the sum of annual change in total biomass carbon stocks (ΔC_{B_t}) during the reference period.

The calculations of Emissions in the Monitoring period using the same method as the Reference Level.

The calculation of the emission over the reference period and the monitoring period are given in files, [fcpf_ekjerp_ermr1_MC_26Juli2022c.xlsx](#). The calculation of the monitored emission (combining Activity Data and Emission Factors) is given in the same file where specific calculation for each carbon pool is given in different sheets with naming convention listed in the following table.

AD_ER_DEF_XXYY	:	Activity Data and Monte Carlo Simulation of Carbon Emission from Deforestation between year 20XX to year 20YY
AD_ER_DEG_XXYY	:	Activity Data and Monte Carlo Simulation of Carbon Emission from Forest Degradation between year 20XX to year 20YY
AD_ER_DEK_XXYY	:	Activity Data and Monte Carlo Simulation of Carbon Emission from Peat Decomposition between year 20XX to year 20YY
ER_SMangrove	:	Activity Data and Monte Carlo Simulation of Carbon Emission from Mangrove Soil for reference and monitoring periods
Peat_Def_Fire	:	Activity Data and Monte Carlo Simulation of Carbon Emission from Fire on Peatland for reference and monitoring periods
FireStableForest	:	Activity Data and Monte Carlo Simulation of Carbon Emission from Fire on Stable Forest for reference and monitoring periods

Beside these main worksheets, the following sheets are also available to help understand the calculation of carbon emission

EF_EKJERP	:	Above ground biomass, root:shoot ratio, carbon fraction, below ground biomass, emissions factors for mangrove, peat and fire used in this work
UncertaintyAD	:	Reference tables for Uncertainties for each land cover change status
ActivityData0616	:	Attribute table of the land cover change map in reference period
ActivityData1521	:	Attribute table of the land cover change map in monitoring period
Sum All	:	Summary of Carbon Emission from each Carbon Pools
Sum Def	:	Summary of Monte Carlo Simulation for Emission from Deforestation
Sum Deg	:	Summary of Monte Carlo Simulation for Emission from Degradation
Sum SMgrv	:	Summary of Monte Carlo Simulation for Emission from Mangrove Soil
Sum PeatDek	:	Summary of Monte Carlo Simulation for Emission from Peat Decomposition
Sum PeatFire	:	Summary of Monte Carlo Simulation for Emission from Fire on Peatland
Sum StableForest	:	Summary of Monte Carlo Simulation for Emission from Fire on Stable Forest
SumSensitivityAnalysis	:	Summary of Sensitivity Analysis for Each Carbon Pools

The following sections show the calculations of emissions for the different components discussed above.

● CARBON STOCK AND EMISSION FACTOR

The estimation of the carbon stock of the above ground biomass of the six forest-types uses local allometric models, i.e.

- Dryland forest (Manuri et al., 2017)

$$AGB = 0.167 \times DBH^{2.56} \times WD^{0.889} \quad (\text{Equation 2})$$
- Swamp forest (Manuri et al., 2014)

$$AGB = 0.242 \times DBH^{2.473} \times WD^{0.736} \quad (\text{Equation 3})$$
- Mangrove forest (Komiyama et al., 2005)

$$AGB = 0.251 \times WD \times DBH^{2.46} \quad (\text{Equation 4})$$

where:

AGB= Above ground biomass

DBH= Diameter at chest height

WD= Weight density

To convert AGB (t/ha) to C (t/ha) for each forest types, carbon fraction of 0.47 is used as suggested by the IPCC 2006 ($C = 0.47 \times AGB$).

The below ground biomass (BGB) for dry forest is estimated using root-shoot ratio from the IPCC GPG LULUCF (Table 3A.1.8. page 3.168). The value of the ratio is 0.24 for dry forest. For mangrove forest the value is 0.36 based on measurement reported in Komiyama et al., 2005 for mangrove forest in Indonesia. For swamp forest is assumed to be the same as that of mangrove forest in Indonesia.

The data source for the carbon stock of non-forest lands is derived from mainly Indonesian literatures (ER-PD Annex 8.3.). The below ground biomass (BGB) of non-forest classes is also estimated using root-shoot ratio based on IPCC default values (IPCC GPG GL for LULUCF page 3.168 table 3A.1.8). The values of the ratio vary between land cover types, i.e. 0.32 for forest plantation and estate crops), 0.48 for dry and wet shrubs, mix dryland agriculture and transmigration area, and 1.58 for savanna/grassland, pure dryland agriculture, rice paddy, bare ground and settlement.

Emission factors EF_f for biomass consumed by fire can be developed based on Eq. 2.27 in the IPCC 2006 Guidelines for National Greenhouse Gas Inventories (GL), Volume 4, using the following formula:

$$L_{fire} = A * EF_f \quad (\text{Equation 5})$$

$$EF_f = M_B * C_f * G_{ef} * 10^{-3} \quad (\text{Equation 6})$$

$$L_{fire} = A * M_B * C_f * G_{ef} * 10^{-3} \quad (\text{Equation 7})$$

L_{fire} = amount of greenhouse gas emissions from fire, tonnes of each GHG e.g., CO₂, CH₄, N₂O

A = burnt area, ha

M_B = mass of fuel available for combustion, tonnes ha⁻¹.

C_f = combustion factor, dimensionless (default values in Table 2.6 of the 2006 IPCC Guideline, Chapter 2-page 2.48). The default value of the IPCC combustion factor, C_f , is 0.36

G_{ef} = emission factor, g kg⁻¹ dry matter burnt (1580 for CO₂, 6.8 for CH₄ and 0.20 for N₂O, Table 2.5 of 2006 IPCC Guideline, Chapter 2- Page 2.47)

Emission factors EF_f for the peat fires can be developed based on Eq. 2.27 in the IPCC 2006 Guidelines for National Greenhouse Gas Inventories (GL), Volume 4, using the following formula:

$$L_{fire} = A * EF_f \quad (\text{Equation 8})$$

$$EF_f = M_B * C_f * G_{ef} * 10^{-3} \quad (\text{Equation 9})$$

$$L_{fire} = A * M_B * C_f * G_{ef} * 10^{-3} \quad (\text{Equation 9})$$

L_{fire} = amount of greenhouse gas emissions from fire, tonnes of each GHG e.g., CO₂, CH₄, N₂O

A = burnt area, ha

M_B = mass of fuel available for combustion, tonnes ha⁻¹.

C_f = combustion factor, dimensionless (default values in Table 2.6 of the 2006 IPCC Guideline, Volume 4, Chapter 2-page 2.48)

G_{ef} = mission factor, g kg⁻¹ dry matter burnt (default values in Table 2.7, Chapter 2 of 2013 Supplement to 2006, page 2.36)

The M_B for the peat is 353 tons dry matter per hectare following IPCC default (Table 2.6 of the Chapter 2 in page 2.40, 2013 Supplement to the 2006 IPCC). The M_B depends on depth of peat and bulk density of the peat. Based on measurement in Central Kalimantan, the M_B is about 505 tons dry matter per hectare with assumption that the average depth of peat burn is 0.33 m and bulk density 0.153 t/m³ (MRI 2013). However, we adopt the IPCC default as the default considering the data was based on measurement from multiple locations that may represent better general condition. The C_f is taken from the IPCC default value (Tables 2.6 of 2006 IPCC Vol. 4 Chapter 2). The G_{EF} for CO₂ is 1,701 g/kg dry matter burnt (Table 2.7 of the Chapter 2 of the 2013 Supplement to the 2006 IPCC, page 2.36) and for CH₄ is 21 g/kg dry matter burnt.

Calculation of emission factor of mangrove soil, i.e. the difference between amount of carbon in the mangrove soil (C_M) and amount of carbon in soil on the floor of the aquaculture system (C_{AQ}). Data on the soil carbon of mangrove and abandoned pond is taken from Kauffman *et al.* (2017) based on measurement from the 20 locations in East Kalimantan. The procedure for the sampling is described in Kauffman *et al.* (2016). Based on measurement in 20 locations in East Kalimantan, the value of C_M is 902.91 tC/ha and the value of C_{AQ} is 487.31 tC/ha, thus the EF for conversion of mangrove soil to aquaculture system is 415.6 tC/ha (Kauffman, 2017¹⁷).

¹⁷ <https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1002/fee.1482>

● EMISSIONS FROM DEFORESTATION

Emissions from deforestation include the following:

- Emissions associated with loss of living forest biomass
- Emissions associated with soil carbon

As described in the previous section, the carbon pools used to measure emissions from deforestation depend on the land type. For deforestation on mineral soils AGB and BGB are included. For deforestation on organic soils (peat forests and mangroves) soil carbon is also included. The methods for calculating emissions from deforestation are described below.

a. Deforestation emissions from living biomass

The method used for the calculation of average annual historical emissions follows the national method (MoEF, 2015)¹⁸ that is consistent with the IPCC. Emissions from deforestation at a given period were calculated by aggregating CO₂ emissions resulting from newly identified deforested areas within that period.

The calculation of CO₂ emissions from deforested areas used the following equation:

$$GE_{ijk} = A_{ijk} \times EF_{jk} \times (44/12) \quad \text{(Equation 10)}$$

GE_{ijk} = CO₂ emissions from deforested area-i at forest change class-j to non-forest class-k, in tCO₂e

A_{ijk} = Deforested area-i in forest change class-j to non-forest class-k, in hectare (ha).

EF_j = Emission Factor which is calculated as the difference between carbon stock of forest class-j and carbon stock of non-forest class-k, in ton carbon per ha (tC ha⁻¹). Emission factors for each forest and non-forest class are listed in sub-chapter 3.1.1 ER-PD/Annex 4 ER-MR.

(44/12) is conversion factor from tC to tCO₂e

Carbon stock of the lands after the conversion used in the calculation of the emission from the deforestation is the lifetime average carbon stock. It is assumed that land-cover types after deforestation will not change. This assumption is adopted since it is not practical to track the changes of land cover after deforestation, and it is unlikely that the natural forest that have been converted to non-forest lands will change back to natural forest. The deforestation of primary or secondary forest to non-forested was also counted only once that occur at one particular area. Identification of primary or secondary forest area in particular year is filtered using the primary or secondary forests of the previous years. Thus, the deforestation of primary and secondary forest to non-forested will be detected only in remaining primary or secondary forests of the previous years that have never been deforested before.

¹⁸ https://redd.unfccc.int/files/national_frel_for_redd_in_indonesia_2015.pdf

The emission from gross deforestation at period t (GE_t), was estimated using equation below,

$$GE_t = \sum_{i=1}^N \sum_{j=1}^P GE_{ijk} \quad (\text{Equation 11})$$

GE_t = total emission at period t from deforested area-l in forest class-j to non-forest class-k, expressed in tCO₂

N = number of deforested area units at period t (from t₀ to t₁), expressed without unit

P = number of forest classes which meet natural forest criterion.

Further, average emissions from deforestation from all periods were calculated as follows:

$$MGE_P = \frac{1}{T} \sum_{t=1}^P GE_t \quad (\text{Equation 12})$$

MGE_P = mean or average emissions from deforestation from all period P (expressed in tCO₂yr⁻¹)

t = number of years in period P

The estimation of emission from deforestation from the loss of living biomass between two years (period) used the land use transition matrix.

The emissions from the change of a land use category to other land use category from the transition matrix used the equation 2 and their corresponding emission factors as defined in sub- chapter 3.1.1.

Indonesia's National Forest Monitoring System (NFMS) categorize the whole land uses into six different forest types and 17 land cover types. Ideal carbon emission accounting shall consider every land cover types since they have different carbon content. However, combining 6 forest cover types and 17 non-forest cover types is indeed a tedious work, so the East Kalimantan Carbon Accounting Task Force decided to weight the emission factors of all non-forest cover types and ended up with only six different combinations of the carbon emissions.

b. Deforestation emissions from soil carbon

b1. Emissions from Peat decomposition in deforested areas

Peat emissions happen slowly over time once land is cleared for a number of years depending on the depth of the peat soil. Thus the emissions in any given year is the sum of emissions from all peat lands disturbed over the previous years. These emissions from prior year deforestation are called 'inherited emissions' (e.g. Agus et al., 2011¹⁹). This means that total emissions from peat decomposition is defined as accumulation of peat emissions from forested lands starting with the Reference Period base year of 2006 onward. Considering the inherited carbon emissions on peatland, the carbon emission from peat decomposition between year 2017-2018 is considered as total carbon emission for the whole reference period (2006-2016).

¹⁹ <http://apps.worldagroforestry.org/sea/Publications/files/manual/MN0051-11.pdf>

The procedures of calculating peat decomposition from deforestation follow three steps as shown in Annex 4 E Figure 8.5. First is defining natural forest in 2006 over peat land, and then step 2 is generating land cover change from each interval year to define a transition area matrix for the associated year of interval. The third step is calculating total annual emissions by multiplying the transition matrix of both areas and associated emission factors.

Calculation of emissions from peat decomposition used the same basis as emissions from deforestation. This is due to the fact that once deforestation occurs in peat forest, there will be emissions from removal of the ABG at the time of conversion as describe above, and plus from peat decomposition subsequently. The formula for estimating the emission from peat decomposition is the following:

$$PDE_{ijt} = A_{ijt} \times EF_j \quad (\text{Equation 13})$$

PDE = CO₂ emission (tCO₂yr-1) from peat decomposition in peat forest area-i changed into land cover type-j within time period-t

A = area-i of peat forest changed into land cover type-j within time period-t

EF = the emission factor from peat decomposition of peat forest changed into land cover class-j (tCO₂ ha yr-1)²⁰

Emission factor for peat decomposition of peat forest change using Paciornik and Rypdal (2006) and IPCC (2014). These emission factors are reported in 2013 Supplement Guideline to 2006 IPCC Guidelines for National GHG Inventory: Wetlands²¹. Most of the data reported in the guideline come from Indonesian experiences.

b2. Emissions from Peat Fire in deforested areas

Emission factors EF_f for the peat fires can be developed based on Eq. 2.27 in the IPCC 2006 Guidelines for National Greenhouse Gas Inventories (GL), Volume 4, using the following formula:

$$L_{fire} = A * EF_f \quad (\text{Equation 14})$$

$$EF_f = M_B * C_f * G_{ef} * 10^{-3} \quad (\text{Equation 15})$$

$$L_{fire} = A * M_B * C_f * G_{ef} * 10^{-3} \quad (\text{Equation 16})$$

L_{fire} = amount of greenhouse gas emissions from fire, tonnes of each GHG e.g., CO₂, CH₄, N₂O

A = burnt area, ha

M_B = mass of fuel available for combustion, tonnes ha⁻¹.

²⁰ Emission factor for an area of change is an average of the emission factors of the respective land cover before and after. This reflects the assumption that conversion of land cover on peatland between two time periods gradually affects the peat water table implying a gradual peat decomposition emission. For example, the emission factor of secondary forest is 19 tCO₂ ha-1 y-1 and the emission factor of bare ground is 51 tCO₂ ha-1 y-1, so that the average emission factor for an area changing from secondary forest to bare ground is 35 tCO₂ ha-1 y-1.

²¹ [CHAPTER 1 \(ipcc.ch\)](#)

C_f = combustion factor, dimensionless (default values in Table 2.6 of the 2006 IPCC Guideline, Volume 4, Chapter 2-page 2.48)

G_{ef} = emission factor, $g\ kg^{-1}$ dry matter burnt (default values in Table 2.7, Chapter 2 of 2013 Supplement to 2006, page 2.36)

The M_B for the peat is 353 tons dry matter per hectare following IPCC default (Table 2.6 of the Chapter 2 in page 2.40, 2013 Supplement to the 2006 IPCC). The M_B depends on depth of peat and bulk density of the peat. Based on measurement in Central Kalimantan, the M_B is about 505 tons dry matter per hectare with assumption that the average depth of peat burn is 0.33 m and bulk density $0.153\ t/m^3$ (MRI 2013). However, we adopt the IPCC default as the default considering the data was based on measurement from multiple locations that may represent better general condition. The C_f is taken from the IPCC default value (Tables 2.6 of 2006 IPCC Vol. 4 Chapter 2). The G_{EF} for CO_2 is 1,701 g/kg dry matter burnt (Table 2.7 of the Chapter 2 of the 2013 Supplement to the 2006 IPCC, page 2.36) and for CH_4 is 21 g/kg dry matter burnt.

Calculation of emissions from peat fire in the deforested area (L_{fire}) is calculated using the following formula (IPCC, 2014):

$$L_{fire} = A * EF_f = A * M_B * C_f * G_{ef} * 10^{-3} \quad (\text{Equation 17})$$

L_{fire} = amount of greenhouse gas emissions from fire, tonnes of each GHG e.g., CH_4 , N_2O , etc.

A = area burnt, ha

M_B = mass of fuel available for combustion, tonnes ha^{-1} .

C_f = combustion factor, dimensionless (default values in Table 2.6 of the 2006 IPCC Guideline, Volume 4 Chapter 2-page 2.48)

G_{ef} = emission factor, $g\ kg^{-1}$ dry matter burnt (default values in Table 2.5 of the 2006 IPCC Guideline, Volume 4 Chapter 2-page 2.47)

b3. Emissions from *Mangrove Soil in deforested areas*

When mangrove forests are converted to aquaculture, they normally are being cleared and the soil being removed or excavated, normally 1.5 to 2 meters deep. When the organic soils are excavated, they exposed to aerobic condition and being oxidized that emit CO_2 . Considering that soil mangrove has very high organic content (Kauffman et al, 2017²² and Murdiyarso et al, 2015²³), conversion of mangroves will result in a significant amount of CO_2 emissions.

Calculation of emissions from mangrove soil in the ER program is considered only for conversion to aquaculture. Emissions released are calculated as potential emissions assuming that emissions from organic soil removed from the floor of the aquaculture system are emitted once

²² <https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1002/fee.1482>

²³ <https://www.nature.com/articles/nclimate2734>

at the time of the conversion. Thus, the calculation of the emissions from conversion of mangrove to aquaculture (E_{MS}) used the following formula:

$$E_{MS} = A_{MA} \times EF_{MA} \quad (\text{Equation 18})$$

A_{MA} is area of mangrove converted to aquaculture, EF_{MA} is emission factor, i.e. the difference between amount of carbon in the mangrove soil (C_M) and amount of carbon in soil on the floor of the aquaculture system (C_{AQ}).

Summary: Average Historical Emissions from Deforestation

Emissions from deforestation is calculated based on the emissions associated with loss of living forest biomass (AGB and BGB), and the emissions associated with soil carbon. The Emission from soil includes the emission from peat soil due to decomposition process, and fire events, and also the emission from mangroves soil due to mangrove conversion to aquaculture.

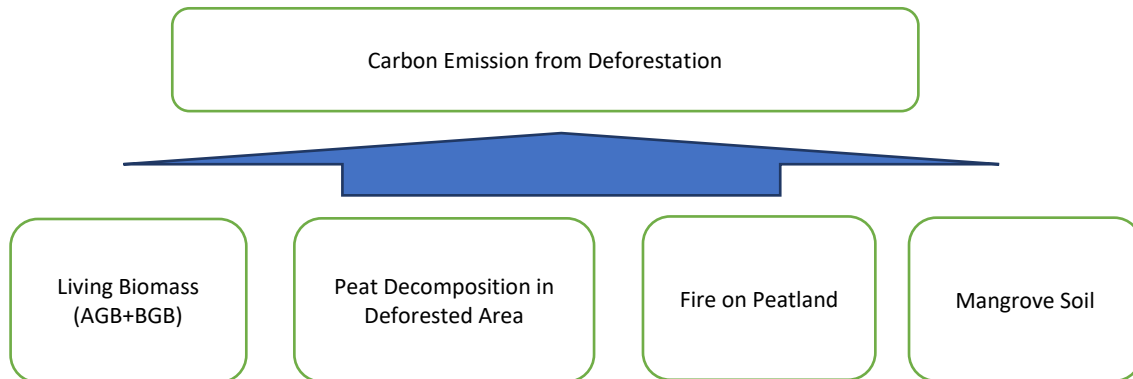


Figure 4. Emission from Deforestation

● EMISSIONS FROM FOREST DEGRADATION

The emission from degradation of natural forest include:

1. *Emissions due to the degradation of primary forest into secondary forest*
2. *Emissions due to further degradation of secondary forest caused by fire*
3. *Emissions from peat decomposition in secondary forests*

a. Emissions from forest degradation of primary forest to secondary forest

The assessment of changes of primary forest to secondary forest and the estimation of emissions from the removal of the living biomass (AGB and BGB) and decomposition of organic soils follows a similar procedure as that of the deforestation (Equations 2-4). The degradation of primary forest to secondary forest was also counted only once that occur at one particular area, similar to the procedure used in calculating the deforested area. Identification of secondary forest area in particular year is filtered using the primary forests of the previous years. Thus, the

degradation of primary forest to secondary forest will be detected only in remaining primary forests of the previous years that have never been degraded before.

The estimation of emission from forest degradation from the loss of living biomass (change of primary to secondary forest) between two years (period) used the land use transition matrix in all forests (production and non-production forests).

The emissions from the change of primary to secondary used the equation 8. For example, the emission from 41,722.33 ha degraded area (Primary dryland forest to Secondary dryland forests; 2001-2002) occurred in the period 2006 and 2009 is calculated as follow:

$$E_{2001-2002} = A * (EF_{BC} - EF_{AC}) * 44/12 \quad (\text{Equation 19})$$

$E_{2001-2002} = 41,722.33 * (167.3 - 122.06) * 44/12 = 6,922,432.35 \text{ ton CO}_2 \text{ or about } 2,307,477.45 \text{ tCO}_2\text{e per year.}$

b. Emissions due to further degradation of stable secondary forest caused by fire

Emission factors EF_f for biomass consumed by fire can be developed based on Eq. 2.27 in the IPCC 2006 Guidelines for National Greenhouse Gas Inventories (GL), Volume 4, using the following equation 14,15 and 16. Gas emission factor from dry matter burnt for CO_2 , CH_4 and N_2O is $1701.33 \text{ g kg}^{-1}$, 21 g kg^{-1} and 0.20 g kg^{-1} respectively.

Fire in secondary forest will result in further degradation and in more emissions. Estimation of the stable forest area affected by fire is by delineating burnt area of the stable forest (forests that remained as secondary forest throughout the reference period) hotspot (see Annex 4 section 8.4.3). This is to avoid double counting of emissions in which the loss of biomass due to fire in the deforested forest is not included. The implication of this is that when the secondary forests affected by fire are deforested during the future ERP reporting period, we will have to use separate emission factors in the calculation of the emission from deforestation which take into account the loss of carbon due to fire that occurred in the reference period.

For example, the area of stable secondary forests affected by fire in 2007 was 280.39 ha which is all secondary dryland forest (2002). The total fire emission reached 46,787.70 ton CO_2e (using equation 6). A similar approach was taken for all other years to estimate the emissions from fire in stable secondary forest.

c. Emissions from peat decomposition in secondary forests

The loss of carbon from the decomposition of organic soil occurs in secondary forest (IPCC, 2014). These are considered to be inherited emissions because the disturbance (which changed the forest from primary to secondary) occurred prior to 2006. The estimation of the emission from peat decomposition uses equation 5. Similar to those in deforestation, considering the inherited carbon emissions on peatland, the carbon emission from peat decomposition between year 2017-2018 is considered as total carbon emission for the whole reference period (2006-2016).

Summary: Average Historical Emissions from Forest Degradation

Emissions from forest degradation is calculated based on the emissions associated with loss of living forest biomass (AGB and BGB) due to transition of primary forest to secondary forest, and fires in stable secondary forest. In addition, the emissions associated with soil carbon on peat secondary forest is also included. The Emission calculation from peat soil on secondary forest follows the method of peat decomposition process.

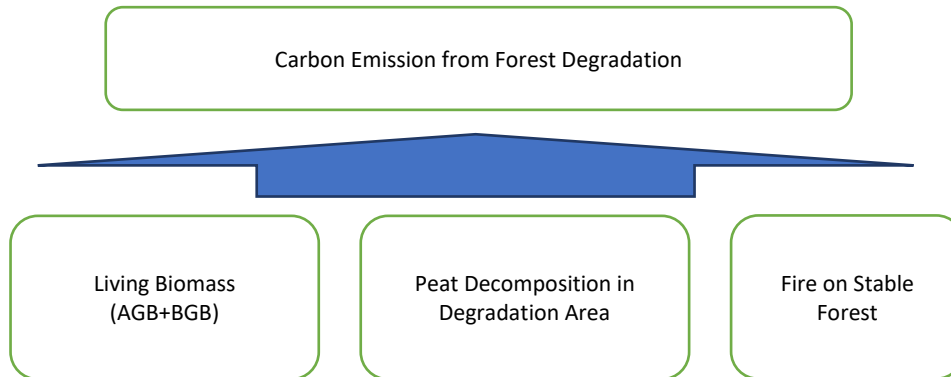


Figure 5. Emission from Forest Degradation

3 DATA AND PARAMETERS

3.1 Fixed Data and Parameters

3.1.1 Carbon Stock for Deforestation and Forest Degradation

Parameter:	Carbon stock used for the estimation of emission from deforestation and degradation
Description:	Emission Factor for deforestation and forest degradation, i.e. living biomass (AGB+BGB) of the six forest classes, primary and secondary dryland forests; primary and secondary swamp forests; primary and secondary mangrove forests; and 17 type of non-forest lands (Plantation forest; Dry shrub; Wet shrub; Savanna and Grasses; Dry agriculture; Mixed dry agriculture; Estate crop' Paddy field' Transmigration areas; Bareland; Settlement; Others (pond, mining, port, open water, open swamp, ponds)
Data unit:	ton /hectare
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	<p>The primary data source for the carbon stock of natural forests is derived from the measurement of AGB from the Permanent Sampling Plots in of National Forest Inventory (NFI) in East Kalimantan (see sheet 'TC_AGB' on file TC_AGB lokal_Uncertainty_23Jul2022 - https://mrv.kaltimprov.go.id/storage/guest/ERM1/CarbonAccounting/TC_AGBlokal_Uncertainty_23Jul2022.xlsx).</p> <p>The estimation of AGB used local allometric equations (Manuri et al , 2017²⁴ for dryland forest; Manuri et al., 2014²⁵ for swamp forests; Komiyama et al., 2005²⁶ for mangrove. The value of the root shoot ratio can be seen on sheet 'TC_Uncertainty' on file TC_AGB lokal_Uncertainty_23Jul2022 – https://mrv.kaltimprov.go.id/storage/guest/ERM1/CarbonAccounting/TC_AGBlokal_Uncertainty_23Jul2022.xlsx.</p> <p>The estimation of the carbon stock of the above ground biomass of the six forest-types uses local allometric models, i.e.</p> <ul style="list-style-type: none"> • Dryland forest (Manuri et al., 2017) $AGB = 0.167 \times DBH^{2.56} \times WD^{0.889}$ • Swamp forest (Manuri et al., 2014) $AGB = 0.242 \times DBH^{2.473} \times WD^{0.736}$ • Mangrove forest (Komiyama et al., 2005)

²⁴ <https://link.springer.com/article/10.1007/s13595-017-0618-1>

²⁵ <https://www.sciencedirect.com/science/article/abs/pii/S0378112714005209>

²⁶ <https://www.cambridge.org/core/journals/journal-of-tropical-ecology/article/abs/common-allometric-equations-for-estimating-the-tree-weight-of-mangroves/6067C26CECE5B0EF18A319B8DB89B771>

	<div>AGB = 0.251 x WD x DBH^{2.46}</div> <div>The data source for the carbon stock of non-forest lands is derived from mainly Indonesian literatures (see sheet 'AGB_Other Studies 'on file TC_AGB 34ocal_Uncertainty_23Jul2022 – https://mrv.kaltimprov.go.id/storage/guest/ERMR1/CarbonAccounting/TC_AGB lokal_Uncertainty_23Jul2022.xlsx).</div> <div>The carbon stock data used are total of above ground (AGB) and below ground biomass (BGB). Calculation for BGB = AGB * Root shoot ratio. The value of the ratio is 0.24 for primary forest. For mangrove and swamp forest the value is 0.36 based on measurement from Komiyama et al., 2005 for mangrove. The values of the ratio vary between land cover types, i.e. 0.32 for forest plantation and estate crops), 0.48 for dry and wet shrubs, mix dryland agriculture and transmigration area, and 1.58 for savanna/grassland, pure dryland agriculture, rice paddy, bare ground and settlement.</div> <div>Spatial level: regional (province)</div>																																																															
Value applied:	<div>Forest lands</div> <table><tr><th>Land cover</th><th>Code</th><th>AGB (t/ha)</th></tr><tr><td>Primary Dryland Forest</td><td>2001</td><td>287.08</td></tr><tr><td>Secondary dryland forest</td><td>2002</td><td>209.44</td></tr><tr><td>Swamp primary forest</td><td>2005</td><td>538.56</td></tr><tr><td>Swamp secondary forest</td><td>20051</td><td>365.30</td></tr><tr><td>Mangrove primary forest</td><td>2004</td><td>263.38</td></tr><tr><td>Mangrove secondary forest</td><td>20041</td><td>181.83</td></tr></table> <div>Non-forest lands</div> <table><tr><th>Land cover</th><th>Code</th><th>AGB (t /ha)</th></tr><tr><td>Plantation forest</td><td>2006</td><td>133.11</td></tr><tr><td>Dry shrub</td><td>2007</td><td>41.36</td></tr><tr><td>Wet shrub</td><td>20071</td><td>46.53</td></tr><tr><td>Savanna and Grasses</td><td>3000</td><td>5.96</td></tr><tr><td>Pure dry agriculture</td><td>20091</td><td>15.96</td></tr><tr><td>Mixed dry agriculture</td><td>20092</td><td>47.89</td></tr><tr><td>Estate crop</td><td>2010</td><td>105.75</td></tr><tr><td>Paddy field</td><td>20093</td><td>9.36</td></tr><tr><td>Transmigration areas</td><td>20122</td><td>21.28</td></tr><tr><td>Bare ground</td><td>2014</td><td>5.32</td></tr><tr><td>Settlement</td><td>2012</td><td>8.51</td></tr><tr><td>Port and harbor</td><td>20121</td><td>0.00</td></tr><tr><td>Open water</td><td>5001</td><td>0.00</td></tr></table>	Land cover	Code	AGB (t/ha)	Primary Dryland Forest	2001	287.08	Secondary dryland forest	2002	209.44	Swamp primary forest	2005	538.56	Swamp secondary forest	20051	365.30	Mangrove primary forest	2004	263.38	Mangrove secondary forest	20041	181.83	Land cover	Code	AGB (t /ha)	Plantation forest	2006	133.11	Dry shrub	2007	41.36	Wet shrub	20071	46.53	Savanna and Grasses	3000	5.96	Pure dry agriculture	20091	15.96	Mixed dry agriculture	20092	47.89	Estate crop	2010	105.75	Paddy field	20093	9.36	Transmigration areas	20122	21.28	Bare ground	2014	5.32	Settlement	2012	8.51	Port and harbor	20121	0.00	Open water	5001	0.00
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	Open swamps	50011	0.00																					
	Mining areas	20141	0.00																					
	Fish pond/aquaculture	20094	0.00																					
	After the AGB successfully calculated, the BGB was estimated by multiplying the AGB with the Root:Shoot Ratio, then multiplying the result with the carbon fraction to estimate the carbon content (C /Ha).																							
QA/QC procedures applied	Guidelines for Quality Assurance and Control (QA/QC) of Indonesia's Greenhouse Gases Inventory (DGCC MoEF, 2018 ²⁷)																							
Uncertainty associated with this parameter:	<p>Key uncertainty comes from (1) sampling error (between 13 to 31%), (2) allometric model (27%-31%), (3) biomass conversion factor to carbon (5.3% Table 4.3 of the 2006 IPCC) and (5) root: shoot ratio (based on the IPCC GPG for LULUCF. And measurement, i.e. between 9% & 32%; See Annex 12.1ERPD for details).</p> <p>The uncertainty of above ground biomass (AGB) for each land cover type was determined through standard statistical measures combining the mean and the 95% confidence interval. For a complete work regarding the uncertainty of the estimates of AGB, please consult the following file TC_AGB 35ocal_Uncertainty_23Jul2022 – https://mrv.kaltimprov.go.id/storage/guest/ERMR1/Carbon Accounting/TC_AGB lokal_Uncertainty_23Jul2022.xlsx .</p> <p>For the case of Deforestation, it was too complex to perform all calculations involving all 23 land cover types with 6 forest types and 17 non-forest types. Therefore, a weighting approach was applied to estimate the AGB while error propagation approach was applied to estimate uncertainty values of those non-forest classes. In the end, there were only 6 values for AGB along with uncertainty and standard error for 6 classes of forest.</p> <p>For forests</p> <table><tr><th>Land cover</th><th>Code</th><th>Uncertainty (%)</th></tr><tr><td>Primary Dryland Forest</td><td>2001</td><td>9.27</td></tr><tr><td>Secondary dryland forest</td><td>2002</td><td>5.24</td></tr><tr><td>Swamp primary forest</td><td>2005</td><td>22.11</td></tr><tr><td>Swamp secondary forest</td><td>20051</td><td>29.87</td></tr><tr><td>Mangrove primary forest</td><td>2004</td><td>14.61</td></tr><tr><td>Mangrove secondary forest</td><td>20041</td><td>18.45</td></tr></table> <p>For non-forests</p>			Land cover	Code	Uncertainty (%)	Primary Dryland Forest	2001	9.27	Secondary dryland forest	2002	5.24	Swamp primary forest	2005	22.11	Swamp secondary forest	20051	29.87	Mangrove primary forest	2004	14.61	Mangrove secondary forest	20041	18.45
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²⁷ http://ditjenppi.menlhk.go.id/reddplus/images/adminppi/dokumen/Pedoman_QA_QC_FULL_ISBN.pdf

	Land cover	Code	Uncertainty (%)
	Plantation forest	2006	14.57
	Dry shrub	2007	31.79
	Wet shrub	20071	42.19
	Savanna and Grasses	3000	31.79
	Pure dry agriculture	20091	14.57
	Mixed dry agriculture	20092	31.79
	Estate crop	2010	15.86
	Paddy field	20093	14.57
	Transmigration areas	20122	31.79
	Bare ground	2014	14.57
	Settlement	2012	14.57
	Port and harbor	20121	0.00
	Open water	5001	0.00
	Open swamps	50011	0.00
	Mining areas	20141	0.00
	Fish pond/aquaculture	20094	0.00
Any comment:			

3.1.2 Fire in Secondary Forest

Parameter:	Emission factors used for the estimation of emission from Fire in Secondary Forest		
Description:	<i>Emission Factor for biomass fire</i>		
Data unit:	<i>t CO₂e/ha</i>		
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	<p>See chapter 2.2.2.</p> <p>Spatial level: regional (province) with data provided nationally by MoEF.</p>		
Value applied:	Parameter	Value	Unit
	Combustion Factor	0.36	Unitless
	EF CO ₂	1580	(g/kg DM)
	EF CH ₄	6.8	(g/kg DM))
	EF N ₂ O	0.2	(g/kg DM)
	Pooled EF	756.24	(g/kg DM)

QA/QC procedures applied	Guidelines for Quality Assurance and Control (QA/QC) of Indonesia's Greenhouse Gases Inventory (DGCC MoEF, 2018)		
Uncertainty associated with this parameter:	Parameter	Uncertainty	Unit
	Combustion Factor	16.67	%
	EF CO ₂	8.29	%
	EF CH ₄	27.94	%
	EF N ₂ O	35.00	%
	Pooled EF	256.60	%
Any comment:	Key of uncertainty is error in estimating the amount of biomass available for burning, combustion factor and EFs of three gases (CO ₂ , CH ₄ and N ₂ O).		

3.1.3 Peat Fire

Parameter:	Emission Factor for deforested peat fire
Description:	<i>Emission Factor for peat fire</i>
Data unit:	<i>t CO₂e/ha</i>
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	<i>See chapter 2.2.2 .</i> Spatial level: regional (province)
Value applied:	756.24 t CO ₂ e/ha. The value is estimated from the summation of the result of the multiplication of MB, C _f , and G _{ef} for CO ₂ and CH ₄ (see equation 11)
QA/QC procedures applied	<i>Guidelines for Quality Assurance and Control (QA/QC) of Indonesia's Greenhouse Gases Inventory (DGCC MoEF, 2018)</i>
Uncertainty associated with this parameter:	<p>Key of uncertainty is error in estimating the amount of biomass available for burning, combustion factor and EFs of three gases (CO₂, and CH₄).</p> <p>Uncertainty level is 66.5% (Pooled uncertainty based on confidence interval EF of Tables 2.6 and 2.7 of the 2013 Supplement to the 2006 IPCC Guidelines,</p> $U_{\text{Pooled}} = \sqrt{(U_{\text{CO}_2})^2 + (U_{\text{EF-CH}_4})^2}$

Any comment:	
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3.1.4 **Emission Factor from Soil**

b. Emission Factors from peat soils

Parameter:	Emission Factor for peat decomposition																																																																				
Description:	Peat emissions happen slowly over time once land is cleared for a number of years depending on the depth of the peat soil. The emissions from peat decomposition do not continue indefinitely, as they cease when the peat has completely decomposed or reached the water table.																																																																				
Data unit:	t CO2e/ha																																																																				
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	See chapter 2.2.2 Spatial level: national																																																																				
Value applied:	<table><tr><th>Land cover</th><th>Code</th><th>EF (t CO2/ha/yr)</th></tr><tr><td>Primary dryland forest</td><td>2001</td><td>0</td></tr><tr><td>Primary mangrove forest</td><td>2004</td><td>0</td></tr><tr><td>Primary swamp forest</td><td>2005</td><td>0</td></tr><tr><td>Secondary dryland forest</td><td>2002</td><td>19</td></tr><tr><td>Secondary mangrove forest</td><td>20041</td><td>19</td></tr><tr><td>Secondary swap forest</td><td>20051</td><td>19</td></tr><tr><td>Plantation forest</td><td>2006</td><td>73</td></tr><tr><td>Estate crop</td><td>2010</td><td>40</td></tr><tr><td>Pure dry agriculture</td><td>20091</td><td>51</td></tr><tr><td>Mixed dry agriculture</td><td>20092</td><td>51</td></tr><tr><td>Dry shrub</td><td>2007</td><td>19</td></tr><tr><td>Wet shrub</td><td>20071</td><td>19</td></tr><tr><td>Savanna and Grasses</td><td>3000</td><td>35</td></tr><tr><td>Paddy Field</td><td>20093</td><td>35</td></tr><tr><td>Open swamp</td><td>50011</td><td>0</td></tr><tr><td>Fish pond/aquaculture</td><td>20094</td><td>0</td></tr><tr><td>Transmigration areas</td><td>20122</td><td>51</td></tr><tr><td>Settlement areas</td><td>2012</td><td>35</td></tr><tr><td>Port and harbor</td><td>20121</td><td>0</td></tr><tr><td>Mining areas</td><td>20141</td><td>51</td></tr><tr><td>Bare ground</td><td>2014</td><td>51</td></tr></table>			Land cover	Code	EF (t CO2/ha/yr)	Primary dryland forest	2001	0	Primary mangrove forest	2004	0	Primary swamp forest	2005	0	Secondary dryland forest	2002	19	Secondary mangrove forest	20041	19	Secondary swap forest	20051	19	Plantation forest	2006	73	Estate crop	2010	40	Pure dry agriculture	20091	51	Mixed dry agriculture	20092	51	Dry shrub	2007	19	Wet shrub	20071	19	Savanna and Grasses	3000	35	Paddy Field	20093	35	Open swamp	50011	0	Fish pond/aquaculture	20094	0	Transmigration areas	20122	51	Settlement areas	2012	35	Port and harbor	20121	0	Mining areas	20141	51	Bare ground	2014	51
Land cover	Code	EF (t CO2/ha/yr)																																																																			
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Port and harbor	20121	0																																																																			
Mining areas	20141	51																																																																			
Bare ground	2014	51																																																																			

		Open water	5001	0	
		Clouds and no-data		Nd	
QA/QC procedures applied	Guidelines for Quality Assurance and Control (QA/QC) of Indonesia's Greenhouse Gases Inventory (DGCC MoEF, 2018)				
Uncertainty associated with this parameter:	Key uncertainty comes from sampling error (number of sampling, timing of sampling, length of the time between sampling taken to processing in laboratory).				
	The uncertainty is taken from the 2013 supplement for 2006 IPCC Guideline (IPCC, 2014)				
	Land cover		Code	Uncertainty (%)	
	Primary dryland forest		2001	0.0	
	Primary mangrove forest		2004	0.0	
	Primary swamp forest		2005	0.0	
	Secondary dryland forest		2002	84.2	
	Secondary mangrove forest		20041	84.2	
	Secondary swap forest		20051	84.2	
	Plantation forest		2006	20.5	
	Estate crop		2010	55.0	
	Pure dry agriculture		20091	86.3	
	Mixed dry agriculture		20092	86.3	
	Dry shrub		2007	84.2	
	Wet shrub		20071	84.2	
	Savanna and Grasses		3000	108.6	
	Paddy Field		20093	108.6	
	Open swamp		50011	0.0	
	Fish pond/aquaculture		20094	0.0	
	Transmigration areas		20122	86.3	
	Settlement areas		2012	108.6	
	Port and harbor		20121	0.0	
	Mining areas		20141	86.3	
	Bare ground		2014	86.3	
	Open water		5001	0	
	Clouds and no-data			Nd	
	Any comment:				

b. Emission Factors from mangrove soils

Parameter:	Emission Factor for mangrove soil and shrimp pond
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Description:	Calculation of emissions from mangrove soil in the ER program is considered only <u>for mangrove forest converted to aquaculture</u> . Emissions released are calculated as potential emissions assuming that emissions from organic soil removed from the floor of the aquaculture system are emitted once at the time of the conversion.
Data unit:	<i>Ton CO_{2e} /hectare</i>
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Data on the soil carbon of mangrove and abandoned pond is taken from Kauffman et al. (2017) ²⁸ based on measurement from the 20 locations in East Kalimantan. The procedure for the sampling is described in Kauffman et al. (2016) ²⁹ Data can see at sheet 'Mangrove Soils 'on file TC_AGB 40ocal_Uncertainty_23Jul2022 – https://mrv.kaltimprov.go.id/storage/guest/ERMR1/CarbonAccounting/TC_AGB_lokal_Uncertainty_23Jul2022.xlsx). Spatial level: province
Value applied:	902.91 tCO _{2e} /ha (mangrove) 487.31 tCO _{2e} /ha (abandoned shrimp pond) EF = 415.6 tCO _{2e} /ha Uncertainty = 33.4%.
QA/QC procedures applied	<i>Guidelines for Quality Assurance and Control (QA/QC) of Indonesia's Greenhouse Gases Inventory (DGCC MoEF, 2018)</i>
Uncertainty associated with this parameter:	Key uncertainty comes from sampling error
Any comment:	

3.2 Monitored Data and Parameters

This section outlines all data and parameters that are monitored during the Period June 2019 – June 2020.

3.2.1. DEFORESTATION

Deforestation

a. Deforestation from forest categories to non-forest categories

Parameter:	Land cover change from forest to non-forest
Description:	Area of land cover change between July 2019 - December 2020. The land use transition matrices between these periods are generated to estimate the change of area from forest categories to non-forest categories.
Data unit:	hectare

²⁸ <https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1002/fee.1482>

²⁹ <https://link.springer.com/article/10.1007/s11273-015-9453-z>

Value monitored during this Monitoring/Reporting Period:	Area:		

	<p>ground resolution or Sentinel-2 with 10 m ground resolution) to conclude the real status of the land cover changes. The result of this assessment is presented in detail in MS Excel file named: https://mrv.kaltimprov.go.id/storage/guest/ERM1/CarbonAccounting/AccuracyAssessmentEK_LandCover2020_2021_v02U.xlsx</p> <p>It is available online at https://nfms.menlhk.go.id/ , which is coupled with webGIS at geoportal.menlhk.go.id for display and viewing. The two websites are part of geospatial portal under the one map policy.</p> <p>Further details on the method for land cover mapping conducted by MoEF , including the method for remote sensing data processing and analysis including type of sensors and the details of the images used can be found here https://jurnal.ugm.ac.id/ijg/article/view/12496/9041</p>
QA/QC procedures applied	<p>SNI 8033-2014 - Methods for Forest Cover Change Interpretation from Optical Satellite Imagerys (https://mrv.kaltimprov.go.id/storage/guest/ERM1/Guidance/SNI_8033_2014.pdf) and Tosiani, et.al (2020) Standard Operating Procedure (SOP): Calculation of Accuracy and Uncertainty of Land Cover Change (https://mrv.kaltimprov.go.id/storage/guest/ERM1/Guidance/SOP_AKURASI_ISI_EBOOK.pdf) .</p>
Uncertainty for this parameter:	<p>Two main sources of uncertainties are from image processing and interpretation of land cover types from the image (depend on quality of satellite images, method of land cover map generation process; uncertainty of land cover) and that of land cover changes.</p> <p>The estimation of uncertainty follows a modified method presented by Olofsson et al. (2014), substituting a post stratified estimator of variance (Olofsson 2019, pers. com.). The uncertainty of the land cover change (deforestation) for the period of July 2019- June 2020 and July 2020 - June 2021 are 4,69% and 5.78%, respectively.</p>
Any comment:	

b. Peat decomposition

Parameter:	Peat decomposition
Description:	<p>Area of land cover changes between July 2019-June 2020 and July 2020-June 2021. The land use transition matrices between these periods are generated to estimate the change of areas from forest categories to non-forest categories that occurred in the peatland for the estimation of emissions from peat decomposition from the deforested areas. The use of July 2017 – June 2018 period, which is different than the reference period of other carbon pools (2006-2016) for peatland deforestation is part of an agreement with CFPs considering the Indicator 13.1 of the Methodological Framework. Indonesia is not eligible for applying an upward adjustment to its reference level, while Indonesia has peatland</p>

	in which such indicator is not possible to be applied for countries that have peatland forest.. For reference level using period between July 2017-June 2018.																																																								
Data unit:	Hectare																																																								
Value monitored during this Monitoring/Reporting Period:	<table><tr><td></td><td>July 2019-June 2020 (Ha)</td><td>July 2020- June 2021 (Ha)*</td></tr><tr><td>Land cover change</td><td></td><td></td></tr><tr><td>2002-2002</td><td>69.10</td><td>69.10</td></tr><tr><td>2004-2004</td><td>1,359.74</td><td>1,360.63</td></tr><tr><td>2005-2005</td><td>6,463.37</td><td>6,463.37</td></tr><tr><td>2007-2007</td><td>9.62</td><td>9.62</td></tr><tr><td>2010-2010</td><td>1,898.13</td><td>1,935.03</td></tr><tr><td>2012-2012</td><td>4.26</td><td>4.26</td></tr><tr><td>2014-2014</td><td>130.51</td><td>145.98</td></tr><tr><td>2014-2010</td><td>36.07</td><td>0.00</td></tr><tr><td>5001-5001</td><td>2.69</td><td>45.58</td></tr><tr><td>20041-20041</td><td>4,423.79</td><td>4,380.18</td></tr><tr><td>20051-20051</td><td>43,189.86</td><td>43,189.86</td></tr><tr><td>20051-2014</td><td>15.31</td><td>0.00</td></tr><tr><td>20071-20071</td><td>646.67</td><td>1,357.91</td></tr><tr><td>20092-20092</td><td>32.17</td><td>32.02</td></tr><tr><td>20141-20141</td><td>45.07</td><td>45.07</td></tr><tr><td>Total</td><td>59,038.59</td><td>59,038.59</td></tr></table> <p><i>Note: The first column shows land cover change using cover class codes</i> * The land cover transition in July 2020 – June 2021 considered only half of the value since the data used for this monitoring period ranges from July 2020 to December 2020</p>				July 2019-June 2020 (Ha)	July 2020- June 2021 (Ha)*	Land cover change			2002-2002	69.10	69.10	2004-2004	1,359.74	1,360.63	2005-2005	6,463.37	6,463.37	2007-2007	9.62	9.62	2010-2010	1,898.13	1,935.03	2012-2012	4.26	4.26	2014-2014	130.51	145.98	2014-2010	36.07	0.00	5001-5001	2.69	45.58	20041-20041	4,423.79	4,380.18	20051-20051	43,189.86	43,189.86	20051-2014	15.31	0.00	20071-20071	646.67	1,357.91	20092-20092	32.17	32.02	20141-20141	45.07	45.07	Total	59,038.59	59,038.59
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Total	59,038.59	59,038.59																																																							
Source of data and description of measurement/calculation methods and procedures applied:	Activity data uses used in the monitoring period came from MoEF Ministry of Environment and Forestry national land cover data (NFMS). The land cover map has been developed by MoEF for the period of 1990 to 2021. Principally, a mosaic of Landsat imageries were prepared to cover the whole area by the Indonesian Space Agency (LAPAN). The MoEF then perform visual interpretation to the image to develop the land cover map consists of 23 land cover types as listed in the SNI No 8033 Year 2014. The land cover map series then further analyzed by the East Kalimantan MMR Technical Team to define the carbon emission as described in this report. The analysis conducted by the East Kalimantan MMR Technical Team includes accuracy assessment of the land cover change status to define overall uncertainty for each land cover change status. This process was performed by generating stratified random samples within the area of land cover changes then analyzed to confirm																																																								

	<p>whether or not the land cover changes stated in the map is correct. The analyst used Higher-resolution imageries (e.g. SPOT-6/7 with 1.5 m ground resolution or Sentinel-2 with 10 m ground resolution) to conclude the real status of the land cover changes. The result of this assessment is presented in detail in MS Excel file named: https://mrv.kaltimprov.go.id/storage/guest/ERM1/CarbonAccounting/AccuracyAssessmentEK_LandCover2020_2021_v02U.xlsx</p> <p>It is available online at https://nfms.menlhk.go.id/ , which is coupled with webGIS at geoportal.menlhk.go.id for display and viewing. The two websites are part of geospatial portal under the one map policy. The peat area map is provided by the Ministry of Agriculture (2011), through national survey of peatland, updated by the MoEF.</p> <p>The description of methods for data derived from remote sensing images including type of sensors and the details of the images used can be found here https://jurnal.ugm.ac.id/iig/article/view/12496/9041</p>																										
QA/QC procedures applied	<p>SNI 8033-2014 - Methods for Forest Cover Change Interpretation from Optical Satellite Imageries and Tosiani, et.al (2020) Standard Operating Procedure (SOP): Calculation of Accuracy and Uncertainty of Land Cover Change.</p>																										
Uncertainty for this parameter:	<p>Two main sources of uncertainties are from image processing and interpretation of land cover types from the image (depend on quality of satellite images, method of land cover map generation process; uncertainty of land cover) and that of land cover changes.</p> <p>The estimation of uncertainty follows a modified method presented by Olofsson et al. (2014), substituting a post-stratified estimator of variance (Olofsson 2019, pers. com.).</p> <p><i>July 2019-June 2020</i></p> <table border="1"> <thead> <tr> <th>Land cover change</th><th>Uncertainty (%)</th></tr> </thead> <tbody> <tr><td>20051-2014</td><td>11.05</td></tr> <tr><td>2002-2002</td><td>10.28</td></tr> <tr><td>2004-2004</td><td>10.28</td></tr> <tr><td>2005-2005</td><td>10.28</td></tr> <tr><td>20041-20041</td><td>10.28</td></tr> <tr><td>20051-20051</td><td>10.28</td></tr> <tr><td>2007-2007</td><td>10.45</td></tr> <tr><td>2010-2010</td><td>10.45</td></tr> <tr><td>2012-2012</td><td>10.45</td></tr> <tr><td>2014-2010</td><td>10.45</td></tr> <tr><td>2014-2014</td><td>10.45</td></tr> <tr><td>5001-5001</td><td>10.45</td></tr> </tbody> </table>	Land cover change	Uncertainty (%)	20051-2014	11.05	2002-2002	10.28	2004-2004	10.28	2005-2005	10.28	20041-20041	10.28	20051-20051	10.28	2007-2007	10.45	2010-2010	10.45	2012-2012	10.45	2014-2010	10.45	2014-2014	10.45	5001-5001	10.45
Land cover change	Uncertainty (%)																										
20051-2014	11.05																										
2002-2002	10.28																										
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20041-20041	10.28																										
20051-20051	10.28																										
2007-2007	10.45																										
2010-2010	10.45																										
2012-2012	10.45																										
2014-2010	10.45																										
2014-2014	10.45																										
5001-5001	10.45																										

	20071-20071	10.45
	20092-20092	10.45
	20141-20141	10.45
	<i>July 2020 – June 2021</i>	
	Land cover change	Uncertainty (%)
	2002-2002	10.52
	2004-2004	10.52
	2005-2005	10.52
	2007-2007	10.38
	2010-2010	10.38
	2012-2012	10.38
	5001-5001	10.38
	20041-20041	10.52
	20051-20051	10.52
	20071-20071	10.38
	20092-20092	10.38
	2014-2014	10.38
	20141-20141	10.38
Any comment:	Deforestation and subsequent land cover changes for peat lands. Tracking change over time is necessary to estimate the future inherited emissions because emissions are related to future land cover.	

c. Deforestation: Mangrove forest to aquaculture

Parameter:	Deforestation: Mangrove forest to aquaculture			
Description:	Area of land cover changes between July 2019 - June 2020 and July 2020 – June 2021. The land use transition matrices between these periods are generated to estimate the change of areas from mangrove forests to aquaculture/fishpond for the estimation of emission from the loss of soil carbon			
Data unit:	Hectare			
Value monitored during this Monitoring/Reporting Period:	Land use change	Area 2019-2020 (ha)	Area 2020-2021 (ha)	
	Primary mangrove forest to pond	0	28.35	
	Primary mangrove forest to pond	0	223.46	
	Total mangrove forest to Pond	0	251.81	
Source of data and description of measurement/calculation methods and procedures	Activity data uses used in the monitoring period came from MoEF Ministry of Environment and Forestry national land cover data (NFMS). The land cover map has been developed by MoEF for the period of 1990 to 2021. Principally, a mosaic of Landsat imageries were prepared to cover the whole area by the Indonesian Space Agency (LAPAN). The			

applied:	<p>MoEF then perform visual interpretation to the image to develop the land cover map consists of 23 land cover types as listed in the SNI No 8033 Year 2014. The land cover map series then further analyzed by the East Kalimantan MMR Technical Team to define the carbon emission as described in this report. The analysis conducted by the East Kalimantan MMR Technical Team includes accuracy assessment of the land cover change status to define overall uncertainty for each land cover change status. This process was performed by generating stratified random samples within the area of land cover changes then analyzed to confirm whether or not the land cover changes stated in the map is correct. The analyst used Higher-resolution imageries (e.g. SPOT-6/7 with 1.5 m ground resolution or Sentinel-2 with 10 m ground resolution) to conclude the real status of the land cover changes. The result of this assessment is presented in detail in MS Excel file named: Accuracy Assessment EK Land Cover 2020-2021 v02U.xlsx</p> <p>It is available online at https://nfms.menlhk.go.id/, which is coupled with webGIS at geoportal.menlhk.go.id for display and viewing. The two websites are part of geospatial portal under the one map policy. The description of methods for data derived from remote sensing images including type of sensors and the details of the images used is can be found https://jurnal.ugm.ac.id/ijg/article/view/12496/9041</p>						
QA/QC procedures applied	<p>SNI 8033-2014 - Methods for Forest Cover Change Interpretation from Optical Satellite Imageries; and</p> <p>Tosiani, et.al (2020) Standard Operating Procedure (SOP): Calculation of Accuracy and Uncertainty of Land Cover Change,</p>						
Uncertainty associated with this parameter:	<p>Two main sources of uncertainties are from image processing and interpretation of land cover types from the image (depend on quality of satellite images, method of land cover map generation process; uncertainty of land cover) and that of land cover changes.</p> <p>The estimation of uncertainty follows a modified method presented by Olofsson et al. (2014), substituting a post-stratified estimator of variance (Olofsson 2019, pers. com.).</p> <table><tr><td>Land use change</td><td>Uncertainty 2019-2020 (%)</td><td>Uncertainty 2020-2021 (%)</td></tr><tr><td>Mangrove forest to pond</td><td>4.69</td><td>5.78</td></tr></table>	Land use change	Uncertainty 2019-2020 (%)	Uncertainty 2020-2021 (%)	Mangrove forest to pond	4.69	5.78
Land use change	Uncertainty 2019-2020 (%)	Uncertainty 2020-2021 (%)					
Mangrove forest to pond	4.69	5.78					
Any comment:	<p>Deforestation and subsequent land cover changes for peat lands. Tracking change over time is necessary to estimate the future inherited emissions because emissions are related to future land cover.</p>						

3.2.2. FOREST DEGRADATION

a. Forest degradation – from primary forest to secondary forest







Parameter:	<i>Forest degradation -- from primary forest to secondary forest</i>																	
Description:	<i>Area of degradation, change of primary forest into secondary forests between July 2019- June 2020 and July 2020 – June 2021, that occurred in all forested land. The land use transition matrices between these periods are generated to estimate the change of area from Primary forests to Secondary Forests</i>																	
Data unit:	<i>hectare</i>																	
Value monitored during this Monitoring/Reporting Period:	<table><tr><td>Land use change</td><td>Area 2019-2020 (ha)</td><td>Area 2020-2021 (ha)</td></tr><tr><td>Primary dryland forest to Secondary forest</td><td>0.00</td><td>2,803.26</td></tr><tr><td>Primary mangrove forest to secondary forest</td><td>0.00</td><td>0.00</td></tr><tr><td>Primary swamp forest to secondary forest</td><td>0.00</td><td>0.00</td></tr><tr><td>Total area</td><td>0.00</td><td>2,803.26</td></tr></table>			Land use change	Area 2019-2020 (ha)	Area 2020-2021 (ha)	Primary dryland forest to Secondary forest	0.00	2,803.26	Primary mangrove forest to secondary forest	0.00	0.00	Primary swamp forest to secondary forest	0.00	0.00	Total area	0.00	2,803.26
Land use change	Area 2019-2020 (ha)	Area 2020-2021 (ha)																
Primary dryland forest to Secondary forest	0.00	2,803.26																
Primary mangrove forest to secondary forest	0.00	0.00																
Primary swamp forest to secondary forest	0.00	0.00																
Total area	0.00	2,803.26																
Source of data and description of measurement/calculation methods and procedures applied:	<p>Activity data uses used in the monitoring period came from MoEF Ministry of Environment and Forestry national land cover data (NFMS). The land cover map has been developed by MoEF for the period of 1990 to 2021. Principally, a mosaic of Landsat imageries were prepared to cover the whole area by the Indonesian Space Agency (LAPAN). The MoEF then perform visual interpretation to the image to develop the land cover map consists of 23 land cover types as listed in the SNI No 8033 Year 2014. The land cover map series then further analyzed by the East Kalimantan MMR Technical Team to define the carbon emission as described in this report. The analysis conducted by the East Kalimantan MMR Technical Team includes accuracy assessment of the land cover change status to define overall uncertainty for each land cover change status. This process was performed by generating stratified random samples within the area of land cover changes then analyzed to confirm whether or not the land cover changes stated in the map is correct. The analyst used Higher-resolution imageries (e.g. SPOT-6/7 with 1.5 m ground resolution or Sentinel-2 with 10 m ground resolution) to conclude the real status of the land cover changes. The result of this assessment is presented in detail in MS Excel file named:</p> <p>Accuracy Assessment EK Land Cover 2020-2021 v02U.xlsx</p>																	

	It is available online at https://nfms.menlhk.go.id/ , which coupled with webGIS at geoportal.menlhk.go.id for display and viewing. The two websites are part of the geospatial portal under the one map policy. The description of methods for data derived from remote sensing images including type of sensors and the details of the images used is can be found https://jurnal.ugm.ac.id/iig/article/view/12496/9041												
QA/QC procedures applied	SNI 8033-2014 - Methods for Forest Cover Change Interpretation from Optical Satellite Imageries; and Tosiani, et.al (2020) Standard Operating Procedure (SOP): Calculation of Accuracy and Uncertainty of Land Cover Change,												
Uncertainty for this parameter	<table><tr><th>Land use change</th><th>2019-2020 (U %)</th><th>2020-2021 (U %)</th></tr><tr><td>Primary dryland forest to Secondary forest</td><td>0.00</td><td>6.89</td></tr><tr><td>Primary mangrove forest to secondary forest</td><td>0.00</td><td>6.89</td></tr><tr><td>Primary swamp forest to secondary forest</td><td>0.00</td><td>6.89</td></tr></table>	Land use change	2019-2020 (U %)	2020-2021 (U %)	Primary dryland forest to Secondary forest	0.00	6.89	Primary mangrove forest to secondary forest	0.00	6.89	Primary swamp forest to secondary forest	0.00	6.89
Land use change	2019-2020 (U %)	2020-2021 (U %)											
Primary dryland forest to Secondary forest	0.00	6.89											
Primary mangrove forest to secondary forest	0.00	6.89											
Primary swamp forest to secondary forest	0.00	6.89											
Any comment:													

b. Forest degradation – secondary forest affected by fires

Parameter:	Forest degradation – Forest degradation – secondary forest affected by fires																	
Description:	Area of secondary forest affected by fires in 2019-2020, that identified using burnt scare area (NFMS)																	
Data unit:	hectare																	
Value monitored during this Monitoring/Reporting Period:	<div>This data is the three secondary forest classes (Dry land forest, swamp forest and mangrove forest).</div> <table><tr><th>Land Cover Change</th><th>2019-2020 Burnt scare area (ha)</th><th>2020-2021 Burnt scare area (ha)</th></tr><tr><td>Secondary dryland forest</td><td>0.00</td><td>0.03</td></tr><tr><td>Secondary mangrove forest</td><td>0.00</td><td>0.00</td></tr><tr><td>Secondary swamp forest</td><td>0.57</td><td>0.00</td></tr><tr><td>Total</td><td>0.57</td><td>0.03</td></tr></table>			Land Cover Change	2019-2020 Burnt scare area (ha)	2020-2021 Burnt scare area (ha)	Secondary dryland forest	0.00	0.03	Secondary mangrove forest	0.00	0.00	Secondary swamp forest	0.57	0.00	Total	0.57	0.03
Land Cover Change	2019-2020 Burnt scare area (ha)	2020-2021 Burnt scare area (ha)																
Secondary dryland forest	0.00	0.03																
Secondary mangrove forest	0.00	0.00																
Secondary swamp forest	0.57	0.00																
Total	0.57	0.03																
Source of data and description of measurement/calculati on methods and	<div>Activity data uses used in the monitoring period came from MoEF Ministry of Environment and Forestry national land cover data (NFMS).</div> <div>The land cover map has been developed by MoEF for the period of 1990 to 2021. Principally, a mosaic of Landsat imageries were prepared to cover the whole area by the Indonesian Space Agency (LAPAN). The MoEF then</div>																	

<p>procedures applied:</p>	<p>perform visual interpretation to the image to develop the land cover map consists of 23 land cover types as listed in the SNI No 8033 Year 2014. The land cover map series then further analyzed by the East Kalimantan MMR Technical Team to define the carbon emission as described in this report. The analysis conducted by the East Kalimantan MMR Technical Team includes accuracy assessment of the land cover change status to define overall uncertainty for each land cover change status. This process was performed by generating stratified random samples within the area of land cover changes then analyzed to confirm whether or not the land cover changes stated in the map is correct. The analyst used Higher-resolution imageries (e.g. SPOT-6/7 with 1.5 m ground resolution or Sentinel-2 with 10 m ground resolution) to conclude the real status of the land cover changes. The result of this assessment is presented in detail in MS Excel file named:</p> <p>Accuracy Assessment EK Land Cover 2020-2021 v02U.xlsx</p> <p>It is available online at https://nfms.menlhk.go.id/ which coupled with webGIS at geoportal.menlhk.go.id for display and viewing. The two websites are part of the geospatial portal under the one map policy. The description of methods for data derived from remote sensing images including type of sensors and the details of the images used is can be found https://jurnal.ugm.ac.id/ijg/article/view/12496/9041</p> <p>The geospatial data used for estimating the fire on secondary forest are produced by the DGCC especially the Forest Fire Mitigation and Control Directorate under the DGCC of MoEF. The technical procedures are given in the DGCC Regulations No P.11/PPI/PKHL/KUM/1/12/2018 (https://mrv.kaltimprov.go.id/storage/guest/ERM1/Guidance/Perdirjen P. 11 Pedoman Teknis Penaksiran Luas Karhutla (2).pdf) .</p> <p>Data Source (before and after fire events):</p> <ol style="list-style-type: none"> 1. Optical medium-resolution satellite imagery data (Landsat, Sentinel) 2. Hotspot indication from NOAA-AVHRR, SNPP-VIIRS, ATSR, Terra/Aqua MODIS, Himawari and other potential satellite missions <p>Technical Procedures:</p> <ol style="list-style-type: none"> 1. Geometric and Radiometric Corrections 2. Visual Interpretation and Delineation of Fire-Affected Forest Areas <ol style="list-style-type: none"> 2.1. Remote Sensing Image Fusion (as necessary) 2.2. Image Sharpening 2.3. Spatial Filtering 2.4. Geometric and Metadata Format Preparation 2.5. Compiling optical data with hotspot data 2.6. Delineation of Fire Affected Forest <p>The fire-affected forest is detected by comparing the previous and current optical satellite imageries by looking at the color of the area. Dark brownish of black dominated areas meant that those particular area were burnt.</p>
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	<p>Contoh ciri area terbakar pada Citra Landsat 8 OLI (kombinasi band 753):</p> <table><tr><th>Citra Sebelum</th><th>Citra Sesudah</th></tr><tr><td></td><td></td></tr></table>	Citra Sebelum	Citra Sesudah										
Citra Sebelum	Citra Sesudah												
													
QA/QC procedures applied	SNI 8033-2014 - Methods for Forest Cover Change Interpretation from Optical Satellite Imageries, Tosiani, et.al (2020) Standard Operating Procedure (SOP): Calculation of Accuracy and Uncertainty of Land Cover Change, and DGCC regulation number P.11/PPI/PKHL/KUM.112/2018 on Technical Guidelines for the Assessment of Forest and Land Fire Areas.												
Uncertainty for this parameter	<p>Two main sources of uncertainties are from image processing and interpretation of land cover types from the image (depend on quality of satellite images, method of land cover map generation process; uncertainty of land cover) and from land cover changes (uncertainty of land cover changes).</p> <p>The estimation of uncertainty follows a modified method presented by Olofsson et al. (2014), substituting a post-stratified estimator of variance (Olofsson 2019).</p> <table><tr><th>Land Cover Change</th><th>Uncertainty 2019-2020 (%)</th><th>Uncertainty 2020-2021 (%)</th></tr><tr><td>Secondar dryland forest</td><td>2.39</td><td>3.26</td></tr><tr><td>Secondary mangrove forest</td><td>2.39</td><td>3.26</td></tr><tr><td>Secondary swamp forest</td><td>2.39</td><td>3.26</td></tr></table>	Land Cover Change	Uncertainty 2019-2020 (%)	Uncertainty 2020-2021 (%)	Secondar dryland forest	2.39	3.26	Secondary mangrove forest	2.39	3.26	Secondary swamp forest	2.39	3.26
Land Cover Change	Uncertainty 2019-2020 (%)	Uncertainty 2020-2021 (%)											
Secondar dryland forest	2.39	3.26											
Secondary mangrove forest	2.39	3.26											
Secondary swamp forest	2.39	3.26											
Any comment:	Forest degradation. This is to estimate the loss of above ground biomass of the stable secondary forest due to fire.												

4 QUANTIFICATION OF EMISSION REDUCTIONS

4.1 ER Program Reference level for the Monitoring/Reporting Period covered in this report

Under the corrected Reference Level (see Annex 4), the average annual historical emissions from deforestation reached 23.9M tCO₂e per year, whereas from forest degradation reached 3,5M tCO₂e per year. 'Deforestation' includes all emissions associated with change from forest to non-forest cover, including living biomass, peat decomposition, peat fires in deforested areas, and mangrove soil in deforested areas. 'Degradation' includes all emissions associated with change from high biomass forest to lower biomass forest and includes living biomass, and peat decomposition and fires in secondary forest. Based on that, the reference level for this reporting period is 27.47M tCO₂e per year. See Annex 4 Table 8.22.

Table 4 - 1. Comparison of Reference Level between 2019 ERPD and Technical Correction

	ER Program Document		Technical Correction	
	Deforestation (ton CO ₂ e)	Forest degradation (ton CO ₂ e)	Deforestation (ton CO ₂ e)	Forest degradation (ton CO ₂ e)
Living biomass	49,735,619.29	14,701,507.87	23,058,668.41	2,391,882.73
Peat decomposition	109,330.85	929,875.96	55,852.41	987,517.06
Fire	33,555.69	1,804,726.13	105,267.80	141,019.29
Mangrove soil	1,091,581.22		729,648.69	
Total	50,970,087.05	17,436,109.96	23,949,437.31	3,520,419.08
	68,406,197.00		27,469,856.40	

Table 4-2. Reference Level from Deforestation and Degradation occurred in 2006 - 2016

Year of Monitoring/ Reporting period t	Average annual historical emissions from deforestation over the Reference Period (tCO ₂ - e/yr)	If applicable, average annual historical emissions from forest degradation over the Reference Period (tCO ₂ - e/yr)	If applicable, average annual historical removals by sinks over the Reference Period (tCO ₂ -e/yr)	Adjustment, if applicable (tCO ₂ -e/yr)	Reference level (tCO ₂ - e/yr)
2019-2020	23,949,437.31	3,520,419.08			27,469,856.40
2020-2021	23,949,437.31	3,520,419.08			27,469,856.40
Total	47,898,874.63	7,040,838.17			54,939,712.80

4.2 Estimation of emissions by sources and removals by sinks included in the ER Program's scope

Based on calculation emissions by sources from the ER program during the Monitoring/Reporting period July 2019-June 2020, emissions from deforestation reached 2.1M tCO₂e whereas from forest degradation reached 0.184M tCO₂e using the same categories described above, and program during the Monitoring/Reporting period July 2020-June 2021, emissions from deforestation reached 5.8M tCO₂e per year whereas from forest degradation reached 1.5M tCO₂e. So, total net emissions for period July 2019-June 2020 is 2.1M tCO₂e per year and July 2020-June 2021 is 7.2M tCO₂e per year. See sheet 'Sum All' on file for emission calculation –

https://mrv.kaltimprov.go.id/storage/guest/ERM1/CarbonAccounting/fcpf_ekjerp_ermr1_MC_26Juli2022c.xlsx

Table 4-3. Emissions from Deforestation and Degradation **July 2019 - June 2021**

Year of Monitoring/Reporting Period	Emissions from deforestation (tCO ₂ -e/yr)	If applicable, emissions from forest degradation (tCO ₂ -e/yr)*	If applicable, removals by sinks (tCO ₂ -e/yr)	Net emissions and removals (tCO ₂ -e/yr)
2019-2020	2,108,501.18	184.72		2,108,685.90
2020-2021	5,765,850.22	1,485,166.81		7,251,017.03
Total	7,874,351.40	1,485,351.53		9,359,702.93

Since the reporting period is from **July 2019 to December 2020**, then the net emissions and removals need to be adjusted as follows:

Table 4-4. Emissions from Deforestation and Degradation **July 2019 - December 2020**

Year of Monitoring/Reporting Period	Emissions from deforestation (tCO ₂ -e/yr)	If applicable, emissions from forest degradation (tCO ₂ -e/yr)*	If applicable, removals by sinks (tCO ₂ -e/yr)	Net emissions and removals (tCO ₂ -e/yr)
2019-2020	2,108,501.18	184.72		2,108,685.90
2020-2021*	2,882,925.11	742,583.40		3,625,508.51
Total	4,991,426.29	742,768.12		5,734,194.41

* The carbon emission in 2020-2021 in this table represents **only half** of the carbon emission value between July 2020 to June 2021, since the data used for this monitoring period ranges from July 2020 to June 2021, while the reporting period lasts from July 2020 to December 2020. Please see the summary of the calculation here
https://mrv.kaltimprov.go.id/storage/guest/ERM1/CarbonAccounting/fcpf_ekjerp_ermr1_summary_26Juli2022c.xlsx

4.3 Calculation of emission reductions

Based on reference level emissions with deduction from net emissions under the ER program during the monitoring period (July 2019- June2020 and July 2020-June 2021), the East Kalimantan has produced emission reductions of 25.77M tCO₂e. See sheet 'Sum All' on file for emission calculation –

https://mrv.kaltimprov.go.id/storage/guest/ERM1/CarbonAccounting/fcpf_ekjerp_ermr1_MC_26Juli2022c.xlsx

Table 4-4. Emissions Reduction Calculation

Total Reference Level emissions during the Monitoring Period (tCO₂-e)	54,939,712.80
Net emissions and removals under the ER Program during the Monitoring Period (tCO₂-e)	9,359,702.92
Emission Reductions during the Monitoring Period (tCO₂-e)	45,580,009.88
Length of the Reporting period/Length of the Monitoring Period (# days/# days)	549/730 days
Emission Reductions during the Reporting Period (tCO₂-e)	34,278,664.9 *).

*) Emission Reduction Calculation during the reporting period presented in table 4-4 covers the period of 548 days, started from 1 July 2019 to 31 December 2020. Therefore calculation of Emission Reduction in the reporting period is confined to between 1 July 2019 to 30 June 2020 and 1 July 2020 to 30 June 2021, (as defined in section 1). The Emission Reduction calculation is then done by subtracting the 1.5 amount of carbon of RL (annual) with the sum of emissions for 2019-2020 + half of (RL minus emissions for 2020-2021). This makes the calculation balanced since both reference period and crediting period lasts 1.5 years (549 days).

Please see the summary of the calculation here https://mrv.kaltimprov.go.id/storage/guest/ERM1/CarbonAccounting/fcpf_ekjerp_ermr1_summary_26Juli2022c.xlsx

5 UNCERTAINTY OF THE ESTIMATE OF EMISSION REDUCTIONS

5.1 Identification, assessment and addressing sources of uncertainty

Identification, assessment and addressing sources of uncertainty are presented below as follows: Sources of uncertainty	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
Activity Data				
<i>Measurement</i>	<ul style="list-style-type: none"> There are two sources of error related to the Landsat images. First stripping problem that leads to a loss of some data from the images and the need for manipulation using different images. Second, Indonesia almost always has a lot of cloud cover. The cloud's shadows and cloud coverage will affect the quality of the images as it generates data gaps. These constraints affect the image interpretation process. Interpretation of satellite images to produce land cover maps is done by trained interpreters who use manual or visual interpretation digitization technique. Standard Operating Procedures (SOPs) and manuals are provided to guide the interpreters to do the satellite image interpretation 	<i>L (random)</i>	YES	NO
<i>Representativeness</i>	The ground truthing uses stratified random sampling. Compilation of several ground truthing results within a specific year interval was used for accuracy assessment that will provide level of accuracy of the land cover classes interpretation.	<i>L (bias)</i>	YES	NO
<i>Sampling</i>	The number of points to represent land cover categories will determine the level of accuracy of the assessment. Ground truthing will reflect the accuracy of the interpretation with real condition. It helps to determine the accuracy of the satellite interpretation results. Therefore, the number of points of ground check will significantly affect the level of uncertainty. The number of sampling plots will be increased in order to reduce the uncertainty rate.	<i>H (random / bias)</i>	YES	YES

Identification, assessment and addressing sources of uncertainty are presented below as follows: Sources of uncertainty	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
<i>Extrapolation</i>	MoEF land cover data which has 23 classes and is reclassified into 5 (five) classes of land cover change, namely deforestation, forest degradation, forest gain (forest growth), stable forest (fixed/unchanged forest cover) and stable non-forest (non-forest cover that remains / does not change).	<i>H (bias)</i>	YES	NO
<i>Approach 3</i>	The approach is carried out by only calculating deforestation from forested areas from the beginning of the reference period until the measurement year, after which it changes to non-forested areas, while degradation is calculated in primary forested areas from the beginning of the reference period until the calculation year.	<i>L (bias)</i>	YES	NO
<i>DBH measurement</i>	Measurement officers in the field have gone through a training process and are provided with technical instructions for measuring, which are accompanied by a process of supervision and QA/QC.	<i>L (random)</i>	YES	NO
<i>H measurement</i>		<i>L (random)</i>	YES	NO
<i>Plot delineation</i>		<i>L (random)</i>	YES	NO
<i>Wood density estimation</i>	The calculation of wood density is carried out through a laboratory measurement approach on the species in the sample plot.	<i>L (random)</i>	YES	NO
<i>Biomass allometric model</i>	The sample tree data used to construct biomass allometric models is still relatively limited to trees of a certain size. Standard errors are also documented in the allometric model process.	<i>L (random)</i>	YES	NO
<i>Sampling</i>	Determination of the location of the sample is done based on proportional random based on forest class area.	<i>H (random)</i>	YES	YES
<i>Carbon Fraction</i>	Carbon fraction uses the values listed in Table 4.3 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4: Agriculture, Forestry and Other Land Use https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_04_Ch4_Forest_Land.pdf	<i>H (bias / random)</i>	YES	YES
<i>Root-to-shoot ratio</i>	Root shoot ratio using the IPCC GPG LULUCF Table 3A.1.8 - https://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Chp3/Anx_3A_1_Data_Tables.pdf	<i>H (bias / random)</i>	YES	YES

Identification, assessment and addressing sources of uncertainty are presented below as follows: Sources of uncertainty	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
<i>Representativeness</i>	Representative sample by purposive sample in each land cover class	<i>L (bias)</i>	YES	NO
<i>Model</i>	The combination of AD & EF does not necessarily need to result in additional uncertainty. QA/QC carried out by the MMR East Kalimantan team	<i>L (bias)</i>	YES	NO
<i>Integration</i>	This source of error is linked to the lack of comparability between the transition classes of the Activity Data and those of the Emission Factors. QA/QC carried out by the MMR East Kalimantan team	<i>L (bias)</i>	YES	NO

5.2 Uncertainty of the estimate of Emission Reductions

Parameters and assumptions used in the Monte Carlo method

The calculation for uncertainty of emissions reduction was based on Monte Carlo method. The parameters and assumptions are presented as follows:

Table 14. Parameter and assumptions used in Monte Carlo Method

Parameter included in the model	Parameter values	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
Project Area	12,734,692 ha			ER program document
Length of reference period	10 years			ER program document
Carbon Fraction	0.47	Measurement	Triangular (lower bound = 0.44, upper bound = 0.49, mode = 0.47)	IPCC 2006
Ratio of molecular weights of CO ₂ and C	44/12			Default
Root shoot ratio	See sheet 'EF_EKJERP' excel file https://mrv.kaltimpr ov.go.id/storage/guest/ERM1/CarbonAccounting/fcpf_ekjerp_ermr1_MC_26Juli2022c.xlsx			2006 IPCC GPG LULUCF Table 3A.1.8.
AGB sample	See sheet 'EF_EKJERP' excel file https://mrv.kaltimpr ov.go.id/storage/guest/ERM1/CarbonAccounting/fcpf_ekjerp_ermr1_MC_26Juli2022c.xlsx	Sampling	Normal distribution	
Activity data	See sheet 'UncertaintyAD' excel file https://mrv.kaltimpr ov.go.id/storage/guest/ERM1/CarbonAc	Sampling	Non-parametric bootstrapping	

Parameter included in the model	Parameter values	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
	counting/fcpf_ekjerp_ermr1_MC_26Juli2_022c.xlsx			

Quantification of the uncertainty of the estimate of Emission Reductions

The calculation of uncertainty from deforestation and forest degradation in the monitoring period has been done with exactly the same method to keep the consistency with those calculated during the reference period. The Monte Carlo technique has also been applied in the monitoring period. The calculation of uncertainty of Emission Reduction at the 90% confidence level is presented as follows:

Table 5. Uncertainty of aggregated Emissions Reduction

		Total Emission Reductions*
A	Median	35,404,709.61
B	Upper bound 90% CI (Percentile 0.95)	31,595,294.53
C	Lower bound 90% CI (Percentile 0.05)	39,343,003.80
D	Half Width Confidence Interval at 90% (B – C/2)	3,873,854.63
E	Relative margin (D/A)	11%
F	Uncertainty discount	0

5.3 Sensitivity analysis and identification of areas of improvement of MRV system

Sensitivity analysis is conducted by switching off each source of uncertainty at a time and assess the impact to the overall uncertainty of Emission Reductions, and generate the error estimates using Monte Carlo. The uncertainty level of these parameters shall be reduced in the next monitoring cycle/period. The results of sensitivity analysis are given in the following table.

Table 6. Sensitivity Analysis

Sensitivity Test	Median	Lower bound (5th percentile)	Upper bound (95th percentile)	Half-width confidence interval at 90%	Relative Margin	Uncertainty (%)
All on	35,404,709.61	31,595,294.53	39,343,003.80	3,873,854.63	0.10	10.94
R:S Uncertainty	35,471,602.13	35,001,607.79	35,949,894.69	474,143.45	0.01	1.34
CF Uncertainty	35,463,547.88	34,959,756.78	35,968,679.38	504,461.30	0.01	1.42
Sampling uncertainty	35,479,001.24	33,736,204.15	37,220,024.41	1,741,910.13	0.05	4.91
Emission Factor uncertainty	35,447,106.81	33,535,207.34	37,352,701.23	1,908,746.94	0.05	5.38

Activity Data	35,476,198.51	32,158,638.15	38,852,025.32	3,346,693.58	0.09	9.43
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The sensitivity analysis was done using Monte Carlo approach by removing one estimation parameter at a time, i.e.:

No	Parameter Used	Approach
1	All on	Using the uncertainty for Root shoot ratio, Carbon Fraction, Sampling uncertainty AGB, and Activity Data
2	R:S Uncertainty	Using the uncertainty for Root shoot ratio, and other uncertainty parameter near zero.
3	CF Uncertainty	Using the uncertainty for carbon fraction ratio, and other uncertainty parameter near zero
4	Sampling uncertainty	Using the uncertainty for AGB biomass sampling, and other uncertainty parameter near zero
5	Emission Factor uncertainty	Using the uncertainty for Root shoot ratio, carbon fraction, and AGB biomass sampling, but uncertainty for activity data near zero
6	Activity Data	Using the uncertainty for activity data (AD), and other parameter near zero

6 TRANSFER OF TITLE TO ERS

6.1 Ability to transfer title

Based on Criterion 36, the ability of a Program Entity to transfer title to ERs needs to be demonstrate through various means, namely: reference to existing legal and regulatory frameworks; sub-arrangements with potential land and resource tenure holders (including those holding legal and customary rights as identified by the assessments conducted under Criterion 28); and benefit sharing arrangements under the Benefit Sharing Plan.

Based on the 1945 Constitution of the Republic of Indonesia, the Government through MoEF has the mandate to regulate natural resources for people, prosperity and welfare. The specific mandate to regulate forest resources, including forest carbon stock, is from Forestry Act 1999 (Article 4 Point 1) through implementation of REDD+, as part of the legal forestry activities. Based on President Regulation No.98/2021 (Article 1 Point 22), carbon right is regulated and managed by Central Government. In this regard, the MoEF is by law considered as Program Entity as having ability to transfer the title of ERs resulting from the REDD+ program, that is conceptualized as “a national approach with sub-national implementation”. In addition, based on Law of Republic of Indonesia No. 23 of 2014 concerning Sub National Governance page 118 which clearly states that Provincial Government has the authority on “environmental services utilization with exception of carbon utilization, carbon storage and/or carbon sequestration”. In other words, carbon utilization, its storage or sequestration is regulated and managed by the Central Government.

In relation to the Title of Emission Reductions (ERs), the term “Title” here is not necessarily identical to “Carbon Rights”. Rather, title is intended to capture an environmental service derived from forests. As such, the volume of ERs is a measure of the performance of this service. Hence, the legal title corresponds to the performance results. Furthermore, the “transfer of Title to ERs” applies both to Contract ERs (22 million ERs) and a Call Option Volume of 20 million tons (for additional ERs). The Title to ERs as referred to the FCPF ERPA document is in the form of “Contract ER Volumes” reflecting the emissions reduction performance achieved by the GoI. Therefore, the Carbon Rights is still owned and governed by the GoI in accordance with the prevailing laws and regulation.

In order to ensure the implementation of the ER program at sub-national level, a Memorandum of Understanding (MoU) between the national (through MoEF) and sub-national level was signed (No.PKS.3/SETJEN/ROKLN/KLN.0/3/2020 and No.197/2439/B.Humas-III)³⁰. The sub-national level hereafter represented by Provincial Government of East Kalimantan, which also represent beneficiaries from province, district, village including indigenous people for the ER implementation in East Kalimantan. The MoU covers a) strategic and program for REDD+ activity in the province, b) working plan of REDD+, c) benefit sharing mechanism between national and sub-national level, d) safeguards implementation, e) carbon rights managed by Central Government, f) data and information exchange on forest and land cover change. The

³⁰ [MoU REDD+ di Kaltim Materai Sekjen KLHK.pdf \(kaltimprov.go.id\)](#)

commitments to implement the ER program from village and indigenous people were also stated in the FPIC Process³¹.

Furthermore, we confirm our understanding that as part of the agreed provisions of ERPA Tranche B, the contract ERs/additional ERs transferred from Indonesia will be re-transferred to Indonesia as soon as possible, but no later than 30 calendar days and claimed as part of Indonesia's achievements under the Nationally Determined Contributions (NDC), as already stated in the signed ERPA.

With reference to the Criterion 38 indicator 38.1 of the Methodological Framework, the GoI has decided to use the FCPF ER Transaction Registry, after all achievements of ERs in EK-JERP in the framework of the Carbon Fund are registered first in the National Registry System (SRN) of MoEF. During the reporting period the ability to transfer Title to ERs was clear and uncontested.

6.2 Implementation and operation of Program and Projects Data Management System

The EK-JERP program was designed through a series of multi-stakeholder consultations from 2017-2019. Based on Criterion 37, the ER Program host country should decide whether to maintain its own comprehensive national REDD+ Program and Projects Data Management System.

Since the Government of Indonesia has appointed the Ministry of Environment and Forestry as a National Focal Point for climate change mitigation and adaptation, the national REDD+ Program and Projects Data Management System are managed by MoEF. However, data and information from the field are managed and stored at Provincial level as Portal Measurement Monitoring Report/MMR (<https://mrv.kaltimprov.go.id/>). All format reports for ER activities have been designed and put onto both web-based and excel-based. Trainings on how to fulfil and submit the reports have been conducted in 7 districts during the reporting period. The field ER activities done by Forest Management Unit (FMU) are reported to the Portal MMR (mrv.kaltimprov.go.id) through online system and copied to Forestry Service (see Figure 4). For FMU that has difficulty to access to the Portal MMR, needs to go to the nearest capital sub-district with the internet coverage. This Portal MMR is managed by Provincial Environmental Service. The Provincial government through The Environment Service then submits an annual report of the EK-JERP program to the MoEF. The Report is automatically embedded into the MoEF website for the National Registration System known as SRN-PPI (<http://srn.menlhk.go.id/>). All REDD+ initiatives in East Kalimantan have to be registered into SRN-PPI. Up to now, there is no voluntary REDD+ initiatives such as VERRA Projects implemented in East Kalimantan (see the list of REDD+ project registered under VERRA³²) and no also Plan VIVO project in East Kalimantan³³.

³¹ [PADIATAPA IMPLEMENTATION REPORT ENG.pdf \(kaltimprov.go.id\)](#)

³² [allprojects Verra in Indonesia.xlsx \(live.com\)](#)

³³ [All Plan Vivo Project in Indonesia.xlsx \(live.com\)](#)

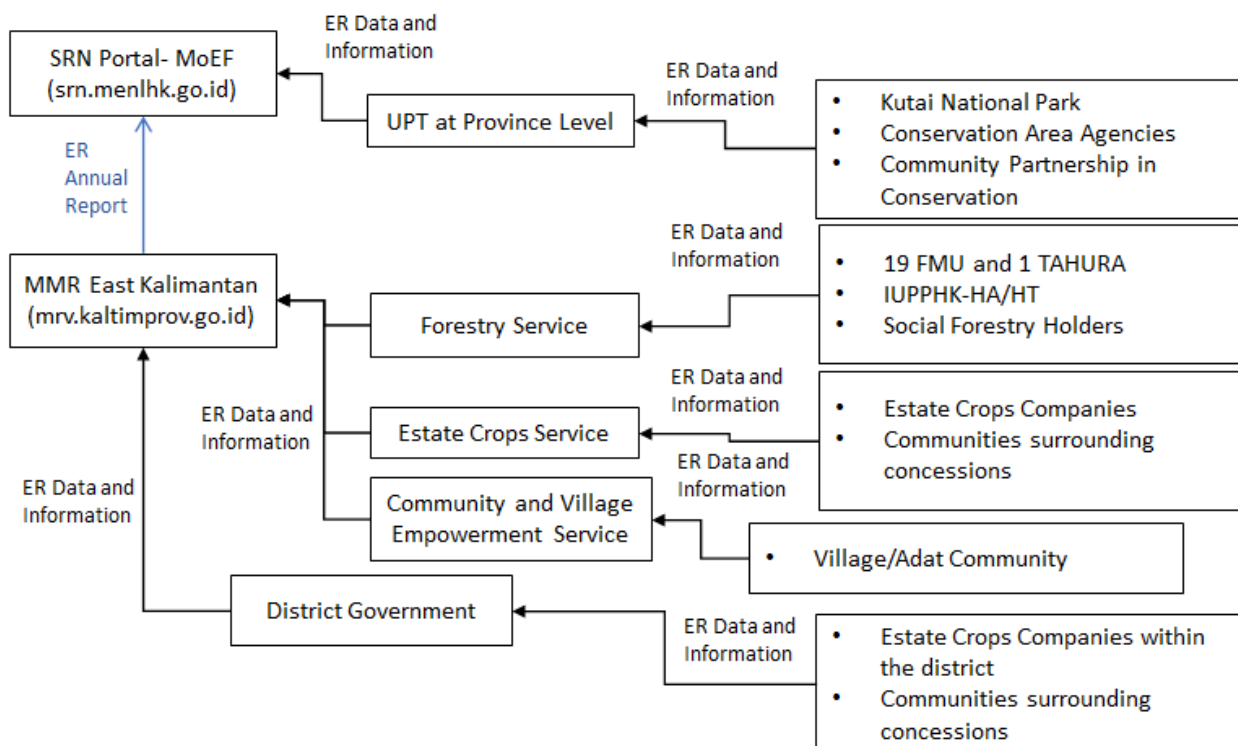


Figure 6. Project Management on ER Data and Information System

Several standard operational procedures (SOPs), such as reporting, data entry, data validation, and data and information exchange are being developed for data management.

6.3 Implementation and operation of ER transaction registry

The development of an ER transaction registry system for Indonesia is being considered. Based on Government Regulation No. 46/2017³⁴, BPD LH is appointed as fund manager and has a mandate (President Regulation No 77/2018³⁵) to collect environment or climate change funds either from government, private, or international donor countries. The future role of BPD LH will be not only to disburse the funds to beneficiaries, but also as the host for domestic carbon trade. The carbon project/REDD+ initiatives in the future might need to register to BPD LH for selling their carbon in domestic market, so that the government target for Indonesia's NDC can be achieved by 2030.

Up to now, the ER transaction registry system for Indonesia has not been developed yet. The MoEF agreed that emission reductions from East Kalimantan Province in the framework of FCPF will be registered first in the National Registry System (SRN) under MoEF³⁶, prior to submission

³⁴ <https://peraturan.bpk.go.id/Home/Details/64701>

³⁵ <https://peraturan.bpk.go.id/Home/Details/94707/perpres-no-77-tahun-2018>

³⁶ President Regulation No.98/2021 (Article 69, Point 1) stated that emissions reported by each entity have to be reported to national registry system. <https://peraturan.bpk.go.id/Home/Details/187122/perpres-no-98-tahun-2021>

to the FCPF-CF through the World Bank CATS for the first and subsequently reporting period, until the Indonesian transaction registry system is developed.

6.4 ERs transferred to other entities or other schemes

Estimation of ERs produced during the reporting period reaches 35.5 MtCO₂e. The amount of these ERs exceeds the allowable trade of FCPF ERs for this period (maximum 5M tCO₂e). The ER Program Entity proposes to offer the exceeding ERs of 30.5 MtCO₂e to the FCPF Carbon Fund with the negotiated price (based on ERPA conditions). No ERs in East Kalimantan are transferred to other entities or other schemes during the reporting period.

7 REVERSALS

7.1 Occurrence of major events or changes in ER Program circumstances that might have led to the Reversals during the Reporting Period compared to the previous Reporting Period(s)

As this first reporting period, the occurrence of major events or changes in the ER program circumstances that might have reversals during the reporting report compared to the previous reporting report is “Not Applicable”.

7.2 Quantification of Reversals during the Reporting Period

As this is the first reporting period, the quantification of reversals during the reporting period is “Not Applicable”

7.3 Reversal risk assessment

Risk Factor A: Lack of comprehensive and sustained support of the relevant stakeholders

The successful implementation and sustainability of emission reductions is dependent on active contributions from the various levels of government, from the private sector, and from local communities. It is confirmed that much of the ER Program’s sustainability depends on the continued political will of the national, provincial, and district governments to implement the policies that the ER Program is supporting. These policies include the policy on sustainable estate crops, the HCV and RIL policies, social forestry, and other key policies linked to land governance.

Current support for these policies is strong at the national and provincial levels, and many of the policies are integrated into the medium-term development plan. Up to 2020, policies to support ER implementation have been formulated and issued such as continuation of moratorium licenses on coal mining, application of one service for all licenses policy, issuance of regulation on sustainable estate crops (No.7/2018³⁷), East Kalimantan Governor Regulation on Criteria of High Conservation Area (HCVA)³⁸, and Berau District’s decree on HCVA (No.287/2020³⁹). This HCVA decree from Berau District is one of important efforts to avoid negative impacts on local development of oil palm expansion to natural forests. It is expected that other 6 (six) districts will follow to produce HCVA regulation.

There is some risk from issues related to benefit sharing. However, in order to give clear understanding the mechanism of benefit sharing for ER payments, consultations with related stakeholders including beneficiaries have been conducted since 2015. In East Kalimantan, benefit sharing working group has been formed. Inputs and feedbacks from beneficiaries through FPIC process in 2019 and 2020 were adopted to benefit sharing document. Based on

³⁷ <https://peraturan.bpk.go.id/Home/Details/185205/perda-prov-kalimantan-timur-no-7-tahun-2018>

³⁸ https://jdih.kaltimprov.go.id/produk_hukum/detail/75185be6-ac76

³⁹ [https://mrv.kaltimprov.go.id/storage/guest/ERMRI/Regulation/SK Bupati Berau 287 2020 ttg Peta Indikatif ANKT.pdf](https://mrv.kaltimprov.go.id/storage/guest/ERMRI/Regulation/SK_Bupati_Berau_287_2020_ttg_Peta_Indikatif_ANKT.pdf)

these consultations, benefit sharing regulation through governor regulation is being formulated and ready to be issued this year.

To support coordination and supports from relevant stakeholders, the other working groups namely MMR working group, Safeguard working group, and Planning and Budgetary working group also have been formed. Each group has exclusively task to invite relevant development partners and government services to discuss and address certain topics of ER program.

Based on the above progress, the risk of reversal due to a lack of comprehensive and sustained support of the relevant stakeholders is categorized as low.

Risk Factor B: Lack of institutional capacities and/or ineffective vertical/inter-sectoral coordination

Poor coordination across sectors could hamper progress in improving land governance, which is an important part of the ER Program's sustainability strategy. Policy coordination, especially for the land-based sectors, is a challenge in Indonesia. Separate ministries are responsible for mining, agriculture, and forestry, and conflicts in the legal frameworks and overlapping mandates of each sector are a barrier to land governance. This is particularly the case for land administration which distinguishes between forest and non-forest land, each with separate regulatory frameworks and institutional arrangements.

In order to empower coordination across sectors, institutional arrangements for the ER program has been developed. At national level, there will be vertical coordination between the levels of government will be important for the program's implementation and its sustainability. As noted under Risk Factor A, the district governments play an important role in implementing reforms related to estate crops. Continued district support for policy implementation will in part depend on the coordination of districts with the province. For issues related to land registration, efforts of multiple agencies in particular of the MoEF and the national land agency (BPN) will need to be coordinated.

Lack of institutional capacities has been identified as an underlying driver of deforestation and is being addressed through the activities in Component 1. Inadequate progress in this area, would mean that policies such as the RIL-C and HCV policies, as well as support for local communities, would be less effective, especially after support for policy implementation has ended.

Based on the above assessment, the risk of reversal due to a lack of institutional capacities and/or ineffective vertical/inter-sectoral coordination is categorized as low.

Risk Factor C: Lack of long-term effectiveness in addressing the underlying causes

The expected long-term effectiveness in addressing the underlying causes of deforestation depends on the complexity of the driver and whether further support will be needed to address the driver after the program has ended. As discussed in the table, some drivers will require continued political will, while others require sustainable solutions to be in place. Based on the assessment provided in the table below, the overall risk of reversal due to a lack of long-term effectiveness in addressing the underlying causes is categorized as low.

Table 7. Underlying Causes

Underlying Driver	Long-term effectiveness in addressing driver
Poor land governance	Improvements are expected to be long-term, but may not be fully in place by the end of the ER Program.
Ineffective forest supervision and administration	Long-term effectiveness in addressing this driver depends on continued political will (see Risk Factor A), and on the ability of FMUs to generate sufficient revenue or to receive budgetary or external funding.
Weak policies for forest protection	Improvements in policies are expected to be long-term, but effectiveness depends also on enforcement (political will and forest supervision).
Lack of incentives for sustainable management practices	The Program is expected to contribute to an improved incentives framework, but direct support will stop when the program ends.
Limited alternative livelihood opportunities for local communities	Long-term effectiveness will depend partly on the level of benefits that the alternative livelihood opportunities can provide.
Lack of fire management capacity and lack of alternatives for land clearing	Long-term effectiveness will depend on continued support and the long-term attractiveness of alternative livelihood options.
Climate factors	Cannot be directly addressed. See discussion under Risk Factor D.

Risk Factor D: Exposure and vulnerability to natural phenomena

Extreme fire events in East Kalimantan are linked to prolonged periods of drought, which in turn are closely linked to El Nino Southern Oscillation events. These occur on average every 3-7 years with the last event occurring in 2016, so there is a high likelihood of an ENSO event occurring during the program period, and the accounting area will of course continue to be affected after the program ends. While the ER Program has no influence on the occurrence of ENSO events, the program includes a number of activities that should lead to a reduction in the scale of fires and their impact on forests. As noted in the table above, the long-term effectiveness of these measures will depend on continued support and on the long-term attractiveness of alternative livelihood options. The risk of future extreme fire impacting remaining forests contributes to the anticipated risk of reversal.

Based on the above assessment, the risk of reversal due to exposure and vulnerability to natural phenomena is categorized as low.

Table 18. Reversal Risk Assessment

Risk Factor	Risk indicators	Default Reversal Risk Set-Aside Percentage	Discount	Resulting reversal risk set-aside percentage

Risk Factor	Risk indicators	Default Reversal Risk Set-Aside Percentage	Discount	Resulting reversal risk set-aside percentage
Default risk	<i>N/A</i>	10%	<i>N/A</i>	<i>10%</i>
Lack of broad and sustained stakeholder support	<i>Low</i> FPIC with villages and communities has been carried out, and minutes of approval from the community are available.	10%	<i>10%</i>	<i>0%</i>
Lack of institutional capacities and/or ineffective vertical/cross sectorial coordination	<i>Low</i> Capacity building for stakeholders (government, community, private sector, non-governmental organizations) has been carried out in program implementation, implementation of social and environmental safeguards, and management of reversals and leakage risks.	10%	<i>10%</i>	<i>0%</i>
Lack of long term effectiveness in addressing underlying drivers	<i>Low</i> The program has been integrated into government development plans and strategic plans of government agencies, as well as development partners.	5%	<i>5%</i>	<i>0%</i>
Exposure and vulnerability to natural disturbances	<i>Low</i> National, provincial and district governments already have disaster management plans, including forest and land fires, and have coordinated disaster management systems.	5%	<i>0%</i>	<i>0%</i>
Total reversal risk set-aside percentage				<i>10%</i>

8 EMISSION REDUCTIONS AVAILABLE FOR TRANSFER TO THE CARBON FUND

A.	Emission Reductions during the Reporting period (tCO ₂ -e)	<i>from section Error! Reference source not found.</i>	34,278,665
B.	If applicable, number of Emission Reductions from reducing forest degradation that have been estimated using proxy-based estimation approaches (use zero if not applicable)		0.00
C.	Number of Emission Reductions estimated using measurement approaches (A-B)		34,278,665
D.	Percentage of ERs (A) for which the ability to transfer Title to ERs is clear or uncontested	<i>from section 6.1</i>	100%
E.	ERs sold, assigned or otherwise used by any other entity for sale, public relations, compliance or any other purpose including ERs accounted separately under other GHG accounting schemes or ERs that have been set-aside to meet Reversal management requirements under other GHG accounting schemes	<i>from section 6.4</i>	0.00
F.	Total ERs (B+C)*D-E		34,278,665
G.	Conservativeness Factor to reflect the level of uncertainty from non-proxy based approaches associated with the estimation of ERs during the Crediting Period	<i>from section 5.2</i>	0
H.	Quantity of ERs to be allocated to the Uncertainty Buffer $(0.15*B/A*F)+(G*C/A*F)$		0
I.	Total reversal risk set-aside percentage applied to the ER program	<i>from section 7.3</i>	10%
J.	Quantity of ERs to allocated to the Reversal Buffer $(F-H)*(I-5\%)$		1,713,933
K.	Quantity of ERs to be allocated to the Pooled Reversal Buffer $(F-H)*5\%$		1,713,933

L. Number of FCPF ERs (F- H – J – K)	30,850,798
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The following annexes are being completed and will be made public as soon as they are available:

ANNEX 1: INFORMATION ON THE IMPLEMENTATION OF THE SAFEGUARDS PLANS

ANNEX 2: INFORMATION ON THE IMPLEMENTATION OF THE BENEFIT-SHARING PLAN

ANNEX 3: INFORMATION ON THE GENERATION AND/OR ENHANCEMENT OF PRIORITY NON-CARBON BENEFITS

ANNEX 4: CARBON ACCOUNTING – ADDENDUM TO THE ERPD

All sections in Annex 4 shall be completed by all ER Programs so as to update information on the ER-PD based on:

- 1) Technical corrections applied to the reference level;*
- 2) Updates of the monitoring plan based on the latest available information;*
- 3) Updates of any other aspect with latest information (policy and design decisions shall not be updated).*

This annex will serve as an addendum to the ER-PD, replacing mutatis mutandis the relevant sections of the ER-PD.

The annex will be subject to validation in the following cases:

- a) If the REDD Country has applied technical corrections, in this case section 8 and 12 will be subject to a validation.*
- b) If the REDD Country wishes to be subject to an extended validation to generate CORSIA compliant units, all sections will be subject to validation.*

Technical Correction

Provide a summary of the technical corrections applied clearly indicating where parameters have changed compared to the original Reference Level.

Please indicate the changes applied and whether these are included in paragraph 3 of Guideline on the application of the Methodological Framework Number 2 – Technical corrections

Indonesia notified the FMT on the intention to apply technical corrections to the reference level for the ER-Program before the signing of the ERPA.

Summary of Technical Correction

Technical correction is applied to the following areas as defined in paragraph 3 of the Guideline on the application of the Methodological Framework Number 2 – Technical corrections. The summary of the corrections are the following:

1. Activity data. The technical corrections for the activity data include
 - Adjustment of the boundary of East Kalimantan Province as the provincial boundary of the 2019 ERPD does not match with the provincial spatial plan. This adjustment results in a change in the total project area from 12,746,546 ha to 12,734,691 ha.
 - Refinement of method for estimation of burnt area. The 2019 ERPD used MRI (2013) method which depend solely on hotspot data, while the current method combine the hotspot data with the Landsat image (quick look original with composite band 645) and fire control activity that is able to delineate the burnt area and supervised by other data (ground check).
 - Change of stratification approach for the estimation of deforestation and degradation area using Sample Based Estimation (SBE) from post stratification to stratification following the procedure of Olofsson (2014), and adoption of the

filtering method to avoid double counting of deforestation and degradation in recovered areas following the gross deforestation and forest degradation definition (gross). The change of the method from post stratification to stratification is to follow the proposed method of Olofson (2014) in which the sample is defined before the SBE analysis.

Comparison of the area of sample-based estimation of the original 2019 ERPD and the Technical Correction is given in Table 1 and that of burnt area is in Tables 2 and 3.

Table 1. Comparison of area of Sample Based Estimation between 2019 ERPD and Technical Correction

LC Change Classification	Map Area (Ha)	Adjusted Area (Ha)	SE for the Adjusted Area (Ha)	CI (95%)	U (%)
Technical Correction ⁴⁰					
Deforestation	631,440	717,740	99,687.01	195,386.53	27.22
Forest Degradation	103,448	140,974	61,236.19	120,022.93	85.14
Forest gain	0				
Stable Forest	6,509,063	7,525,408	195,722.67	383,616.44	5.10
Stable Non-Forest	5,490,741	4,360,569	193,622.34	379,499.79	8.70
Total	12,734,692	12,734,692			
Original ERPD					
Deforestation	701,685	1,140,536	131,451.88	257,646	22.59
Degradation	93,979	276,780	72,953.51	142,989	51.66
Forest gain	372,712	-	-	-	-
Stable Forest	6,525,057	6,058,260	171,176.77	335,506	5.54
Stable Non-Forest	5,151,246	5,369,103	167,066.93	327,451	6.10
Total	12,844,679	12,844,679			

Table 2. Comparison burnt area of stable forest between 2019 ERPD and Technical Correction

Year	Land Use Code	Burnt Area-2019 ERPD(ha)	Burnt Area-Technical Correction (ha)
2007	2002	6,260	280
	20041	210	
	20051	154	
2008	2002	3,875	135
	20041	141	
	20051	-	
2009	2002	19,908	671

⁴⁰ See sheet 'UncertaintyAD' on file fcpf_ekjerp_ermr1_MC_26Juli2022c.xlsx
https://mrv.kaltimprov.go.id/storage/guest/ERMRI/CarbonAccounting/fcpf_ekjerp_ermr1_MC_26Juli2022c.xlsx

Year	Land Use Code	Burnt Area-2019 ERP(ha)	Burnt Area-Technical Correction (ha)
	20041	405	4
	20051	696	126
2010	2002	4,706	222
	20041	19	
	20051	469	21
2011	2002	7,996	435
	20041	167	13
	20051	159	63
2012	2002	11,716	1,216
	20041	56	12
	20051	194	30
2013	2002	7,731	695
	20041	120	
	20051	387	2
2014	2002	20,127	1,578
	20041	326	4
	20051	1,405	
2015	2002	17,738	0.04
	20041	316	0.01
	20051	912	
2016	2002	2,923	1,179
	20041	105	395
	20051	257	116

Table 3. Comparison burnt area of peat between 2019 ERP(ha) and Technical Correction

Year	Burnt peat 2019 ERP(ha)	Burnt peat Technical Correction (ha)
2013	370	323
2014	-	-
2015	51	395
2016	23	674

2. Emission Factors. The technical corrections for the EF include the

- Replacement of emission factors of dryland forest by using data from permanent sampling plots of the National Forest Inventory (NFI) located in East Kalimantan Province rather than the smaller sample specifically collected for FCPF in 2018-2019.
- Replacing the allometric equation from Basuki *et al.* 2005 to Manuri *et al.* (2017); and
- Establishment of new FCPF plots in mangrove forest for increasing number of samples.

Allometric equations used for swamp and mangrove forest remains the same. The changes of the EFs compared to original values in ERPD are presented in Table 4.

Table 4. Comparison of EF (living biomass) between the 2019 ERPD and Technical Correction

Land Cover Types	2019 ERPD			Technical Correction		
	n	C Stock (t/ha)	U (%)	n	C stock (t/ha)	U (%)
Primary dryland forest ¹	55	281.3	37.5	79	167.3	40.0
Secondary dryland forest ¹	68	147.3	33.3	408	122.1	39.5
Secondary dryland forest (burnt area)				50	120.5	39.8
Primary peat swamp forest ²	18	344.2	38.9	18	343.9	38.3
Secondary peat swamp forest ²	42	233.5	41.3	42	237.3	40.9
Dry shrub ³	7	29.9	41.0	25	28.8	44.9
Wet shrub ³	6	26.7	41.0	12	32.4	52.8
Primary mangrove forest	37	160.8	36.4	80	168.2	29.8
Secondary mangrove forest	23	128.6	34.0	54	118.1	30.9

¹ Higher Uncertainty After Technical Correction For The Dryland Forest Due To Higher Uncertainty Of The Allometric Equation Of Manuri Et Al 2017 Compare To Basuki Et Al. 2009 (Dryland Forest)

² Slight Decrease In Living Biomass For Primary And Secondary Swamp Forest Due To The Decrease In Root:Shoot Ratio Of The Mangrove Forest Following The Assumption That The Ratio Of The Swamp Forest Is The Same As That Of The Mangrove Forest.

Data On Shrubs Are Taken From The National Forest Inventory Located In East Kalimantan. Previous Data Are All From Outside East Kalimantan, Thus They Are Excluded.

Start Date of the Crediting Period

The ER Program Start Date is: June 18, 2019

7. CARBON POOLS, SOURCES AND SINKS

Table 7.1 illustrates the REDD+ activities (adopted by 1/CP.16, paragraph 70) selected by the ER-Program and the associated emission sources and sinks.

7.1 Description of Sources and Sinks Selected

Table 7.1 Sources and Sinks Selected

Sources/Sinks	Included?	Justification / Explanation
Emissions from deforestation	Yes	Emissions from deforestation are identified as GHG emissions from the IPCC Land Use Change category of forest land to non-forest land, plus emissions from peat decomposition, peat fire, and mangrove soils that are linked to deforestation.

Sources/Sinks	Included?	Justification / Explanation
		<p>Deforestation in this context is defined as a conversion of natural forest to other land uses (non-natural forest; see section 8.2). In the period 2006 to 2016 deforestation contributed 80% of total emissions in East Kalimantan. Conversion to agriculture, particularly to oil palm plantations, was the major cause of the deforestation, while conversion to monoculture timber plantations also contributed significantly.</p> <p>It is worthy to note that considering the lengthy reference period, i.e. 10 years, there is a chance for a deforested area to regrow into young secondary forest in 10 years or even earlier. To ensure this regrowth does not count twice as deforestation when it is deforested again during monitoring period, deforestation only identified in areas where it was consistently forest until the first year of monitoring.</p>
Emissions from forest degradation	Yes	<p>Emissions from forest degradation</p> <p>Forest degradation in the national FREL is defined as a change of a primary forest class to a secondary forest class. Primary forest classes include primary dryland, primary mangrove and primary swamp forests. However, this definition of forest degradation excludes losses of carbon in the secondary forest classes due to further disturbance. Identifying the degree of forest degradation within secondary forests is not a simple task, especially not on a routine basis with the currently used medium-resolution satellite imagery (Landsat); and at present, Indonesia has no capacity and data available to assess different levels of degradation within secondary forests. However, it is possible to estimate the loss of carbon due to fire within the secondary forest classes. Thus, included emissions from forest degradation comprise the following:</p> <p>Emissions due to the degradation of primary forest into secondary forest. This includes emissions due to the associated loss of tree cover; as well as emissions due to peat decomposition, where the change from primary to secondary forest occurs on swamp forest.</p> <p>Emissions due to fire within areas that are classified as secondary forest at the beginning and at the end of the measurement period (stable secondary forest). Emissions due to fire in secondary forests that have changed to a non-forest class (including shrubs) at the end of the</p>

Sources/Sinks	Included?	Justification / Explanation
		measurement period, are reported under deforestation. Limiting consideration of fire to stable secondary forest avoids double-counting the emissions from fire with emissions from deforestation.
Emissions and removals from conservation of carbon stocks	No	The national REDD+ framework does not define activities for the conservation of carbon stocks.
Emissions and removals from sustainable management of forest	No	This activity is not included due to limited data and information.
Removals from enhancement of carbon stocks	No	The national FREL does not account for removals from the enhancement of carbon stocks. Also, there is limited data and information, especially on relevant emission factors. Inclusion of this activity would not be in line with the national REDD+ framework and would result in a higher uncertainty level.

7.2 Description of Carbon Pools and greenhouse gases selected

The following Table 7.2. explains which pools were recorded in the FREL for each activity.

Table 7.2 Carbon Pools

Carbon Pools	Selected?	Justification / Explanation
Above Ground Biomass (AGB)	Yes	<p>According to Indonesia's FREL document, emissions from AGB accounted for around 70% of total emissions from biomass, making AGB the largest pool of emissions.</p> <p>Moreover, many studies for estimating above-ground tree biomass in Indonesia are available, enabling Tier 2 or Tier 3 approaches. AGB data are widely available and can be estimated from forest inventory or sample plot data.</p>
Below Ground Biomass (BGB)	Yes	Based on research conducted at sites in Sumatra and Kalimantan, this pool accounts for an average of 13.6% of total biomass (MoEF, 2016). This pool is estimated using shoot-root ratios, following IPCC (2014).
Dead Wood	No	Based on research conducted at sites in Sumatra and Kalimantan, this pool accounts for an average of 14.3% of total biomass emissions. In spite of being significant, this carbon pool is excluded due to lack of sampling data.
Litter	No	Emissions from litter are excluded as per Indonesia's FREL document. It was estimated that emissions from litter accounted for only 1% of total emissions from biomass, and the pool is therefore considered insignificant.
Soil Carbon	Yes for organic Soils No for mineral soils	The ERP accounts for losses of carbon from organic soils (peat and mangrove soils) due to decomposition (gradual loss following deforestation or forest degradation) and fire. Emissions from soil carbon in other mineral soils is excluded, since they are not significant.

Table 7.3 Type of Gases

Greenhouse gases	Selected?	Justification / Explanation
CO₂	Yes	The ER Program shall always account for CO ₂ emissions and removals
CH₄	No/Yes	Excluded for peat drainage due to insufficient data in estimating methane emissions and included for peat and forest fire following the IPCC (2014)
N₂O	Yes	Included only for forest fire following the IPCC (2014)

8. REFERENCE LEVEL

8.1 Reference Period

Following the Criteria 11 of the FCPF Methodological Framework (2016), the end-date for the Reference Period should be the most recent date prior to two years before the TAP starts the independent assessment of the draft ER Program Document (i.e. 2018-2 years = 2016) and for which forest-cover data is available to enable IPCC Approach 3; and the start date of the Reference Period is about 10 years before the end-date. Considering this criterion, the reference period selected for the ERPD is from 2006-2007 to 2015-2016. This period is chosen to cover a 10 year period from July 2006 to June 2016, reflecting the 10-year period between the forest cover map developed for 2006 and the forest cover map developed for 2016. To ensure consistency with the national framework, the land use/cover data for the development of the FREL for the ER Program are the same as the data used in the development of the national FREL supplied by the Ministry of Environment and Forestry, i.e. data of years 2006, 2009, 2011, 2012, 2013, 2014, 2015 and 2016.

8.2 Forest definition used in the construction of the Reference Level

In accordance with UNFCCC decision 12/CP.17, forest in Indonesia is defined as a land area of more than 6.25 ha with trees higher than 5 meters at maturity and a canopy cover of more than 30 percent. This is a formal definition of forest that mostly based on forest ecology. For the construction of the national FREL for REDD+, Indonesia used a different definition that considers limitations of methods and data used in generating the Indonesia forest data. A “working definition” of forest was used to produce land-cover maps through visual interpretation of satellite images at a scale where the minimum area for polygon delineation is 0.25 cm² at 1: 50,000 of scale which represents 6.25 ha. This definition is in accordance with the Indonesian National Standard (SNI) 8033:2014 on “Method for calculating forest cover change based on results of visual interpretation of optical satellite remote sensing image” (<http://sni.bsn.go.id/product/detail/22270>). Other definitions of forest submitted to international organizations by Indonesia can be accessed from http://ditjenppi.menlhk.go.id/kcpi/dokumen/national_frel_final%20revisi_10des.pdf.

The SNI defined forest based on satellite data features including color, texture and brightness. Forests were classified into 7 classes based on forest types and degradation or succession level, while non-forests were classified into 15 classes with one class being cloud (Table 8.1). The first six forest classes are natural forests, and the seventh class is plantation forest. These 23 land cover classes are based on physiognomy and biophysical appearance that is captured by remote sensing (Landsat at 30 meter spatial resolution). However, the object identification is purely based on the appearance in the imagery. Manual-visual classification through an on-screen digitizing technique based on key elements of image/photo-interpretation was applied as a classification method. Several ancillary data sets (including concession boundaries of logging and plantation, forest area boundaries) were utilized during the process of delineation, to integrate additional information valuable for classification. The process for analyzing satellite data to monitor the land/forest cover change is described in detail in Margono et al. (2016) and can be accessed from the following link <https://nfms.menlhk.go.id/> and <https://jurnal.ugm.ac.id/iig/article/view/12496/9041>. References for technical assessment related to the carbon accounting

can be seen in Annex 8.2. The data/information/methodology was posted in <http://puspijak.org/index.php/front/content/erpd> (official website of Research and Development Center for Social Economy, Policy and Climate Change, Ministry of Environment and Forestry).

For the construction of the national FREL, Indonesia only included natural forest in its forest definition; plantation forest is treated as non-forest land for purposes of the FREL, and the ERPD follows the same convention for consistency.

The submitted national FREL has successfully undergone technical assessment by the UNFCCC. In the construction of the FREL for the ER Program, the same definition has been adopted, which excludes plantation forests. The use of this definition is in line with the spirit of REDD+ activities as defined in paragraph 2e in the Appendix 1 of Decision 1/CP.16 that REDD activities should not be used for the conversion of natural forests, but are instead used to incentivize the protection and conservation of natural forests.

Table 8.1 Characterization of natural forests in Indonesia used in national land cover mapping.

No	Land cover type	Code	Description
Forests			
1	Primary dry land forest	2001	Natural tropical forests growing on non-wet habitat including lowland, upland, and montane forests with no signs of logging activities. The forest includes heath forest and forest on ultramafic and lime-stone, as well as coniferous, deciduous and mist or cloud forest, which shows no, or little, influence from human activities such as logging.
2	Secondary dry land forest / logged forest	2002	Natural tropical forests growing on non-wet habitat including lowland, upland, and montane forests that exhibit signs of logging activities indicated by patterns and signs of logging (appearance roads and patches of logged-over area). The forest includes heath forest and forest on ultramafic and lime-stone, as well as coniferous, deciduous and mist or cloud forest.
3	Primary swamp forest	2005 biics2020test	Natural tropical forests growing on wet habitat in swamp form, including, brackish swamp, marshes, sago and peat swamp, which shows no, or little, influence from human activities such as logging.
4	Secondary swamp forest / logged forest	20051	Natural tropical forests growing on wet habitat in swamp form, including brackish swamp, marshes, sago and peat swamp that exhibit signs of logging activities indicated by patterns and signs of logging (appearance roads and logged-over patches).
5	Primary mangrove forest	2004	Wetland forests in coastal areas such as plains that are still influenced by the tides, muddy and brackish water and dominated by species of mangrove including Nipa (<i>Nipafrutescens</i>), which shows no, or little, influence from human activities such as logging.

No	Land cover type	Code	Description
6	Secondary mangrove forest / logged forest	20041	Wetland forests in coastal areas such as plains that are still influenced by the tides, muddy and brackish water and dominated by species of mangrove and Nipa (<i>Nipa frutescens</i>), and exhibit signs of logging activities, indicated by patterns and signs of logging activities.
7	Plantation forest	2006	The appearance of the structural composition of the forest vegetation in large areas, dominated by homogeneous trees species, and planted for specific purposes. Planted forests include areas of reforestation, industrial plantation forest and community plantation forest.
Non-Forests			
8	Dry shrub	2007	Highly degraded logged over areas on non-wet habitat that are ongoing process of succession but not yet reach stable forest ecosystem, having natural scattered trees or shrubs.
9	Wet shrub	20071	Highly degraded logged over areas on wet habitat that are ongoing process of succession but not yet reach stable forest ecosystem, having natural scattered trees or shrubs.
10	Savanna and Grasses	3000	Areas with grasses and scattered natural trees and shrubs. This is typical of natural ecosystem and appearance on Sulawesi Tenggara, Nusa Tenggara Timur, and south part of Papua island. This type of cover could be on wet or non-wet habitat.
11	Pure dry agriculture	20091	All land covers associated with agriculture activities on dry/non-wet land, such as tegalan (moor), mixed garden and ladang (agriculture fields).
12	Mixed dry agriculture	20092	All land covers associated with agriculture activities on dry/non-wet land that is mixed with shrubs, thickets, and log over forest. This cover type often results of shifting cultivation and its rotation, including on karts.
13	Estate crop	2010	Estate areas that has been planted, mostly with perennials crops or other agriculture trees commodities.
14	Paddy field	20093	Agriculture areas on wet habitat, especially for paddy, that typically exhibit dyke patterns (pola pematang). This cover type includes rainfed, seasonal paddy field, and irrigated paddy fields.
15	Transmigration areas	20122	Kind of unique settlement areas that exhibit association of houses and agroforestry and/or garden at surrounding.
16	Fish pond/aquaculture	20094	Areas exhibit aquaculture activities including fish ponds, shrimp ponds or salt ponds.
17	Bare ground	2014	Bare grounds and areas with no vegetation cover

No	Land cover type	Code	Description
			yet, including open exposure areas, craters, sandbanks, sediments, and areas post fire that has not yet exhibit regrowth.
18	Mining areas	20141	Mining areas exhibit open mining activities such as open-pit mining including tailing ground.
19	Settlement areas	2012	Settlement areas including rural, urban, industrial and other settlements with typical appearance.
20	Port and harbor	20121	Sighting of port and harbor that big enough to independently delineated as independent object.
21	Open water	5001	Sighting of open water including ocean, rivers, lakes, and ponds.
22	Open swamps	50011	Sighting of open swamp with few vegetation.
23	Clouds and no-data		Sighting of clouds and clouds shadow with size more than 4 cm2 at 100.000 scales display.

8.3 Average annual historical emissions over the Reference Period

Description of method used for calculating the average annual historical emissions over the Reference Period

The following is a high level overview of the steps taken to calculate the average annual historical emissions over the Reference Period. These steps are discussed in more detail in the following sections.

- Activity Data, the estimated areas of deforestation and degradation, are generated from a sample-based approach called as Sample Based Estimation (SBE) following the procedure of Olofsson (2014), with stratification using land cover maps. In the previous assessment (ERPD), the study area were stratified after selection of the sample called post-stratification.
- Emission Factors come from forest inventory data and biomass equations (for forest land and shrubs) and from published literature (for other non-forest land, fire and soil), with IPCC default assumptions for converting biomass to carbon.
- Activity Data and Emission Factors are combined to estimate emissions from different activities.
- Historical Emissions will be calculated and reported for the following components:
 - Emissions from changes in biomass associated with deforestation (change from forest to non-forest cover class) and forest degradation (change from primary to secondary forest cover class).
 - Emissions from organic soil associated with deforestation of swamp and mangrove forest (change from forest to non-forest cover class)
 - Emissions from forest fires in stable secondary forest and peat lands (emissions from fires in primary forest are captured in the land cover mapping described above)

All Emissions are only counted from land which was in a forested class at the start of the Reference Period in 2006. Removals are not counted, only Emissions are counted.

The method used for the calculation of average annual historical emissions follows the method that is consistent with the IPCC Guidelines for National Greenhouse Gas Inventories. Historical emissions over the reference period is calculated as combination of the Activity Data (AD) and Emission Factor (EF) from different sources. According to the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, AD is defined as a data on the magnitude of human activity resulting in GHG emissions or removals taking place during a given period of time, such as area of deforestation, and area of forest degradation. AD is primarily taken from the analysis of land cover maps in certain periods, and also from the fire hot spots data sets.

EF is defined as the average emission rate of a given GHG for a given source, relative to units of activity. EF in this emission calculation comes from site specific forest inventory data in East Kalimantan, and from the literature published internationally.

Annual GHG emissions or removals over the reference period in the Accounting Area ($RL_{i,t}$) are estimated as the sum of annual change in total living biomass, dead organic matter and Soil Organic Carbon and the non-CO₂ GHG emissions (L_{fire}).

$$GHG_{i,t} = \Delta C_B + \Delta C_{SOC} + L_{fire}$$

Changes in carbon stocks in the AGB and BGB pools

$$\Delta C_B = \sum_{j,i} (AGB_{Before,j} \times (1 + R_j) - AGB_{After,i} \times (1 + R_i)) \times CF \times \frac{44}{12} \times A(j,i) \quad \text{Equation 1}$$

Where:

$A(j,i)$	Area converted/transited from old land-use category j to new land use category i during the period, in hectare per year.
$AGB_{Before,j}$	Aboveground biomass of land-use category j before conversion/transition, in tonne of dry matter per ha. This was obtained through terrestrial inventory and defined at the time of RL establishment.
R_j	ratio of below-ground biomass to above-ground biomass for land-use category j , in tonne d.m. below-ground biomass (tonne d.m. above-ground biomass) ⁻¹ . See column F on sheet 'EF_EKJERP' on file fcpf_ekjerp_ermr1_MC_24Juli2022b.xlsx, according to 2006 IPCC GL, TABLE 4.4, Volume 4, Chapter 4. This is the case for land-use category j1 and land-use category j2.
$AGB_{After,i}$	Aboveground biomass of land-use category i after conversion/transition, in tonnes dry matter per ha. This was obtained through terrestrial inventory and defined at the time of RL establishment.
R_i	ratio of below-ground biomass to above-ground biomass for land-use category i , in tonne d.m. below-ground biomass (tonne d.m. above-ground biomass) ⁻¹ . See column F on sheet 'EF_EKJERP' on file fcpf_ekjerp_ermr1_MC_24Juli2022b.xlsx, according to 2006 IPCC GL, TABLE 4.4, Volume 4, Chapter 4. This is the case for land-use category j1 and land-use category j2.
CF	Carbon fraction of dry matter in tC per ton dry matter. The value used is 0,47 is the default for tropical forest as per IPCC AFOLU guidelines 2006, table 4.3.
44/12	Conversion of C to CO ₂

Changes in Soil Organic Carbon

$$\Delta C_{SOC} = \frac{\sum_{j,i} \left((SOC_{Before,j} - SOC_{After,i}) \times \frac{44}{12} \times A(j,i) \right)}{D} \quad \text{Equation 2}$$

Where:

- $A(j,i)$ area undergoing conversion from old to new land-use category, ha.. This is the same as parameter $A(j,i)$ above.
- $SOC_{Before,j}$ the reference carbon stock, tonnes C ha⁻¹ for land-use category j . This was obtained through terrestrial inventory and defined at the time of RL establishment. See sheet 'EF_EKJERP' on file fcpf_ekjerp_ermr1_MC_24Juli2022b.xlsx
- $SOC_{After,i}$ the carbon stock, tonnes C ha⁻¹ for land-use category i This was obtained through terrestrial inventory and defined at the time of RL establishment. See sheet 'EF_EKJERP' on file fcpf_ekjerp_ermr1_MC_24Juli2022b.xlsx
- D time period of the transition from land-use category j to landuse category i , yr. The Tier 1 default is 20 years.
- 44/12 Conversion of C to CO₂

Emissions for biomass consumed by fire

Emission factors EF_f for biomass consumed by fire can be developed based on Eq. 2.27 in the IPCC 2006 Guidelines for National Greenhouse Gas Inventories (GL), Volume 4, using the following formula:

$$L_{fire} = A(i) * EF_f \quad \text{(Equation 5)}$$

$$EF_f = M_B * C_f * G_{ef} * 10^{-3} \quad \text{(Equation 6)}$$

$$L_{fire} = A * M_B * C_f * G_{ef} * 10^{-3} \quad \text{(Equation 7)}$$

L_{fire} = amount of greenhouse gas emissions from fire, tonnes of each GHG e.g., CO₂, CH₄, N₂O

A = burnt area, ha

M_B = mass of fuel available for combustion, tonnes ha⁻¹.

C_f = combustion factor, dimensionless (default values in Table 2.6 of the 2006 IPCC Guideline, Chapter 2-page 2.48). The default value of the IPCC combustion factor, C_f , is 0.36

G_{ef} = emission factor, g kg⁻¹ dry matter burnt (1580 for CO₂, 6.8 for CH₄ and 0.20 for N₂O, Table 2.5 of 2006 IPCC Guideline, Chapter 2- Page 2.47)

The M_B for the peat is 353 tons dry matter per hectare following IPCC default (Table 2.6 of the Chapter 2 in page 2.40, 2013 Supplement to the 2006 IPCC). The M_B depends on depth of peat and bulk density of the peat. Based on measurement in Central Kalimantan, the M_B is about 505 tons dry matter per hectare with assumption that the average depth of peat burn is 0.33 m and bulk density 0.153 t/m³ (MRI 2013). However, we adopt the IPCC default as the default considering the data was based on measurement from multiple locations that may represent better general condition. The C_f is taken from the IPCC default value (Tables 2.6 of 2006 IPCC Vol. 4 Chapter 2). The G_{EF} for CO₂ is 1,701 g/kg dry matter burnt (Table 2.7 of the Chapter 2 of

the 2013 Supplement to the 2006 IPCC, page 2.36) and for CH₄ is 21 g/kg dry matter burnt. Detail data can be see on See sheet 'EF_EKJERP' on file fcpf_ekjerp_ermr1_MC_24Juli2022b.xlsx

Activity data and emission factors used for calculating the average annual historical emissions over the Reference Period

Activity data

There are several kinds of activity data used in the historical emissions calculation;

- Activity Data from land cover mapping; for emissions calculation due to deforestation (forest to non-forest) and forest degradation (primary forest to secondary forest). The 23 land cover classification was built based on visual on-screen digitizing interpretation of Landsat mosaic data of East Kalimantan for periods 2006, 2009, 2011, 2012, 2013, 2014, 2015, and 2016. The activity data were shown in land cover change matrix transition to describe their emission. Land cover change can describe deforestation, forest degradation, forest and non-forest stable as well as forest gain. This information was combined with Reference Data to conduct a sample based estimation (SBE) analysis (see updated Annex 12.1 ERPD)
- Activity data from satellite based fire mapping or hot spot analysis, for emission calculation due to fire on stable secondary forest. These data are spatially explicit, derived from Modis mapping of fire activity (described below).

Deforestation

Description of the parameter including the time period covered (e.g. forest-cover change between 2006-2016 or transitions between forest categories X and Y between 2006-2016:	Area of land cover change between 2006-2009, 2009-2011, 2011-2012, 2012-2013, 2013-2014, 2014-2015, and 2015-2016. The land use transition matrices between these periods are generated to estimate the change of area from forest categories to non-forest categories.																
Explanation for which sources or sinks the parameter is used (e.g. deforestation or forest degradation):	Deforestation																
Data unit (e.g. ha/yr):	Ha/yr																
Value for the parameter:	<table border="1"> <thead> <tr> <th>Period</th><th>Deforestation area (ha/year)</th></tr> </thead> <tbody> <tr> <td>2006-2009</td><td>214,691.44</td></tr> <tr> <td>2009-2011</td><td>65,629.95</td></tr> <tr> <td>2011-2012</td><td>113,544.25</td></tr> <tr> <td>2012-2013</td><td>81,758.93</td></tr> <tr> <td>2013-2014</td><td>38,106.56</td></tr> <tr> <td>2014-2015</td><td>69,754.53</td></tr> <tr> <td>2015-2016</td><td>134,254.55</td></tr> </tbody> </table> <p>Detail data can be see on sheet 'AD_EF_DEF_XXXX' on file <i>fcpf_ekjerp_ermr1_MC_26Juli2022c.xlsx</i>. XXXX ini year eq. 0609, 0911, etc.</p> <p>https://mrv.kaltimprov.go.id/storage/quest/ERM1/CarbonAccounting/fcpf_ekjerp_ermr1_MC_26Juli2022c.xlsx</p>	Period	Deforestation area (ha/year)	2006-2009	214,691.44	2009-2011	65,629.95	2011-2012	113,544.25	2012-2013	81,758.93	2013-2014	38,106.56	2014-2015	69,754.53	2015-2016	134,254.55
Period	Deforestation area (ha/year)																
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2014-2015	69,754.53																
2015-2016	134,254.55																
Source of data (e.g. official statistics) or description of the method for developing the data, including (pre-) processing methods for data derived from remote sensing images (including the type of sensors and the details of the images used):	<p>National Forest Monitoring System (NFMS) named Simontana (<i>Sistem Monitoring Hutan Nasional</i>) (MoFor, 2014).</p> <p>It is available online at https://nfms.menlhk.go.id/, which is coupled with webGIS at https://sigap.menlhk.go.id/ for display and viewing. The two websites are part of geospatial portal under the one map policy.</p> <p>The description of methods for data derived from remote sensing images including type of sensors and the details of the images used can be found https://jurnal.ugm.ac.id/ijg/article/view/12496/9041</p>																

Spatial level (local, regional, national or international):	Regional (Province)
Discussion of key uncertainties for this parameter:	Two main sources of uncertainties are from image processing and interpretation of land cover types from the image (depend on quality of satellite images, method of land cover map generation process; uncertainty of land cover) and that of land cover changes.
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	The estimation of uncertainty follows method presented by Olofsson <i>et al.</i> (2014), substituting the post-stratified estimator of variance (Olofsson 2019). The uncertainty of the land cover change (deforestation) is 27.31% (see Annex 12.1).

Peat decomposition - deforestation and degradation

Description of the parameter including the time period covered (e.g. forest-cover change between 2006-2016 or transitions between forest categories X and Y between 2006-2016):	<p>Area of land cover changes between 2006-2009, 2009-2011, 2011-2012, 2012-2013, 2013-2014, 2014-2015, 2015-2016, 2016-2017, and 2017-2018. The land use transition matrices between these periods are generated to estimate the change of areas from forest categories to non-forest categories that occurred in the peatland for the estimation of emissions from peat decomposition from the deforested areas. The use of a longer time period than the reference period (2007-2016) for peatland deforestation is part of an agreement with CFPs considering the Indicator 13.1 of the Methodological Framework. Indonesia is not eligible for applying an upward adjustment to its reference level, while Indonesia has peatland in which such indicator is not possible to be applied for countries that have peatland forest.</p> <p>In peatland forest, that has been deforested, peat decomposition will continue to release emissions, leading to future inherited emissions. Following resolution CFM/19/2019/1, the CFPs and Indonesia agreed to remove the calculation for emissions associated with projected future deforestation in peat forest and apply the estimate of the most recent data not later than 2018 and the CFPs agreed to provide a one-time waiver to Indicator 13.1.</p>								
Explanation for which sources or sinks the parameter is used (e.g. deforestation or forest degradation):	Deforestation and subsequent land cover changes for peat lands. Tracking change over time is necessary to estimate the future inherited emissions because emissions are related to future land cover.								
Data unit (e.g. ha/yr):	Ha/yr								
Value for the parameter:	<table><tr><th>Period</th><th>Peat</th><th>Area</th></tr><tr><td></td><td></td><td></td></tr></table>			Period	Peat	Area			
Period	Peat	Area							

		Decomposition	
	2017-2018	20041-2010	0.17
		20041-20071	23.88
		20051-2010	157.30
		20051-2014	4.06
		20051-20141	35.53
		2014-2014	524.70
		2014-20071	312.25
		20071-20071	776.52
		2010-2010	1,260.11
	<p>Note: The second column shows land cover change using cover class codes. Black figures are emissions from new land cover changes in each period, red numbers are continuing decomposition emissions from land cover change in prior years.</p> <p>See sheet 'AD_ER_DEK_1718' on file fcpf_ekjerp_ermr1_MC_26Juli2022c.xlsx https://mrv.kaltimprov.go.id/storage/quest/ERM1/CarbonAccounting/fcpf_ekjerp_ermr1_MC_26Juli2022c.xlsx</p>		
Source of data (e.g. official statistics) or description of the method for developing the data, including (pre-) processing methods for data derived from remote sensing images (including the type of sensors and the details of the images used):	<p>National Forest Monitoring System (NFMS) named Simontana (<i>Sistem Monitoring Hutan Nasional</i>) (MoFor, 2014).</p> <p>It is available online at https://nfms.menlhk.go.id/, which coupled with webGIS at https://nfms.menlhk.go.id/ is for display and viewing. The two websites are part of the geospatial portal under the one map policy.</p> <p>The description of methods for data derived from remote sensing images including type of sensors and the details of the images used can be found https://jurnal.ugm.ac.id/ijg/article/view/12496/9041</p>		
Spatial level (local, regional, national or international):	Regional (Province)		
Discussion of key uncertainties for this parameter:	Two main sources of uncertainties are from image processing and interpretation of land cover types from the image (depend on quality of satellite images, method of land cover map generation process; uncertainty of land cover), that of land cover changes, and that of peatland.		
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of	The estimation of uncertainty follows a modified method presented by Olofsson <i>et al.</i> (2014), substituting the post-stratified estimator of variance (Olofsson 2019). The uncertainty of the land cover change (deforestation) is 27.31%, that of stable forest is 5.10%, and that of stable non-forest is 8.70%. Uncertainty of		

assumptions/methodology in the estimation	peatland is estimated to be about 10%.
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Soil mangrove

Description of the parameter including the time period covered (e.g. forest-cover change between 2006-2016 or transitions between forest categories X and Y between 2006-2016):	Area of land cover changes between 2006-2009, 2009-2011, 2011-2012, 2012-2013, 2013-2014, 2014-2015, and 2015-2016. The land use transition matrices between these periods are generated to estimate the change of areas from mangrove forests to aquaculture/fishpond for the estimation of emission from the loss of soil carbon																																								
Explanation for which sources or sinks the parameter is used (e.g. deforestation or forest degradation):	Deforestation: Mangrove forest to aquaculture																																								
Data unit (e.g. ha/yr):	Ha/yr																																								
Value for the parameter:	<table><tr><th>Period</th><th>Changes</th><th>Area (ha)</th></tr><tr><td rowspan="2">2006-2009</td><td>2004-20094</td><td>15.07</td></tr><tr><td>20041-20094</td><td>915.17</td></tr><tr><td rowspan="2">2009-2011</td><td>2004-20094</td><td>-</td></tr><tr><td>20041-20094</td><td>59.85</td></tr><tr><td rowspan="2">2011-2012</td><td>2004-20094</td><td>9.64</td></tr><tr><td>20041-20094</td><td>445.09</td></tr><tr><td rowspan="2">2012-2013</td><td>2004-20094</td><td>-</td></tr><tr><td>20041-20094</td><td>774.05</td></tr><tr><td rowspan="2">2013-2014</td><td>2004-20094</td><td>-</td></tr><tr><td>20041-20094</td><td>-</td></tr><tr><td rowspan="2">2014-2015</td><td>2004-20094</td><td>-</td></tr><tr><td>20041-20094</td><td>1,881.86</td></tr><tr><td rowspan="2">2015-2016</td><td>2004-20094</td><td>12.50</td></tr><tr><td>20041-20094</td><td>684.62</td></tr></table> <p>Note: Second column shows land cover change using cover class codes. See sheet 'ER_SMangrove' on file fcpf_ekjerp_ermr1_MC_26Juli2022c.xlsx https://mrv.kaltimprov.go.id/storage/quest/ERM1/CarbonAccount</p>			Period	Changes	Area (ha)	2006-2009	2004-20094	15.07	20041-20094	915.17	2009-2011	2004-20094	-	20041-20094	59.85	2011-2012	2004-20094	9.64	20041-20094	445.09	2012-2013	2004-20094	-	20041-20094	774.05	2013-2014	2004-20094	-	20041-20094	-	2014-2015	2004-20094	-	20041-20094	1,881.86	2015-2016	2004-20094	12.50	20041-20094	684.62
Period	Changes	Area (ha)																																							
2006-2009	2004-20094	15.07																																							
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	ing/fcpf_ekjerp_ermr1_MC_26Juli2022c.xlsx
Source of data (e.g. official statistics) or description of the method for developing the data, including (pre-) processing methods for data derived from remote sensing images (including the type of sensors and the details of the images used):	<p>National Forest Monitoring System (NFMS) named Simontana (<i>Sistem Monitoring Hutan Nasional</i>) (MoFor, 2014). It is available online at https://nfms.menlhk.go.id/, which coupled with webGIS at https://sigap.menlhk.go.id/ for display and viewing. The two websites are part of geospatial portal under the one map policy.</p> <p>The description of methods for data derived from remote sensing images including type of sensors and the details of the images used can be found https://jurnal.ugm.ac.id/ijg/article/view/12496/9041</p>
Spatial level (local, regional, national or international):	Regional (Province)
Discussion of key uncertainties for this parameter:	Two main sources of uncertainties are from image processing and interpretation of land cover types from the image (depend on quality of satellite images, method of land cover map generation process; uncertainty of land cover) and that of land cover changes.
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	The estimation of uncertainty follows a modified method presented by Olofsson <i>et al.</i> (2014), substituting a stratified estimator of variance (Olofsson 2019). The uncertainty of the land cover change (deforestation) is 27.31%.

Forest Degradation

Description of the parameter including the time period covered (e.g. forest-cover change between 2006-2016 or transitions between forest categories X and Y between 2006-2016):	Area of degradation, change of primary forest into secondary forests between 2006-2009, 2009-2011, 2011-2012, 2012-2013, 2013-2014, 2014-2015, and 2015-2016 that occurred in all forested land. The land use transition matrices between these periods are generated to estimate the change of area from Primary forests to Secondary Forests.	
Explanation for which sources or sinks the parameter is used (e.g. deforestation or forest degradation):	Degradation	
Data unit (e.g. ha/yr):	Ha/yr	
Value for the parameter:	This data is an aggregation of the degradation of the three natural forest classes (Dry land forest, swamp forest and mangrove forest)	
	Period	Production

		forest (ha)
	2006-2009	39,723.67
	2009-2011	8,865.46
	2011-2012	2,778.53
	2012-2013	1,065.34
	2013-2014	8,505.32
	2014-2015	65,834.93
	2015-2016	14,201.14
<p>Detail data can be see on sheet 'AD_EF_DEG_XXXX' on file <i>fcpf_ekjerp_ermr1_MC_26Juli2022c.xlsx</i> . XXXX ini year eq. 0609, 0911, etc.</p> <p>https://mrv.kaltimprov.go.id/storage/guest/ERM1/CarbonAccounting/fcpf_ekjerp_ermr1_MC_26Juli2022c.xlsx</p>		
Source of data (e.g. official statistics) or description of the method for developing the data, including (pre-) processing methods for data derived from remote sensing images (including the type of sensors and the details of the images used):	<p>National Forest Monitoring System (NFMS) named Simontana (<i>Sistem Monitoring Hutan Nasional</i>) (MoFor, 2014).</p> <p>It is available online at https://nfms.menlhk.go.id/, which coupled with webGIS at https://sigap.menlhk.go.id/ for display and viewing. The two websites are part of the geospatial portal under the one map policy.</p> <p>The description of methods for data derived from remote sensing images including type of sensors and the details of the images used can be found https://jurnal.ugm.ac.id/ijg/article/view/12496/9041</p>	
Spatial level (local, regional, national or international):	Regional (Province)	
Discussion of key uncertainties for this parameter:	<p>Two main sources of uncertainties are from image processing and interpretation of land cover types from the image (depend on quality of satellite images, method of land cover map generation process; uncertainty of land cover) and from land cover changes (uncertainty of land cover changes).</p>	
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	<p>The estimation of uncertainty follows stratified estimation (Olofsson <i>et al.</i> 2013) using 880 samples. This replaced the post-stratified estimation previously used. The uncertainty of the land cover change (degradation) is 85.14%.</p>	

Fire on stable forest

The estimation of burnt area follows the method developed by MRI (2013) that was applied by the REDD+ demonstration activity project in Central Kalimantan. There are three steps of the analysis to estimate the burnt area from the hotspot data (Figure 8.3). First, MODIS hotspot data are compiled annually and data with a confidence level of more than 80% are selected. 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 (100 ha) pixel with at least one hotspot is considered as burned but with the

assumption that the burned area is 76.9% of the pixel area (76.9 ha). This rule applies for each pixel regardless of the number of hotspots within a particular pixel. Third, these burned areas were overlaid with the land cover map of 2016 to identify fires in stable secondary forest class. The calculation only on the stable secondary forest is for avoiding double counting of emission when the burnt secondary forest that occurred during the reference period is subsequently deforested. The calculation of fire emission is confined to secondary forest as carbon loss from forest fire in primary forest is captured in emission from the loss of carbon from the change of land cover from Primary to Secondary forests. It should be noted for the future that for forest areas that have been affected by fire during the reference period, when they are exposed to deforestation, the estimation of the emission during the reporting period should use separate emission factors.

Description of the parameter including the time period covered (e.g. forest-cover change between 2006-2016 or transitions between forest categories X and Y between 2006-2016):	Area of secondary forest affected by fires in 2006, 2009, 2011, 2012, 2013, 2014, 2015, and 2016. Burnt area estimated from Hotspot data, derived from NASA FIRMS (https://earthdata.nasa.gov/firms)																				
Explanation for which sources or sinks the parameter is used (e.g. deforestation or forest degradation):	Forest degradation. This is to estimate the loss of above ground biomass of the stable secondary forest due to fire.																				
Data unit (e.g. ha/yr):	Ha																				
Value for the parameter:	<div>This data is an aggregation of the three secondary forest classes (Dry land forest, swamp forest and mangrove forest).</div> <table><tr><th>Year</th><th></th><th>Burnt Area (ha)</th></tr><tr><td rowspan="3">2007</td><td>2002</td><td>280.39</td></tr><tr><td>20041</td><td>0</td></tr><tr><td>20051</td><td>0</td></tr><tr><td rowspan="3">2008</td><td>2002</td><td>135.32</td></tr><tr><td>20041</td><td>0</td></tr><tr><td>20051</td><td>0</td></tr><tr><td>2009</td><td>2002</td><td>670.94</td></tr></table>	Year		Burnt Area (ha)	2007	2002	280.39	20041	0	20051	0	2008	2002	135.32	20041	0	20051	0	2009	2002	670.94
Year		Burnt Area (ha)																			
2007	2002	280.39																			
	20041	0																			
	20051	0																			
2008	2002	135.32																			
	20041	0																			
	20051	0																			
2009	2002	670.94																			

		20041	3.93
		20051	126.38
	2010	2002	222.17
		20041	0
		20051	21.22
	2011	2002	434.68
		20041	12.96
		20051	63.30
	2012	2002	1,216.04
		20041	11.83
		20051	30.00
	2013	2002	695.31
		20041	0
		20051	1.95
	2014	2002	1,577.89
		20041	4.19
		20051	0
	2015	2002	0.04
		20041	0.01
		20051	0
	2016	2002	1,179.18
		20041	395.23
		20051	115.51
Detail data can be see on sheet 'FireStableForest' on file <i>fcpf_ekjerp_ermr1_MC_26Juli2022c.xlsx</i> . https://mrv.kaltimprov.go.id/storage/guest/ERMRI/CarbonAccounting/fcpf_ekjerp_ermr1_MC_26Juli2022c.xlsx			
Source of data (e.g. official statistics) or description of the method for developing the data, including (pre-) processing methods for data derived from remote sensing images (including the type of sensors and the details of the images used):	Hotspot data, derived from NASA FIRMS (https://earthdata.nasa.gov/firms). Method for estimating the burnt area uses semi-automatic approach that replace the MRI (2013) method. In this approach, the burnt area is initially determined using point density analysis of hotspot data (with ≥80% confidence level) from spatial analyst tools and then followed by visual analysis using composite RGB of band 654 for LANDSAT TM 8 and composite RGB of band 543 for LANDSAT TM 5 supported by burnt data and ground check.		

Spatial level (local, regional, national or international):	Regional (Province)
Discussion of key uncertainties for this parameter:	Key uncertainty comes from the processing of Hotspot data and selection of confidence level of the Hotspot data for this analysis, which is >80%, and processing of image and interpretation of burnt area.
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	Uncertainty level is about 15% (based on the analysis to fire data of 2014). The uncertainty of burnt area was calculating following Olofsson et al. (2013, 2014).

Activity Data for peat burn areas in deforested forest after 2006

The estimation of peat burn area follows the same method as the estimation of Activity Data for additional forest degradation in secondary forest from fire. However, in the third step the overlay of burned areas was done with the land cover and peat land map (produced by MoA) to identify the type of land cover being affected by the fire. The method for estimating burnt area has been improved from the previous method from MRI (2013) by combining the hotspot data with the Landsat image (quick look original with composite band 645) and fire control activity that is able to delineate the burnt area and supervised by other data (e.g. fire control activity and ground check). The technical guidance for the estimation of burnt area is regulated under the Regulation of Director General of Climate Change Number P11/2018. Comparison of the two methods in estimating peat burnt area can be seen in Rossita et al. (2019). The MRI tends to be overestimated.

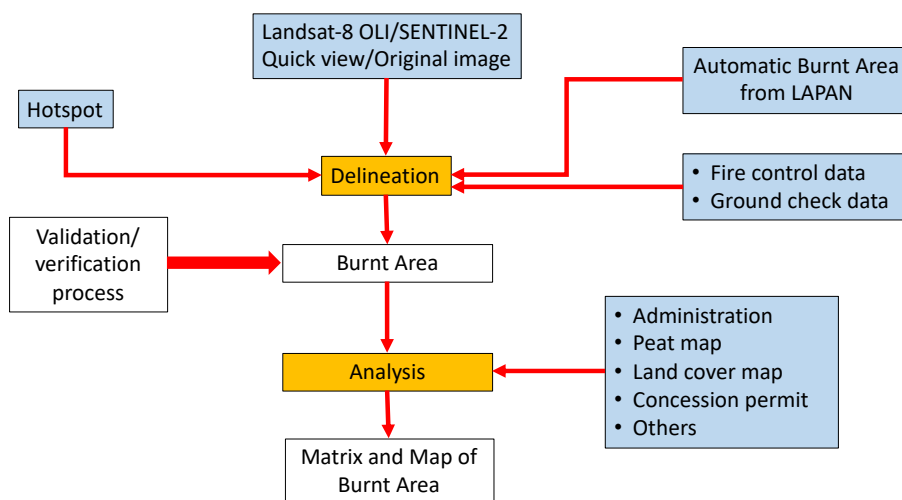


Figure 8.1 Method for estimating burnt area from hotspot data (MoEF, 2021)

Description of the parameter including the time period covered (e.g. forest-cover change between 2006-2016 or transitions between forest categories X and Y between 2006-2016):	Area of peat deforested after 2006 affected by fires in the period 2006-2016. Burnt area estimated from Hotspot data, derived from NASA FIRMS (https://earthdata.nasa.gov/firms)										
Explanation for which sources or sinks the parameter is used (e.g. deforestation or forest degradation):	Deforestation. This is to estimate the emission from the loss of peat due to fire in non-forested land that was deforested after 2006.										
Data unit (e.g. ha/yr):	Ha										
Value for the parameter:	<table border="1"> <thead> <tr> <th>Year</th><th>Burnt peat (ha)</th></tr> </thead> <tbody> <tr> <td>2013</td><td>322.79</td></tr> <tr> <td>2014</td><td>-</td></tr> <tr> <td>2015</td><td>395.05</td></tr> <tr> <td>2016</td><td>674.14</td></tr> </tbody> </table> <p>Detail data can be see on sheet 'PeatDefFire' on file <i>fcpf_ekjerp_ermr1_MC_26Juli2022c.xlsx</i> .</p> <p>https://mrv.kaltimprov.go.id/storage/guest/ERM1/CarbonAccounting/fcpf_ekjerp_ermr1_MC_26Juli2022c.xlsx</p>	Year	Burnt peat (ha)	2013	322.79	2014	-	2015	395.05	2016	674.14
Year	Burnt peat (ha)										
2013	322.79										
2014	-										
2015	395.05										
2016	674.14										

Source of data (e.g. official statistics) or description of the method for developing the data, including (pre-) processing methods for data derived from remote sensing images (including the type of sensors and the details of the images used):	Hotspot data, derived from NASA FIRMS (https://earthdata.nasa.gov/firms). Method for estimating the burnt area follows the method described in the Regulation of Director General of Climate Change Number P11/2018.
Spatial level (local, regional, national or international):	Regional (Province)
Discussion of key uncertainties for this parameter:	Key uncertainty comes from the processing of Hotspot data and selection of confidence level of the Hotspot data for this analysis, which is >80%
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation	Uncertainty level 13.25%. This is combined uncertainties of accuracy estimates of land cover classification estimated using Olofsson (2014, 2019) for stable non forest (8.7%) and that of sample burnt area (10%).

Emission Factors

Emission Factors from deforestation and degradation from change in land use/land cover class

ESTIMATES OF C/HA FOR FOREST CLASSES

The main sources of data used to derive emission factors for six forest types is from Permanent Sample Plots (PSP) established in East Kalimantan. Technical correction for the emission factors

was conducted for the dryland forest and mangrove forest through the increase number of sample and change of allometric equations. For the dryland forest, the sample are taken from PSPs of the National Forest Inventory (NFI), while for swamp and mangrove forest, they are from PSPs established in 2016-2019 under FCPF Readiness program (the ones established in 2019 are additional plots for increasing number of sample of mangrove only as part of technical correction). Sample from the PSPs in the dryland forest developed under the FCPF Readiness program are not used in the estimation of the EF since the design of the FCPF plots are not the same as that of NFI. The number of PSPs of the NFI in East Kalimantan are much larger than that of the FCPF, while for the other two forest types the number of NFI plots are very limited.

The establishment of the Permanent Sampling Plot (PSP) for carbon measurement in East Kalimantan under the FCPF Readiness program follows stratified random sampling in which the locations are selected based on Ministry of Environment and Forestry land cover map. The method used for data collection is based on Indonesian National Standard (SNI) 7724:2011 regarding forest carbon accounting. The size of each plot is 20mx20m, and within the plot there are 3 nested plots with the size of 10mx10m, 5mx5m and 2mx2m (Figure 8.4). For aboveground carbon measurement, we collected vegetation data from seedlings (diameter < 2cm), saplings (diameter 2 cm to < 10cm), poles (DBH 10cm to < 20 cm) and trees (DBH ≥ 20cm). Seedlings data was collected in 2x2m sub plot, saplings in 5x5m sub plot, poles in 10x10m sub plot and trees in 20x20m sub plot. Species name and diameter of each individual found within the plots were recorded. The wood density for each sample tree is taken from species wood density database develop by ICRAF (<http://db.worldagroforestry.org/wd>). Summary of the sample trees is presented in Table 8.8.

A. Number of Permanent Sampling Plots (PSPs)			
Land cover types	Number of PSP	Data summary	Location
Primary swamp forest	18	Max D: 109.6 #genus: 20	Muara Siran; Genteng Tanah
Secondary swamp forest / logged forest	42	Max D: 109 #genus: 23	Muara Siran; Penyinggahan Melak; Genteng Tanah; Sebelimbingan
Primary mangrove forest	37+43	Max D: 76.8 #genus: 5	Delta Mahakam; BTNK
Secondary mangrove forest / logged forest	23+11	Max D: 89.2 #genus: 7	Delta Mahakam; CA Teluk Adang; PT. Inhutani I Batu Ampar; BTNK
Total A	243		
B. Number of NFI's Permanent Sampling Plots in the dryland forests and shrubs along with maximum D and number of species observed			
Land cover types	Number of PSP	Data summary	Location
Primary dry land forest	79	Max D: ? #genus: ?	Distributed throughout the province systematically in grids
Secondary dry land forest/logged forest	408	Max D: ? #genus: ?	Distributed throughout the province systematically in grids
Dry shrubs	7	Max D: ?	Scattered
Wet shrubs	6	Max D: ?	Scattered
Total B	500		
Total A+ B	743		

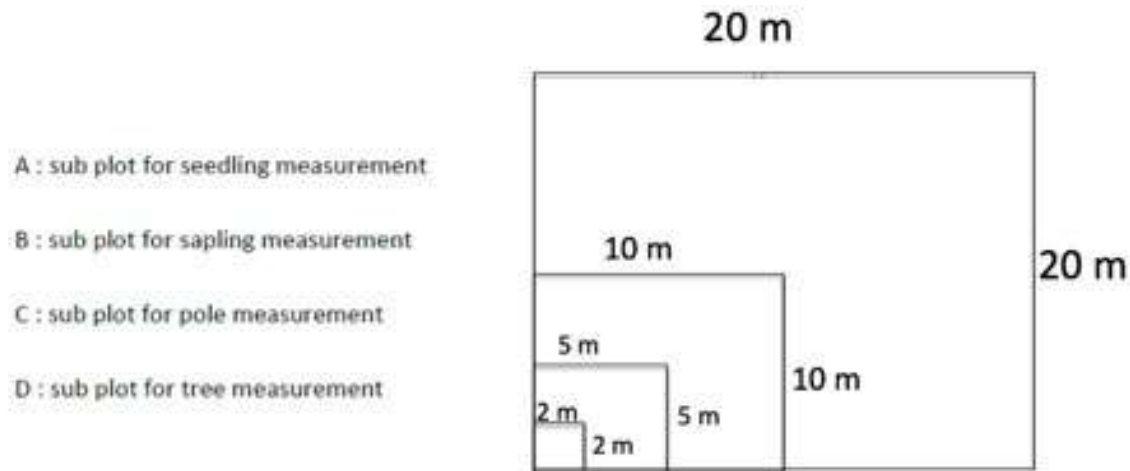


Figure 8.2 The design of permanent sample plot (PSP) in East Kalimantan

The NFI plots were primarily designed for conducting forest resource assessment at national scale initiated in 1989. The establishment of the NFI was supported by the Food and Agriculture Organization of the United Nations (FAO) and the World Bank. Sample plots are distributed systematically on 20x20 km, 10x10 km and 5x5 km grids across the country. Each cluster consists of a permanent sample plot (PSP) with a size of 100x100m surrounded by 8 temporary sample plots (TSP). Individual trees within the 1-ha PSP were measured within 16 recording units (RU) as numbered 25x25m sub-plots. Biomass estimation only includes PSP data. Since the main purpose of NFI was to monitor forest resources, data to generate timber volume or stocks were strongly required. These include species name (local name), tree diameter at breast height or above buttress, tree height and bole height and buttress height. The quality of the trees was also recorded for both stem and crown quality. All trees measured in PSP according to the size class:

- Sub plot circle with radius = 5 m for measuring dbh between 5 cm – 19.9 cm
- All trees inside the recording unit with dbh > 20 cm are measured

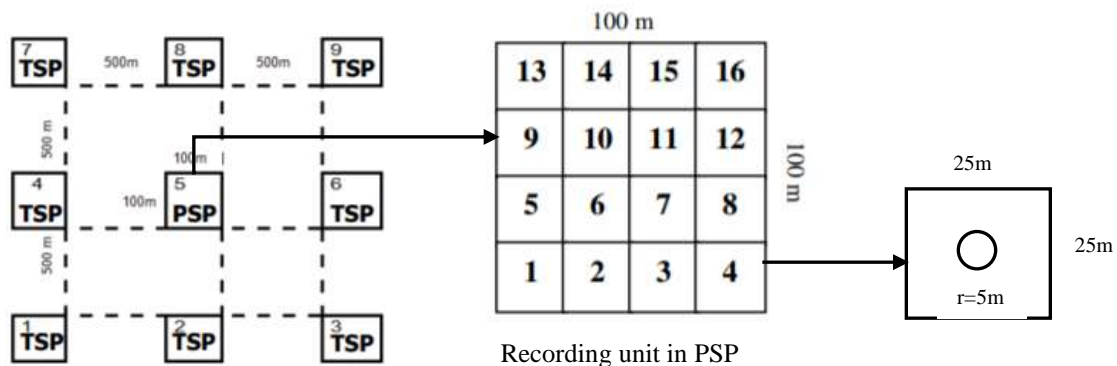


Figure 8.3. The design of permanent sample plots

East Kalimantan has published, peer reviewed biomass equations for the three forest types (Basuki 2009 for dry forest; Manuri 2014 for peat swamp forest; and Komiyama 2005 for mangrove forest). In order to decide whether or not to use the local equations, we considered several factors including the sample domain and forest type where the sample was collected;

the sample size; and the maximum diameter included in the sample. Based on the assessment of the allometric equations considering those aspects, it was found that the use of Basuki et al. (2009) equation for estimating the biomass of dryland forest tend to be bias (Manuri et al., 2016). The estimates of biomass using Basuki et al. equation are overestimated for small trees and underestimated for large trees. Improved allometric equations should use large sample with large diameter range.

The Chave equation clearly has the largest sample size, but this sample is an aggregate from all tropical regions of the globe and all forest types and may not well reflect the specific sample population of East Kalimantan. The three local biomass equations are much more specifically targeted to the specific populations of interest for East Kalimantan. The local equations also included higher diameter trees in the sample compared to Chave. This last factor is very important because extrapolation of a biomass equation beyond the range of its data can quickly lead to biased results. In general the Chave equation yielded higher estimates of the local equations; the difference was small within the range of D of the Chave data (up to about D=160), but Chave departed (increased) quite dramatically for higher diameters.

Specific allometric equations for Indonesia lowland (dryland) forests have been developed (Manuri et al., 2017) using 1300 sample representing large range of diameter and all major islands in Indonesia and Malaysia (Figure 8.6). These samples include the samples from Indonesia used in Chave et al., 2014 equations development, totalling of more than 30% of the samples. Manuri et al. (2017) provides various option of equation selection for accommodating available forest inventory data. Tree diameter and species name are the most common data collected during field inventory in Indonesia. Thus using the equation with diameter (D) and wood density (G) variables is recommended. In addition, Manuri et al. (2017) also found that region variable (East, Center and West) explains the variation of the AGB and Kalimantan situated in West Region.

This information is summarized in the table below:

Attribute	Equation source					
	Chave 2005	Basuki 2009	Manuri 2014	Komiyama 2005	Manuri et al. 2016	Manuri et al. 2017
Sample Domain	Global, pan-tropical	E Kalimantan	Sumatra and W Kalimantan	Indonesia	Kalimantan	Indonesia
Forest type	pan tropical	low dipterocarp	peat swamp	Mangrove	Low dipterocarp	Low dipterocarp
Sample size (trees)	2,410	122	148	104	108	1300
Max D(cm)	156	200	167	55	172	172

Based on this analysis we believe that the local equations are more suited for application in the ERP and so have used these to generate estimates of AGB for calculating Emission Factors. The estimation of the carbon stock of the above ground biomass of the six forest-types uses local allometric models, i.e.

- Dryland forest (Manuri et al., 2017)

$$AGB = 0.167 \times DBH^{2.56} \times WD^{0.889} \quad (\text{Equation 2})$$

- Swamp forest (Manuri et al., 2014)

$$AGB = 0.242 \times DBH^{2.473} \times WD^{0.736} \quad (\text{Equation 3})$$

- Mangrove forest (Komiyama et al., 2005)

$$AGB = 0.251 \times WD \times DBH^{2.46} \quad (\text{Equation 4})$$

To convert AGB (t/ha) to C (t/ha) for each forest types, carbon fraction of 0.47 is used as suggested by the IPCC 2006 ($C = 0.47 \times AGB$).

The below ground biomass (BGB) for dry forest is estimated using root-shoot ratio from the IPCC GPG LULUCF (Table 3A.1.8. page 3.168). The value of the ratio is 0.24 for dry forest. For mangrove forest the value is 0.36 based on measurement reported in Komiyama et al., 2005 for mangrove forest in Indonesia. For swamp forest is assumed to be the same as that of mangrove forest in Indonesia.

ESTIMATES OF C/HA FOR NON-FOREST CLASSES

The data source for the carbon stock of non-forest lands is derived from mainly Indonesian literatures (Annex 8.3.). The below ground biomass (BGB) of non-forest classes is also estimated using root-shoot ratio based on IPCC default values (IPCC GPG GL for LULUCF page 3.168 table 3A.1.8). The values of the ratio vary between land cover types, i.e. 0.32 for forest plantation and estate crops), 0.48 for dry and wet shrubs, mix dryland agriculture and transmigration area, and 1.58 for savanna/grassland, pure dryland agriculture, rice paddy, bare ground and settlement.

Description of the parameter including the forest class if applicable:	Emission Factor for deforestation and forest degradation, i.e. living biomass (AGB+BGB) of the six forest classes, primary and secondary dryland forests; primary and secondary swamp forests; primary and secondary mangrove forests; and non-forest lands																													
Data unit (e.g. t CO ₂ /ha):	Ton C/ha																													
Value for the parameter:	<div>Forest lands</div> <table><tr><th>Land cover</th><th>Code</th><th>C stock (t C/ha)</th></tr><tr><td>Primary dryland forest</td><td>2001</td><td>167.3</td></tr><tr><td>Secondary dryland forest</td><td>2002</td><td>122.1</td></tr><tr><td>Primary swamp forest</td><td>2005</td><td>343.9</td></tr><tr><td>Secondary swamp forest</td><td>20051</td><td>237.3</td></tr><tr><td>Primary mangrove forest</td><td>2004</td><td>168.2</td></tr><tr><td>Secondary mangrove forest</td><td>20041</td><td>118.1</td></tr></table> <div>Non-forest lands</div> <table><tr><th>Land cover</th><th>Code</th><th>C stock (t C/ha)</th></tr><tr><td>Plantation forest</td><td>2006</td><td>82.6</td></tr></table>			Land cover	Code	C stock (t C/ha)	Primary dryland forest	2001	167.3	Secondary dryland forest	2002	122.1	Primary swamp forest	2005	343.9	Secondary swamp forest	20051	237.3	Primary mangrove forest	2004	168.2	Secondary mangrove forest	20041	118.1	Land cover	Code	C stock (t C/ha)	Plantation forest	2006	82.6
Land cover	Code	C stock (t C/ha)																												
Primary dryland forest	2001	167.3																												
Secondary dryland forest	2002	122.1																												
Primary swamp forest	2005	343.9																												
Secondary swamp forest	20051	237.3																												
Primary mangrove forest	2004	168.2																												
Secondary mangrove forest	20041	118.1																												
Land cover	Code	C stock (t C/ha)																												
Plantation forest	2006	82.6																												

	Dry shrub	2007	28.8
	Wet shrub ^[1] _{SEP}	20071	32.4
	Savanna and Grasses ^[1] _{SEP}	3000	7.2
	Pure dry agriculture ^[1] _{SEP}	20091	19.4
	Mixed dry agriculture ^[1] _{SEP}	20092	33.3
	Estate crop	2010	65.6
	Paddy field	20093	11.4
	Transmigration areas	20122	14.8
	Fish pond/aquaculture	20094	0
	Bare ground	2014	6.5
	Mining areas	20141	0
	Settlement	2012	10.3
	Port and harbor	20121	0
	Open water	5001	0
	Open swamps	50011	0
Source of data (e.g. official statistics, IPCC, scientific literature) or description of the assumptions, methods and results of any underlying studies that have been used to determine the parameter:	<p>The primary data source for the carbon stock of dryland forest is derived from the measurement of AGB from the Permanent Sampling Plots (PSPs) in East Kalimantan under National Forest Inventory (NFI) and those of swamp and mangrove forests are from PSPs under the FCPF. The carbon stock data used are total of above ground (AGB) and below ground biomass (BGB). The estimation of AGB used local allometric equations (Manuri et al., 2015 for swamp forests; Manuri et al., 2017 for dryland forest; Komiyama et al., 2005 for mangrove). The below ground biomass (BGB) is estimated using root-shoot ratio from the IPCC GPG LULUCF (Table 3A.1.8. page 3.168). The value of the ratio is 0.24 for primary forest. For mangrove forest the value is 0.36 based on measurement from Komiyama et al., 2005. For swamp forest is assumed to be the same as that of mangrove.</p> <p>The data source for the carbon stock of non-forest lands is derived from mainly Indonesian literatures, except for shrubs are from the National Forest Inventory (NFI). The below ground biomass (BGB) is also estimated using root-shoot ratio based on IPCC default values (IPCC GPG GL for LULUCF page 3.168 table 3A.1.8). The values of the ratio vary between land cover types, i.e. 0.32 for forest plantation and estate crops), 0.48 for dry and wet shrubs, mix dryland agriculture and transmigration area, and 1.58 for savanna/grassland, pure dryland agriculture, rice paddy, bare ground and settlement.</p>		
Spatial level (local, regional, national or international):	Regional (Kalimantan island)		
Discussion of key uncertainties for this	Key uncertainty comes from (1) sampling error (between 13 to 31%), (2) allometric model (27%-31%), (3) biomass conversion		

parameter:	factor to carbon (5.3% Table 4.3 of the 2006 IPCC) and (5) root:shoot ratio (based on the IPCC GPG for LULUCF. And measurement, i.e. between 9% & 32%; See Annex 12.1 for details).																																																									
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	<p>Method to estimate the uncertainty of the living biomass is using error propagation: $\sqrt{U_1^2+ U_2^2+ ...+U_n^2}$, the subscript 1, 2, ... n are uncertainties for source of error 1th, 2nd etc. respectively.</p> <p>For forests</p> <table><tr><th>Land cover</th><th>Code</th><th>Uncertainty (%)</th></tr><tr><td>Primary dryland forest</td><td>2001</td><td>39.97</td></tr><tr><td>Secondary dryland forest</td><td>2002</td><td>39.49</td></tr><tr><td>Primary swamp forest</td><td>2005</td><td>38.25</td></tr><tr><td>Secondary swamp forest</td><td>20051</td><td>40.91</td></tr><tr><td>Primary mangrove forest</td><td>2004</td><td>29.79</td></tr><tr><td>Secondary mangrove forest</td><td>20041</td><td>30.94</td></tr></table> <p>For non-forests</p> <table><tr><th>Land cover</th><th>Code</th><th>Uncertainty (%)</th></tr><tr><td>Plantation forest</td><td>2006</td><td>22.5</td></tr><tr><td>Dry shrub</td><td>2007</td><td>44.9</td></tr><tr><td>Wet shrub ^[L]_[SEP]</td><td>20071</td><td>52.8</td></tr><tr><td>Savanna and Grasses ^[L]_[SEP]</td><td>3000</td><td>44.9</td></tr><tr><td>Pure dry agriculture ^[L]_[SEP]</td><td>20091</td><td>35.5</td></tr><tr><td>Mixed dry agriculture ^[L]_[SEP]</td><td>20092</td><td>44.9</td></tr><tr><td>Estate crop</td><td>2010</td><td>23.3</td></tr><tr><td>Paddy field</td><td>20093</td><td>35.5</td></tr><tr><td>Transmigration areas</td><td>20122</td><td>44.9</td></tr><tr><td>Bare ground</td><td>2014</td><td>35.5</td></tr><tr><td>Settlement</td><td>2012</td><td>35.5</td></tr></table>	Land cover	Code	Uncertainty (%)	Primary dryland forest	2001	39.97	Secondary dryland forest	2002	39.49	Primary swamp forest	2005	38.25	Secondary swamp forest	20051	40.91	Primary mangrove forest	2004	29.79	Secondary mangrove forest	20041	30.94	Land cover	Code	Uncertainty (%)	Plantation forest	2006	22.5	Dry shrub	2007	44.9	Wet shrub ^[L] _[SEP]	20071	52.8	Savanna and Grasses ^[L] _[SEP]	3000	44.9	Pure dry agriculture ^[L] _[SEP]	20091	35.5	Mixed dry agriculture ^[L] _[SEP]	20092	44.9	Estate crop	2010	23.3	Paddy field	20093	35.5	Transmigration areas	20122	44.9	Bare ground	2014	35.5	Settlement	2012	35.5
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Settlement	2012	35.5																																																								

Emission factors from fire in secondary forest

Description of the parameter including the forest class if applicable:	Emission Factor for biomass fire							
Data unit (e.g. t CO ₂ /ha):	t CO ₂ e/ha							
Value for the parameter:	Forest Cover		EF_CO2	EF_CH4_CO2	EF_N2O_CO2			
	Secondary Dryland	2002	147.72	13.35	5.8			
	Secondary swamp	20051	287.14	25.95	11.27			
	Secondary mangrove	20041	142.93	12.92	5.61			
	The value is estimated from the multiplication of MB, C _f , G _{ef} for CO ₂ , N ₂ O and CH ₄ (see equation 7), and GWP. GWP for C) ₂ , CH ₄ and N ₂ O are 1, 21 and 310 respectively.							
Source of data or description of the assumptions, methods and results of any underlying studies that have been used to determine the parameter:	2006 IPCC Guideline (Table 2.5 and 2.6 of IPCC 2006 Vol 4-CH2 Table 2.6)							
Spatial level:	Regional (province)							
Discussion of key uncertainties for this parameter:	Key of uncertainty is error in estimating the amount of biomass available for burning, combustion factor and EFs of three gases (CO ₂ , CH ₄ and N ₂ O).							
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	Forest Cover	Code	U M _B	U C _f	U CO ₂	U CH ₄	U N ₂ O	U Pooled
	Secondary Dryland	2002	39.49	16,67	8.29	27.94	35.0	62.54
	Secondary swamp	20051	40.91	16.67	8.29	27.94	35.0	63.45
	Secondary mangrove	20041	30.94	16.67	8.29	27.94	35.0	57.53

8.3.1 Emission Factors from Peat fires

Description of the parameter including the forest class if applicable:	Emission Factor for peat fire
Data unit (e.g. t CO₂/ha):	t CO ₂ e/ha burnt area
Value for the parameter:	756 t CO ₂ e/ha. The value is estimated from the summation of the result of the multiplication of MB, C _f , and G _{ef} for CO ₂ and CH ₄ (see equation 8)
Source of data (e.g. official statistics, IPCC, scientific literature) or description of the assumptions, methods and results of any underlying studies that have been used to determine the parameter:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (GL), Volume 4 IPCC 2013_Supplement Wetland (Table 2.6 and Table 2.7 of the 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands, page 2.40 and 2.41).
Spatial level (local, regional, national or international):	Regional (province)
Discussion of key uncertainties for this parameter:	Key of uncertainty is error in estimating the amount of biomass available for burning, combustion factor and EFs of three gases (CO ₂ , and CH ₄).
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	Uncertainty level is 66.5% (Pooled uncertainty based on confidence interval EF of Tables 2.6 and 2.7 of the 2013 Supplement to the 2006 IPCC Guidelines, $U_{\text{Polled}} = \sqrt{U_{\text{CO}_2}^2 + U_{\text{EF-CH}_4}^2}$

Emission Factors from soil

EMISSION FACTORS FROM PEAT SOILS

Peat emissions happen slowly over time once land is cleared for a number of years depending on the depth of the peat soil. Thus the emissions in any given year is the sum of emissions from all peat lands disturbed over the previous years. These emissions from prior year deforestation are called 'inherited emissions' (e.g. Agus et al., 2011). This means that total emissions from peat decomposition is defined as accumulation of peat emissions from forested lands starting with the Reference Period base year of 2006 onward.

The procedures of calculating peat decomposition from deforestation follow three steps as shown in Figure 8.6. First is defining natural forest in 2006 over peat land, and then step 2 is generating land cover change from each interval year to define a transition area matrix for the associated year of interval. The third step is calculating total annual emissions by multiplying the transition matrix of both areas and associated emission factors².

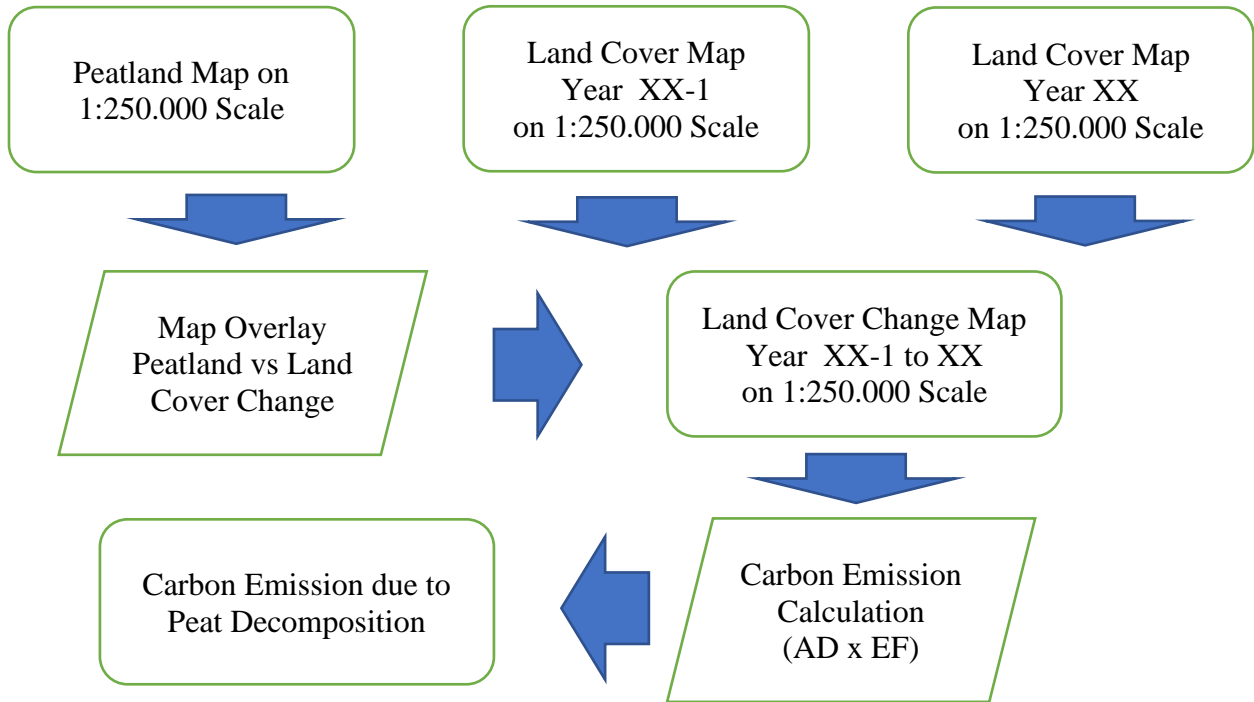


Figure 8.4 Flow chart for calculation of emissions from peat decomposition

The emissions from peat decomposition do not continue indefinitely, as they cease when the peat has completely decomposed or reached the water table. For the purpose of the ER Program, the time frame ends in 2024 by which time the peat will not be completely decomposed and should not thus affect the calculation. On average, the rate of loss of peat due to decomposition after drainage is about 5.6 cm per year in secondary forest (Maswar and Agus, 2015). After a period of 5 years of drainage in acacia and oil palm plantations, the rates appear to stabilize at around 5 cm per year (Hooijer et al, 2012). With an average peat depth of more than 2 m, it will thus take about 40 years to decompose the peat. By reference to the existing data on peat depth in Sumatra and Kalimantan, it appears that peat depth of deforested areas in Indonesia is generally more than 2 m (Ritung et al. 2011). A refinement of the peat depth map particularly in deforested areas is required for the development of the Reference Level beyond 2024.

Description of the parameter including the forest class if applicable:	Emission Factor for peat decomposition
Data unit (e.g. t CO₂/ha):	Ton CO ₂ /ha/year

Value for the parameter:	<table><tr><th>Land cover</th><th>Code</th><th>EF (t CO₂/ha/yr)</th></tr><tr><td>Primary forest</td><td>2001, 2004, 2005</td><td>0</td></tr><tr><td>Secondary forest</td><td>2002, 20041, 2051</td><td>19</td></tr><tr><td>Plantation forest</td><td>2006</td><td>73</td></tr><tr><td>Estate crop</td><td>2010</td><td>40</td></tr><tr><td>Pure dry agriculture</td><td>20091</td><td>51</td></tr><tr><td>Mixed dry agriculture</td><td>20092</td><td>51</td></tr><tr><td>Dry shrub</td><td>2007</td><td>19</td></tr><tr><td>Wet shrub</td><td>20071</td><td>19</td></tr><tr><td>Savanna and Grasses</td><td>3000</td><td>35</td></tr><tr><td>Paddy Field</td><td>20093</td><td>35</td></tr><tr><td>Open swamp</td><td>50011</td><td>0</td></tr><tr><td>Fish pond/aquaculture</td><td>20094</td><td>0</td></tr><tr><td>Transmigration areas</td><td>20122</td><td>51</td></tr><tr><td>Settlement areas</td><td>2012</td><td>35</td></tr><tr><td>Port and harbor</td><td>20121</td><td>0</td></tr><tr><td>Mining areas</td><td>20141</td><td>51</td></tr><tr><td>Bare ground</td><td>2014</td><td>51</td></tr><tr><td>Open water</td><td>5001</td><td>0</td></tr><tr><td>Clouds and no-data</td><td></td><td>Nd</td></tr></table>	Land cover	Code	EF (t CO ₂ /ha/yr)	Primary forest	2001, 2004, 2005	0	Secondary forest	2002, 20041, 2051	19	Plantation forest	2006	73	Estate crop	2010	40	Pure dry agriculture	20091	51	Mixed dry agriculture	20092	51	Dry shrub	2007	19	Wet shrub	20071	19	Savanna and Grasses	3000	35	Paddy Field	20093	35	Open swamp	50011	0	Fish pond/aquaculture	20094	0	Transmigration areas	20122	51	Settlement areas	2012	35	Port and harbor	20121	0	Mining areas	20141	51	Bare ground	2014	51	Open water	5001	0	Clouds and no-data		Nd
	Land cover	Code	EF (t CO ₂ /ha/yr)																																																										
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	Open water	5001	0																																																										
Clouds and no-data		Nd																																																											
Source of data (e.g. official statistics, IPCC, scientific literature) or description of the assumptions, methods and results of any underlying studies that have been used to determine the parameter:	Paciornik and Rypdal (2006) and IPCC (2014). These emission factors are reported in 2013 Supplement Guideline to 2006 IPCC Guidelines for National GHG Inventory: Wetlands. Most of the data reported in this guideline come from Indonesian sites.																																																												
Spatial level (local, regional, national or international):	National																																																												
Discussion of key uncertainties for this parameter:	Key uncertainty comes from sampling error (number of sampling, timing of sampling, length of the time between sampling taken to processing in laboratory).																																																												
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in	The uncertainty is taken from the 2013 supplement for 2006 IPCC Guideline (IPCC, 2014)																																																												
	<table><tr><th>Land cover</th><th>Code</th><th>Uncertainty (%)</th></tr></table>	Land cover	Code	Uncertainty (%)																																																									
Land cover	Code	Uncertainty (%)																																																											

the estimation:	Primary forest	2001, 2004, 2005	0.0
	Secondary forest	2002, 20041, 2051	84.2
	Plantation forest	2006	20.5
	Estate crop	2010	55.0
	Pure dry agriculture	20091	86.3
	Mixed dry agriculture	20092	86.3
	Dry shrub	2007	84.2
	Wet shrub	20071	84.2
	Savanna and Grasses	3000	108.6
	Paddy Field	20093	108.6
	Open swamp	50011	0.0
	Fish pond/aquaculture	20094	0.0
	Transmigration areas	20122	86.3
	Settlement areas	2012	108.6
	Port and harbor	20121	0.0
	Mining areas	20141	86.3
	Bare ground	2014	86.3
	Open water	5001	0
	Clouds and no-data		Nd

EMISSION FACTORS FROM MANGROVE SOILS

Description of the parameter including the forest class if applicable:	Emission Factor for mangrove soil and abandoned shrimp pond
Data unit (e.g. t CO₂/ha):	Ton C/ha
Value for the parameter:	902.91 (mangrove) 487.31 (abandoned shrimp pond) EF = 415.6
Source of data (e.g. official statistics, IPCC, scientific literature) or description of the assumptions, methods and results of any underlying studies that have been used to determine the parameter:	Data on the soil carbon of mangrove and abandoned pond is taken from Kauffman <i>et al.</i> (2017) based on measurement from the 20 locations in East Kalimantan. The procedure for the sampling is described in Kauffman et al. (2016)
Spatial level (local, regional, national or international):	National

Discussion of key uncertainties for this parameter:	Key uncertainty comes from sampling error.
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	Uncertainty level 33.4%. The estimation of uncertainty is provided in Annex 12.1.

8.4 Estimated Reference Emission Level

ER Program Reference level

Crediting Period year <i>t</i>	Average annual historical emissions from deforestation over the Reference Period (tCO ₂ -e/yr)	If applicable, average annual historical emissions from forest degradation over the Reference Period (tCO ₂ -e/yr)	If applicable, average annual historical removals by sinks over the Reference Period (tCO ₂ -e/yr)	Adjustment, if applicable (tCO ₂ -e/yr)	Reference level (tCO ₂ -e/yr)
2019	23,949,437.31	3,520,419.08			27,469,856.40
2020	23,949,437.31	3,520,419.08			27,469,856.40
2021	23,949,437.31	3,520,419.08			27,469,856.40
2022	23,949,437.31	3,520,419.08			27,469,856.40
2023	23,949,437.31	3,520,419.08			27,469,856.40
2024	23,949,437.31	3,520,419.08			27,469,856.40

Calculation of the average annual historical emissions over the Reference Period

The reference level is calculated using: [average of deforestation (living biomass, mangrove soil, and fires on peat) in the reference year (2006-2016) added with peat decomposition of the deforested area in 2017-2018], then added with [average of forest degradation (living biomass, fires in stable forest) in the reference year (2006-2016) added to peat decomposition in degraded areas in 2017-2018].

Period	Deforestation	Forest Degradation	Total
2006-2007	22,265,406.41	2,203,162.16	24,468,568.63
2007-2008	22,265,406.41	2,203,162.16	24,468,568.63
2008-2009	22,265,406.41	2,203,162.16	24,468,568.63
2009-2010	11,283,098.47	735,459.61	12,018,558.04
2010-2011	11,283,098.47	735,459.61	12,018,558.04
2011-2012	34,372,668.98	461,002.08	34,833,671.06
2012-2013	29,557,250.31	426,479.08	29,983,729.39
2013-2014	9,655,366.26	1,438,282.73	11,093,648.99
2014-2015	26,845,754.93	11,156,226.95	38,001,981.88

Period	Deforestation	Forest Degradation	Total
2015-2016	40,793,227.35	2,356,430.72	43,149,658.07
Average (2006-2016)	24,967,538.96	2,682,434.76	27,649,973.72
Peat decomposition (2017-2018)	55,852.41	987,517.06	1,043,369.48
Reference Level	24,967,538.96	2,682,434.76	27,649,973.72

8.5 Upward or downward adjustments to the average annual historical emissions over the reference period

Explanation and justification of proposed upward or downward adjustment to the average annual historical emissions over the Reference Period

Considering the unique case of accumulating emissions from peat soil over time, Indonesia in the January 2019 ERPD, proposed the inclusion of a slight upward adjustment above average annual historical emissions over the reference period. This was intended to account for the fact that (1) emissions from peat forests which had been deforested or degraded during the reference period would continue at levels equal to the end of the period, which is higher than the average of the reference period, and (2) future baseline deforestation or degradation projected during the ER period in peat forests will also have future cumulative emissions.

As Indonesia does not meet the qualifications for an upward adjustment as outlined in the Methodological Framework, and the Methodological Framework does not otherwise consider the uniqueness of peat forests, the CFPs agreed to provide a one-time waiver to Indicator 13.1 of the Methodological Framework, but Indonesia has to revise the approach used to estimate the emission from peat decomposition by applying the estimate of the most recent emission from peat decomposition not later than 2018. The implications of this decision for the final Reference Emission Level is that the estimated emissions from peat degradation will increase from 975.631 tCO₂e/yr (the average over the reference period) to 1,036,236 tCO₂e in 2017 and 1,043,684 tCO₂e in 2018, staying constant for years after 2018.

Thus, the projected reference level of this ERP for the peat decomposition is presented in Figure 8.9. The CFPs and Indonesia note that this decision is specific to this ER-Program and does not imply precedent for any program under the Carbon Fund or in Indonesia.

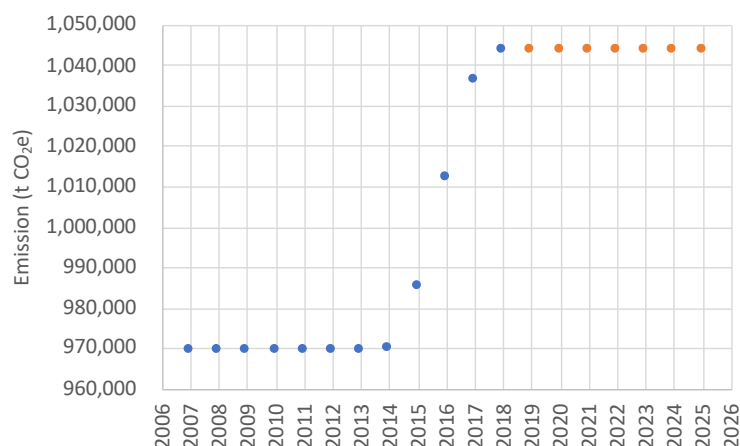


Figure 8.5 Projected emission from peat decomposition to 2025 taking into account the inherited emission

Final Estimated Reference Emission Level for East Kalimantan

Quantification of the proposed upward or downward adjustment to the average annual historical emissions over the Reference Period

Crediting Period year <i>t</i>	Average annual historical emissions from deforestation over the Reference Period (tCO ₂ -e/yr)	If applicable, average annual historical emissions from forest degradation over the Reference Period (tCO ₂ -e/yr)	If applicable, average annual historical removals by sinks over the Reference Period (tCO ₂ -e/yr)	Adjustment, if applicable (tCO ₂ -e/yr)	Reference level (tCO ₂ -e/yr)
2019	23,949,437.31	3,499,274.76			27,448,712.07
2020	23,949,437.31	3,499,274.76			27,448,712.07
2021	23,949,437.31	3,499,274.76			27,448,712.07
2022	23,949,437.31	3,499,274.76			27,448,712.07
2023	23,949,437.31	3,499,274.76			27,448,712.07
2024	23,949,437.31	3,499,274.76			27,448,712.07

8.6 Relation between the Reference Level, the development of a FREL/FRL for the UNFCCC and the country's existing or emerging greenhouse gas inventory

The RL for the ER Program was developed using the same approach as that used for the national FREL which Indonesia submitted to the UNFCCC in 2016 (<http://unfccc.int/resource/docs/2016/tar/idn.pdf>), with some enhancements, notably (1) application of sample based area estimation for Activity Data, (2) use of region-specific forest inventory data rather than national averages, and (3) use of locally derived biomass estimation equations rather than global equations. The National FREL is the result of a process involving a series of initial technical analyses followed by

public multi-stakeholder consultation. The procedure follows FCCC guidelines as detailed in the annex of [FCCC/CP/2013/10/Add.1](#). The two REDD+ activities included in the national FREL were *Deforestation* and *Forest Degradation*, consistent with Decision 1/CP.16, paragraph 70 and covering national forest. The reference period used in the National FREL is 1990 to 2012 (22 years; MoEF, 2015). The use of this long reference period is to better capture the dynamic land policies in Indonesia⁴¹.

The ERP's RL uses a reference period of 10 years (2006-2016) in order to conformity with the Carbon Funds Methodological Framework. The activity data used in the development of the reference level begin with the same data used in the National assessment but have been enhanced by application of the sample based approach (Olofsson) to improve accuracy in estimation of AD. The RL also includes activities which are not included in the national REL, namely the inclusion of below ground biomass and soil carbon for mangroves. The estimation of emission from peat soil is also consistent with the national GHG gas inventory and national FREL. This consistency would be enhanced by CFP agreement to allow a small upward adjustment to the historical emission level, to account for the unusual National Circumstance of inherited emissions from peat deforestation and degradation.

The emission factors (AGB) used for the estimation of historical emission do not use the national data as GHG Inventory and national FREL. This ERP used local data based on measurement in a number of permanent sampling plots of NFI and that of the FCPF. Thus, this ERP used higher tier of emission factor as suggested by the IPCC. In addition, the ERP's RL take into account the carbon stock after the conversion in the calculation of emission from deforestation. It is expected that the ER Program will generate lessons that will contribute to the next submission of the national FRL/FREL, e.g. the addition of REDD+ activities, or the improvement of activity data and emission factors.

Indonesia's GHG Inventory is managed by the Directorate for GHG Inventory and MRV, which also maintains the national registry system. The ER Program (through the local Environmental Agency) will report on the emission reductions generated by the implementation of the ER Program to the national registry system (see Section 9 for details). The implementation of the ER Program will also provide inputs to the development of the national GHG Inventory.

At present, the estimation of the GHG emission from deforestation and forest degradation in the National GHG Inventory is not consistent with the ones used in the ERPD. In term of method, the GHG Inventory used gain and loss approach while the ERPD used the stock difference approach. In term of sources, the GHG Inventory also does not include soil-carbon emission from mangrove conversion as in the ERPD. The emission factors used in the GHG Inventory are also not similar to the ones in the ERPP, particularly for the above ground biomass. As mentioned above, the ERPD used local data, higher tier while GHG Inventory and National FREL used national data. In addition, some of conversion factors are also not consistent. The GHG Inventory used the one conversion factor for all forest types and also one conversion factors for all non-forest covers. In the case of ERPD, the conversion factors differ between types of forest and non-forest. Most of sources of uncertainties of the AD and EF are

⁴¹ MoEF, 2015, National Forest Reference Emission Level for REDD+ In the Context of Decision 1/CP.16 Paragraph 70, Directorate General of Climate Change. The Ministry of Environment and Forestry. Indonesia

included in the ERPD while in the National FREL and the National GHG Inventory only part of the uncertainty sources. The ERPD also used higher tier of method for estimating the uncertainty, i.e. Monte Carlo, while National GHG Inventory used Tier 1 (error propagation approach). The Directorate for GHG Inventory and MRV plans to change the method from Gain and Loss to Stock Difference methods and to apply best practices used in the ERPD for the development of GHG Inventory. These efforts are to increase the consistency between the ERPD and the National GHG Inventory.

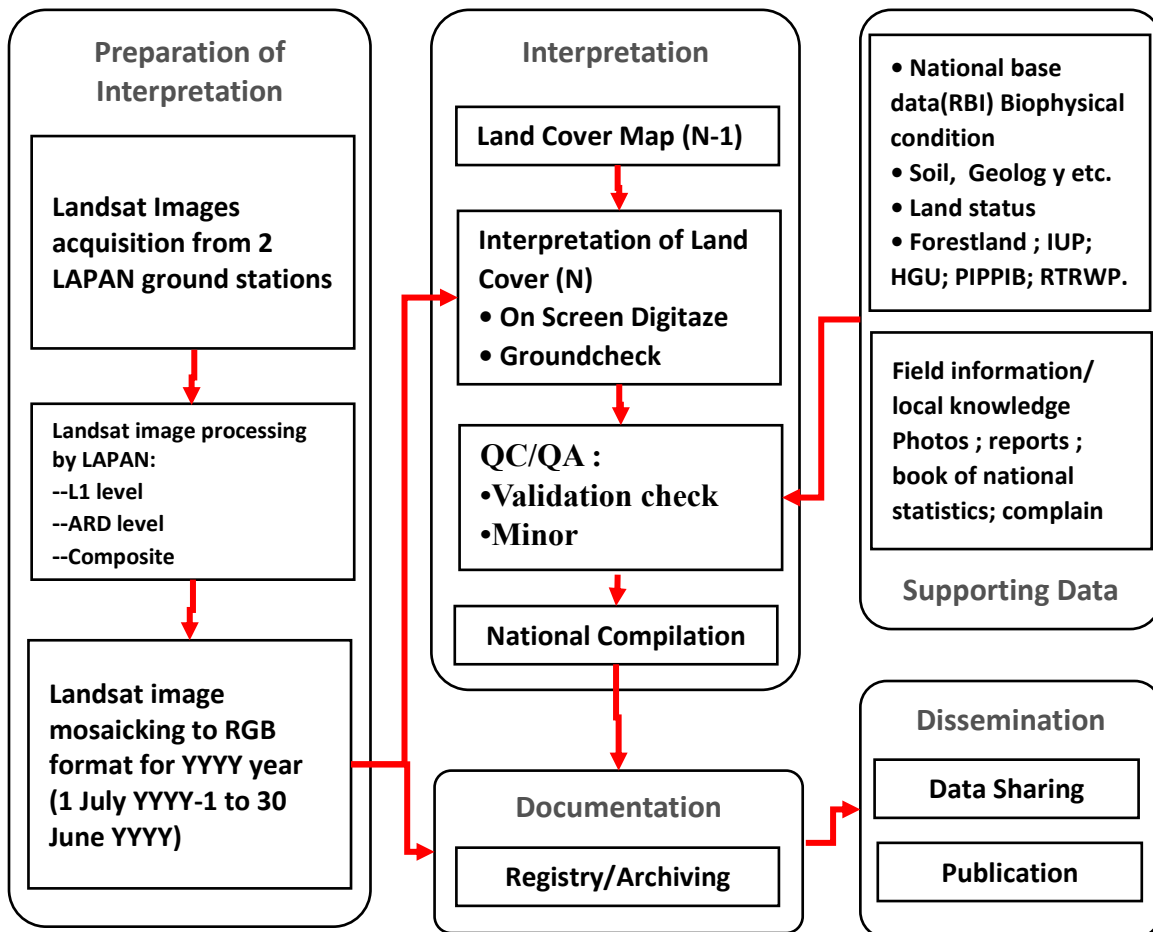
9. APPROACH FOR MEASUREMENT, MONITORING AND REPORTING

The Ministry of Environment and Forestry regulation No.70/2017 includes guidance on MRV for REDD+. For example, the regulation states that measurement should take place at least twice a year (Article 10), that an independent verifier shall be used (Article 12), and that the system shall include a registry (Article 13). The ER Program's MRV design will conform to the regulation, and will involve an independent verifier in addition to verification by the Ministry of Environment and Forestry.

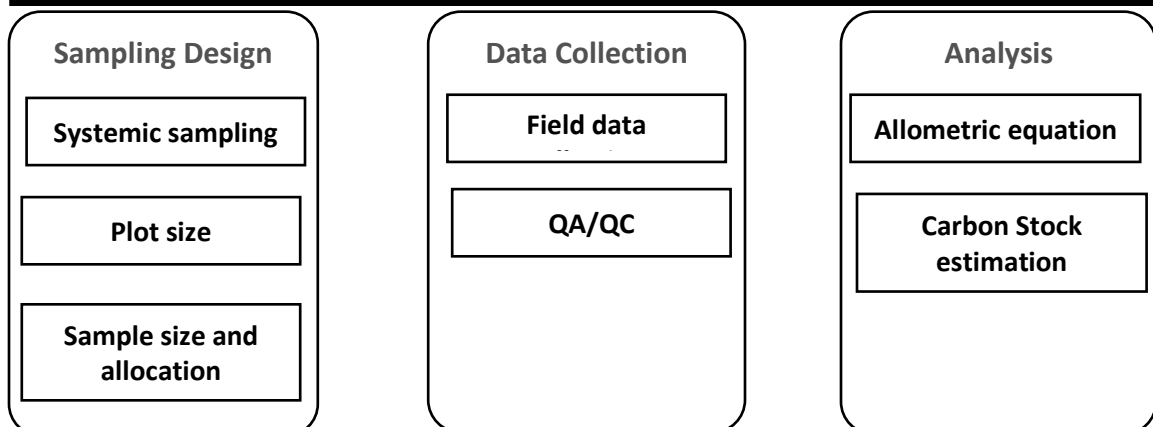
9.1 Measurement, monitoring and reporting approach for estimating emissions occurring under the ER Program within the Accounting Area

Line Diagram

[1] ACTIVITY DATA



[2] EMISSION FACTOR



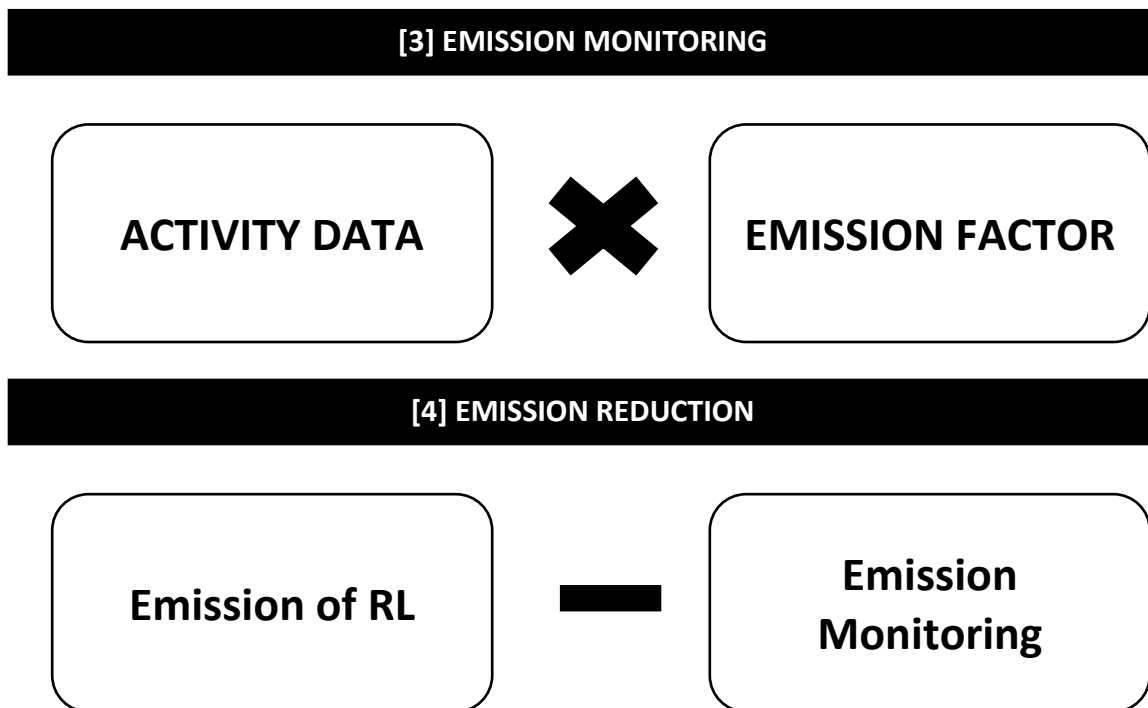


Figure 6. Flow chart for calculation of emissions from deforestation and forest degradation

Method for monitoring activity data and emission factors

The ER Program will apply methods for monitoring activity data and for estimating emission factors that are aligned with the approach used in developing Indonesia's FREL and that comply with established standards for the measurement of satellite imagery (LANDSAT) interpretation to estimate forest cover changes (SNI 8033:2014).⁴² These standards have been defined in the annex of the Regulation of the Director General of Forest Planology Number P.1/VII-IPSDH/2015⁴³. Technical guidelines for field observation and ground check procedure for land cover accuracy assessment can be seen in Annex 9.1. and Annex 9.2. of the 2019 ERPD, respectively.

Specifically:

1. Measurement of Activity Data for land cover change will continue to utilize the National Forest Monitoring System (NFMS) plus addition of the sample-based area estimation (i.e. Olofsson approach) to derive unbiased estimates of Activity Data when reporting during the ER program. This is the same process used for establishing the REL, with the addition of a stratified sampling approach and more sample locations in the future in

⁴² Standar Nasional Indonesia (Indonesia National Standard) No. 8033 year 2014 regarding Method for Estimation of Forest Cover Changes based on Result of Visual Interpretation of Optical Remote Sensing Imagery.

⁴³ Perdirjen Planologi (2015). Pedoman pemantauan penutupan lahan (guidance for monitoring land cover change). http://appgis.dephut.go.id/appgis/download/Pemantauan%20Hutan%20Nasional/Perdirjen_Plano_2015_01_Pedoman_PSD_H.pdf

order to ensure a minimum of 30 observations each for deforestation and degradation classes.

Additionally the ER Program will collect Activity Data for fire areas using the same procedures utilized in developing the REL.

2. Emission Factors for forest land classes will continue to be based on the forest inventory for East Kalimantan. There may be opportunity to increase sample sizes for the purpose of increasing precision. Methods and biomass calculations will be the same. Emission factors for non-forest land classes will continue to be based on published literature. Additional literature will be added to the data base as it becomes available and where appropriate estimates of C stock will be updated. IPCC conversion factors will remain the same.

Calculation

Emission reduction calculation

$$ER_{ERP,t} = RL_t - GHG_t \quad \text{Equation 1}$$

Where:

- | | | |
|------------|---|--|
| ER_{ERP} | = | Emission Reductions under the ER Program in year t ; $tCO_2e \cdot year^{-1}$. |
| RL_{RP} | = | Gross emissions of the RL from deforestation and forest degradation over the Reference Period; $tCO_2e \cdot year^{-1}$. This is sourced from Annex 4 to the ER Monitoring Report and equations are provided below. |
| GHG_t | = | Monitored gross emissions from deforestation and forest degradation at year t ; $tCO_2e \cdot year^{-1}$; |
| t | = | Number of years during the monitoring period; dimensionless. |

Reference Level (RL_t)

Following the TAP assessment of the ERPD, Indonesia notified the FMT on the intention to apply technical corrections to the reference level for the ER-Program before the signing of the ERPA. The corrected RL estimation may be found in Annex 4, yet a description of the equations is provided below.

Gross emissions of the RL from deforestation over the Reference Period (RL_{RP}) are estimated as the sum of annual change in total biomass carbon stocks (ΔC_{B_t}) during the reference period.

● CARBON STOCK AND EMISSION FACTOR

The estimation of the carbon stock of the above ground biomass of the six forest-types uses local allometric models, i.e.

- Dryland forest (Manuri et al., 2017)
 $AGB = 0.167 \times DBH^{2.56} \times WD^{0.889}$ (Equation 2)
- Swamp forest (Manuri et al., 2014)
 $AGB = 0.242 \times DBH^{2.473} \times WD^{0.736}$ (Equation 3)
- Mangrove forest (Komiya et al., 2005)

$$AGB = 0.251 \times WD \times DBH^{2.46}$$

(Equation 4)

where:

AGB= Above ground biomass

DBH= Diameter at chest height

WD= Weight density

To convert AGB (t/ha) to C (t/ha) for each forest types, carbon fraction of 0.47 is used as suggested by the IPCC 2006 ($C = 0.47 \times AGB$).

The below ground biomass (BGB) for dry forest is estimated using root-shoot ratio from the IPCC GPG LULUCF (Table 3A.1.8. page 3.168). The value of the ratio is 0.24 for dry forest. For mangrove forest the value is 0.36 based on measurement reported in Komiyama et al., 2005 for mangrove forest in Indonesia. For swamp forest is assumed to be the same as that of mangrove forest in Indonesia.

The data source for the carbon stock of non-forest lands is derived from mainly Indonesian literatures (ER-PD Annex 8.3.). The below ground biomass (BGB) of non-forest classes is also estimated using root-shoot ratio based on IPCC default values (IPCC GPG GL for LULUCF page 3.168 table 3A.1.8). The values of the ratio vary between land cover types, i.e. 0.32 for forest plantation and estate crops), 0.48 for dry and wet shrubs, mix dryland agriculture and transmigration area, and 1.58 for savanna/grassland, pure dryland agriculture, rice paddy, bare ground and settlement.

Emission factors EF_f for biomass consumed by fire can be developed based on Eq. 2.27 in the IPCC 2006 Guidelines for National Greenhouse Gas Inventories (GL), Volume 4, using the following formula:

$$L_{fire} = A \times EF_f \quad \text{(Equation 5)}$$

$$EF_f = M_B \times C_f \times G_{ef} \times 10^{-3} \quad \text{(Equation 6)}$$

$$L_{fire} = A \times M_B \times C_f \times G_{ef} \times 10^{-3} \quad \text{(Equation 7)}$$

L_{fire} = amount of greenhouse gas emissions from fire, tonnes of each GHG e.g., CO₂, CH₄, N₂O

A = burnt area, ha

M_B = mass of fuel available for combustion, tonnes ha⁻¹.

C_f = combustion factor, dimensionless (default values in Table 2.6 of the 2006 IPCC Guideline, Chapter 2-page 2.48). The default value of the IPCC combustion factor, C_f , is 0.36

G_{ef} = emission factor, g kg⁻¹ dry matter burnt (1580 for CO₂, 6.8 for CH₄ and 0.20 for N₂O, Table 2.5 of 2006 IPCC Guideline, Chapter 2- Page 2.47)

Emission factors EF_f for the peat fires can be developed based on Eq. 2.27 in the IPCC 2006 Guidelines for National Greenhouse Gas Inventories (GL), Volume 4, using the following formula:

$$L_{fire} = A \times EF_f \quad \text{(Equation 8)}$$

$$EF_f = M_B * C_f * G_{ef} * 10^{-3} \text{ (Equation 9)}$$

$$L_{fire} = A * M_B * C_f * G_{ef} * 10^{-3} \text{ (Equation 9)}$$

L_{fire} = amount of greenhouse gas emissions from fire, tonnes of each GHG e.g., CO₂, CH₄, N₂O

A = burnt area, ha

M_B = mass of fuel available for combustion, tonnes ha⁻¹.

C_f = combustion factor, dimensionless (default values in Table 2.6 of the 2006 IPCC Guideline, Volume 4, Chapter 2-page 2.48)

G_{ef} = emission factor, g kg⁻¹ dry matter burnt (default values in Table 2.7, Chapter 2 of 2013 Supplement to 2006, page 2.36)

The M_B for the peat is 353 tons dry matter per hectare following IPCC default (Table 2.6 of the Chapter 2 in page 2.40, 2013 Supplement to the 2006 IPCC). The M_B depends on depth of peat and bulk density of the peat. Based on measurement in Central Kalimantan, the M_B is about 505 tons dry matter per hectare with assumption that the average depth of peat burn is 0.33 m and bulk density 0.153 t/m³ (MRI 2013). However, we adopt the IPCC default as the default considering the data was based on measurement from multiple locations that may represent better general condition. The C_f is taken from the IPCC default value (Tables 2.6 of 2006 IPCC Vol. 4 Chapter 2). The G_{EF} for CO₂ is 1,701 g/kg dry matter burnt (Table 2.7 of the Chapter 2 of the 2013 Supplement to the 2006 IPCC, page 2.36) and for CH₄ is 21 g/kg dry matter burnt.

Calculation of emission factor of mangrove soil, i.e. the difference between amount of carbon in the mangrove soil (C_M) and amount of carbon in soil on the floor of the aquaculture system (C_{AQ}). Data on the soil carbon of mangrove and abandoned pond is taken from Kauffman *et al.* (2017) based on measurement from the 20 locations in East Kalimantan. The procedure for the sampling is described in Kauffman *et al.* (2016). Based on measurement in 20 locations in East Kalimantan, the value of C_M is 902.91 tC/ha and the value of C_{AQ} is 487.31 tC/ha, thus the EF for conversion of mangrove soil to aquaculture system is 415.6 tC/ha (Kauffman, 2017⁴⁴).

● EMISSIONS FROM DEFORESTATION

Emissions from deforestation include the following:

- Emissions associated with loss of living forest biomass
- Emissions associated with soil carbon

As described in the previous section, the carbon pools used to measure emissions from deforestation depend on the land type. For deforestation on mineral soils AGB and BGB are included. For deforestation on organic soils (peat forests and mangroves) soil carbon is also included. The methods for calculating emissions from deforestation are described below.

a. Deforestation emissions from living biomass

⁴⁴ <https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1002/fee.1482>

The method used for the calculation of average annual historical emissions follows the national method (MoEF, 2015)⁴⁵ that is consistent with the IPCC. Emissions from deforestation at a given period were calculated by aggregating CO₂ emissions resulting from newly identified deforested areas within that period.

The calculation of CO₂ emissions from deforested areas used the following equation:

$$GE_{ijk} = A_{ijk} \times EF_{jk} \times (44/12) \quad (\text{Equation 10})$$

GE_{ijk} = CO₂ emissions from deforested area-i at forest change class-j to non-forest class-k, in tCO₂e

A_{ijk} = Deforested area-i in forest change class-j to non-forest class-k, in hectare (ha).

EF_j = Emission Factor which is calculated as the difference between carbon stock of forest class-j and carbon stock of non-forest class-k, in ton carbon per ha (tC ha⁻¹). Emission factors for each forest and non-forest class are listed in sub-chapter 3.1.1 ER-PD/Annex 4 ER-MR.

(44/12) is conversion factor from tC to tCO₂e

Carbon stock of the lands after the conversion used in the calculation of the emission from the deforestation is the lifetime average carbon stock. It is assumed that land-cover types after deforestation will not change. This assumption is adopted since it is not practical to track the changes of land cover after deforestation, and it is unlikely that the natural forest that have been converted to non-forest lands will change back to natural forest. The deforestation of primary or secondary forest to non-forested was also counted only once that occur at one particular area. Identification of primary or secondary forest area in particular year is filtered using the primary or secondary forests of the previous years. Thus, the deforestation of primary and secondary forest to non-forested will be detected only in remaining primary or secondary forests of the previous years that have never been deforested before.

The emission from gross deforestation at period t (GE_t), was estimated using equation below,

$$GE_t = \sum_{i=1}^N \sum_{j=1}^P GE_{ijk} \quad (\text{Equation 11})$$

GE_t = total emission at period t from deforested area-l in forest class-j to non-forest class-k, expressed in tCO₂

N = number of deforested area units at period t (from t₀ to t₁), expressed without unit

P = number of forest classes which meet natural forest criterion.

Further, average emissions from deforestation from all periods were calculated as follows:

⁴⁵ https://redd.unfccc.int/files/national_frel_for_redd_in_indonesia_2015.pdf

$$MGE_p = \frac{1}{T} \sum_{t=1}^P GE_t \quad (\text{Equation 12})$$

MGE_p = mean or average emissions from deforestation from all period P (expressed in tCO₂yr⁻¹)

t = number of years in period P

The estimation of emission from deforestation from the loss of living biomass between two years (period) used the land use transition matrix.

The emissions from the change of a land use category to other land use category from the transition matrix used the equation 2 and their corresponding emission factors as defined in sub- chapter 3.1.1.

b. Deforestation emissions from soil carbon

b1. Emissions from Peat decomposition in deforested areas

Peat emissions happen slowly over time once land is cleared for a number of years depending on the depth of the peat soil. Thus the emissions in any given year is the sum of emissions from all peat lands disturbed over the previous years. These emissions from prior year deforestation are called 'inherited emissions' (e.g. Agus et al., 2011⁴⁶). The reference level for peat emissions uses peat decomposition emissions that occurred in 2017-2018, and for the monitoring period uses peat decomposition emissions in the monitored year period.

The procedures of calculating peat decomposition from deforestation follow three steps as shown in Annex 4 E Figure 8.5. First is defining natural forest in 2006 over peat land, and then step 2 is generating land cover change from each interval year to define a transition area matrix for the associated year of interval. The third step is calculating total annual emissions by multiplying the transition matrix of both areas and associated emission factors.

Calculation of emissions from peat decomposition used the same basis as emissions from deforestation. This is due to the fact that once deforestation occurs in peat forest, there will be emissions from removal of the ABG at the time of conversion as describe above, and plus from peat decomposition subsequently. The formula for estimating the emission from peat decomposition is the following:

$$PDE_{ijt} = A_{ijt} \times EF_j \quad (\text{Equation 13})$$

PDE = CO₂ emission (tCO₂yr⁻¹) from peat decomposition in peat forest area-i changed into land cover type-j within time period-t

A = area-i of peat forest changed into land cover type-j within time period-t

EF = the emission factor from peat decomposition of peat forest changed into land cover class-j (tCO₂ ha yr⁻¹)⁴⁷

⁴⁶ <http://apps.worldagroforestry.org/sea/Publications/files/manual/MN0051-11.pdf>

⁴⁷ Emission factor for an area of change is an average of the emission factors of the respective land cover before and after. This reflects the assumption that conversion of land cover on peatland between two time periods gradually affects the peat water table implying a gradual peat decomposition emission. For example, the emission factor of

Emission factor for peat decomposition of peat forest change using Paciornik and Rypdal (2006) and IPCC (2014). These emission factors are reported in 2013 Supplement Guideline to 2006 IPCC Guidelines for National GHG Inventory: Wetlands. Most of the data reported in this guideline come from Indonesian sites.

b2. Emissions from Peat Fire in deforested areas

Emission factors EF_f for the peat fires can be developed based on Eq. 2.27 in the IPCC 2006 Guidelines for National Greenhouse Gas Inventories (GL), Volume 4, using the following formula:

$$L_{fire} = A * EF_f \quad (\text{Equation 14})$$

$$EF_f = M_B * C_f * G_{ef} * 10^{-3} \quad (\text{Equation 15})$$

$$L_{fire} = A * M_B * C_f * G_{ef} * 10^{-3} \quad (\text{Equation 16})$$

L_{fire} = amount of greenhouse gas emissions from fire, tonnes of each GHG e.g., CO₂, CH₄, N₂O

A = burnt area, ha

M_B = mass of fuel available for combustion, tonnes ha⁻¹.

C_f = combustion factor, dimensionless (default values in Table 2.6 of the 2006 IPCC Guideline, Volume 4, Chapter 2-page 2.48)

G_{ef} = mission factor, g kg⁻¹ dry matter burnt (default values in Table 2.7, Chapter 2 of 2013 Supplement to 2006, page 2.36)

The M_B for the peat is 353 tons dry matter per hectare following IPCC default (Table 2.6 of the Chapter 2 in page 2.40, 2013 Supplement to the 2006 IPCC). The M_B depends on depth of peat and bulk density of the peat. Based on measurement in Central Kalimantan, the M_B is about 505 tons dry matter per hectare with assumption that the average depth of peat burn is 0.33 m and bulk density 0.153 t/m³ (MRI 2013). However, we adopt the IPCC default as the default considering the data was based on measurement from multiple locations that may represent better general condition. The C_f is taken from the IPCC default value (Tables 2.6 of 2006 IPCC Vol. 4 Chapter 2). The G_{EF} for CO₂ is 1,701 g/kg dry matter burnt (Table 2.7 of the Chapter 2 of the 2013 Supplement to the 2006 IPCC, page 2.36) and for CH₄ is 21 g/kg dry matter burnt.

Calculation of emissions from peat fire in the deforested area (L_{fire}) is calculated using the following formula (IPCC, 2014):

$$L_{fire} = A * EF_f = A * M_B * C_f * G_{ef} * 10^{-3} \quad (\text{Equation 17})$$

L_{fire} = amount of greenhouse gas emissions from fire, tonnes of each GHG e.g., CH₄, N₂O, etc.

secondary forest is 19 tCO₂ ha⁻¹ y⁻¹ and the emission factor of bare ground is 51 tCO₂ ha⁻¹ y⁻¹, so that the average emission factor for an area changing from secondary forest to bare ground is 35 tCO₂ ha⁻¹ y⁻¹.

A = area burnt, ha

M_B = mass of fuel available for combustion, tonnes ha⁻¹.

C_f = combustion factor, dimensionless (default values in Table 2.6 of the 2006 IPCC Guideline, Volume 4 Chapter 2-page 2.48)

G_{ef} = emission factor, g kg⁻¹ dry matter burnt (default values in Table 2.5 of the 2006 IPCC Guideline, Volume 4 Chapter 2-page 2.47)

b3. Emissions from *Mangrove Soil in deforested areas*

When mangrove forests are converted to aquaculture, they normally are being cleared and the soil being removed or excavated, normally 1.5 to 2 meters deep. When the organic soils are excavated, they exposed to aerobic condition and being oxidized that emit CO₂. Considering that soil mangrove has very high organic content (Kauffman et al, 2017⁴⁸ and Murdiyarso et al, 2015⁴⁹), conversion of mangroves will result in a significant amount of CO₂ emissions.

Calculation of emissions from mangrove soil in the ER program is considered only for conversion to aquaculture. Emissions released are calculated as potential emissions assuming that emissions from organic soil removed from the floor of the aquaculture system are emitted once at the time of the conversion. Thus, the calculation of the emissions from conversion of mangrove to aquaculture (E_{MS}) used the following formula:

$$E_{MS} = A_{MA} \times EF_{MA} \quad \text{(Equation 18)}$$

A_{MA} is area of mangrove converted to aquaculture, EF_{MA} is emission factor, i.e. the difference between amount of carbon in the mangrove soil (C_M) and amount of carbon in soil on the floor of the aquaculture system (C_{AQ}).

Summary: Average Historical Emissions from Deforestation

Emissions from deforestation is calculated based on the emissions associated with loss of living forest biomass (AGB and BGB), and the emissions associated with soil carbon. The Emission from soil includes the emission from peat soil due to decomposition process, and fire events, and also the emission from mangroves soil due to mangrove conversion to aquaculture.

● EMISSIONS FROM FOREST DEGRADATION

The emission from degradation of natural forest include:

4. *Emissions due to the degradation of primary forest into secondary forest*
5. *Emissions due to further degradation of secondary forest caused by fire*
6. *Emissions from peat decomposition in secondary forests*

a. Emissions from forest degradation of primary forest to secondary forest

⁴⁸ <https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1002/fee.1482>

⁴⁹ <https://www.nature.com/articles/nclimate2734>

The assessment of changes of primary forest to secondary forest and the estimation of emissions from the removal of the living biomass (AGB and BGB) and decomposition of organic soils follows a similar procedure as that of the deforestation (Equations 2-4). The degradation of primary forest to secondary forest was also counted only once that occur at one particular area, similar to the procedure used in calculating the deforested area. Identification of secondary forest area in particular year is filtered using the primary forests of the previous years. Thus, the degradation of primary forest to secondary forest will be detected only in remaining primary forests of the previous years that have never been degraded before.

The estimation of emission from forest degradation from the loss of living biomass (change of primary to secondary forest) between two years (period) used the land use transition matrix in all forests (production and non-production forests).

The emissions from the change of primary to secondary used the equation 8. For example, the emission from 41,722.33 ha degraded area (Primary dryland forest to Secondary dryland forests; 2001-2002) occurred in the period 2006 and 2009 is calculated as follow:

$$E_{2001-2002} = A * (EF_{BC} - EF_{AC}) * 44/12 \quad (\text{Equation 19})$$

$E_{2001-2002} = 41,722.33 * (167.3 - 122.06) * 44/12 = 6,922,432.35 \text{ ton CO}_2 \text{ or about } 2,307,477.45 \text{ tCO}_2\text{e per year.}$

b. Emissions due to further degradation of stable secondary forest caused by fire

Emission factors EF_f for biomass consumed by fire can be developed based on Eq. 2.27 in the IPCC 2006 Guidelines for National Greenhouse Gas Inventories (GL), Volume 4, using the following equation 14,15 and 16. Gas emission factor from dry matter burnt for CO_2 , CH_4 and N_2O is $1701.33 \text{ g kg}^{-1}$, 21 g kg^{-1} and 0.20 g kg^{-1} respectively.

Fire in secondary forest will result in further degradation and in more emissions. Estimation of the stable forest area affected by fire is by delineating burnt area of the stable forest (forests that remained as secondary forest throughout the reference period) hotspot (see Annex 4 section 8.4.3). This is to avoid double counting of emissions in which the loss of biomass due to fire in the deforested forest is not included. The implication of this is that when the secondary forests affected by fire are deforested during the future ERP reporting period, we will have to use separate emission factors in the calculation of the emission from deforestation which take into account the loss of carbon due to fire that occurred in the reference period.

For example, the area of stable secondary forests affected by fire in 2007 was 280.39 ha which is all secondary dryland forest (2002). The total fire emission reached 46,787.70 ton CO_2e (using equation 6). A similar approach was taken for all other years to estimate the emissions from fire in stable secondary forest.

c. Emissions from peat decomposition in secondary forests

The loss of carbon from the decomposition of organic soil occurs in secondary forest (IPCC, 2014). These are considered to be inherited emissions because the disturbance (which changed the forest from primary to secondary) occurred prior to 2006. The estimation of the emission from peat decomposition uses equation 5.

Parameters to be monitored

During the ERPA term (2020-2024), activity data (AD) and emission factors (EF) will be monitored in the Accounting Area to measure emissions from deforestation and forest degradation. Monitoring will follow the procedures defined in the NFMS (national forest monitoring system) and in the East Kalimantan forest inventory. Parameters to be monitored include the same parameters used to develop the REL, specifically:

Activity Data

- Forest cover change resulting in deforestation or forest degradation for all land that was forested in 2016.
- Areas of burned forest land in stable secondary forest starting in 2016.

Emission Factors

Emission factors for live biomass by land cover classes (forested and non-forested)
Emission factors for peat and mangrove soils
Emission factors for fires

The following tables provide information on the monitored parameters.

9.1.1.1 DEFORESTATION AND DEGRADATION

Parameter:	Area of forest cover change to estimate emissions from deforestation and degradation
Description:	Applicable to all transitions, including forest remaining forest (degradation, i.e. from primary to secondary forest) and forest to non-forest (Deforestation)
Data unit:	Ha/yr
Source of data or measurement/calculation methods and procedures to be applied (e.g. field measurements, remote sensing data, national data, official statistics, IPCC Guidelines, commercial and scientific literature), including the spatial level of the data (local, regional, national, international) and if and how the data or methods will be approved during the Term of the ERPA	<p>Remote sensing data is processed by the National Forest Monitoring System (NFMS) named Simontana (<i>Sistem Monitoring Hutan Nasional</i>) (MoFor, 2014).</p> <p>It is available online at webGIS of MoEF https://nfms.menlhk.go.id/</p> <p>for display and viewing. The websites are part of the geospatial portal under the one map policy (http://tanahair.indonesia.go.id/portal-web). The detailed explanation of the methods for monitoring the forest resource can be seen in Margono et al. (2016; https://jurnal.ugm.ac.id/ijg/article/view/12496/9041)</p> <p>Field observations to check the accuracy of the interpretation of land cover change are also conducted as part of the NFMS, with the involvement of ER Program Entities that include local communities.</p>

Frequency of monitoring/recording:	<i>Annually</i>
Monitoring equipment:	National Forest Monitoring System (NFMS)
Quality Assurance/Quality Control procedures to be applied:	<i>Following the Standard Operating Procedure on QA/QC developed by the IPSDH (Inventory and Monitoring of Forest Resources) unit under the Directorate General of Forest Planology, Ministry of Environment and Forestry.</i>
Identification of sources of uncertainty for this parameter	Uncertainty comes from the quality of satellite images used, land cover map generation process, and the number of ground truth points.
Process for managing and reducing uncertainty associated with this parameter	<ul style="list-style-type: none"> - <i>Increase the number of ground checking</i> - <i>Provide additional training for the interpreters</i> - <i>Refine the selection of Landsat and other supported images (Hi-res)</i> - <i>Application of sample based estimation (Olofsson 2014) using a stratified random sample to estimate area of change, and to assess map accuracy.</i>
Any comment:	In the current NFMS, the system is still not capable of monitoring the different level of degradation of the natural forests. Level of degradation is only able to be divided into two categories, i.e. primary intact forest called primary forest, and degraded primary intact forest called secondary forest. There is no category for shrubs as well. In fact some shrubs have regrowth and will be back into forest again (called old shrubs). As the current NFM only recognize this as shrubs, this land considered as non-forest. Based on the study conducted in two districts of Kalimantan, i.e. Kutai Barat & Mahakam Ulu, the category of degradation of the natural forest and shrubs can be monitored using the current method. The result of accuracy assessment indicates that this improved method can be applied for East Kalimantan or even national (see Annex 9.3 of the 2019 ERPD). The national government may use the method for the improvement of the land cover data given availability of resources.

Parameter:	Above ground biomass (AGB)
Description:	The above ground biomass is estimated based on the DBH (Diameter at Breast Height) and wood density that is measured from trees in the permanent sampling

	plots (PSP) using local allometric equations of Manuri et al. (2017), Manuri et al. (2014) and Komiyama et al. (2005)
Data unit:	Tonne of carbon per hectare
Source of data or measurement/calculation methods and procedures to be applied (e.g. field measurements, remote sensing data, national data, official statistics, IPCC Guidelines, commercial and scientific literature), including the spatial level of the data (local, regional, national, international) and if and how the data or methods will be approved during the Term of the ERPA	Field measurement from the permanent sampling plots (PSPs) of the Kalimantan Timur established for the FCPF (for swamp and mangrove forests) and from PSPs of the National Forest Inventory (for dryland forest). New permanent sampling plots for mangrove have been established in 2019, in total 120 PSPs. These data were used for the technical correction of RL. The locations of the PSPs in all forest types in East Kalimantan Province are provided in Annex A9.2.
Frequency of monitoring/recording:	<i>During the ERPA monitoring and recording will be carried out at minimum in 2022 and 2024. In the ER Program, the new data from the PSP will be used to improve the accuracy. In the case the improvement is significant, the recalculation of the Reference Level will be performed.</i>
Monitoring equipment:	
Quality Assurance/Quality Control procedures to be applied:	Following the standard methods that have been developed for the NFI (SNI 7724:2011)
Identification of sources of uncertainty for this parameter	<p>Sources of uncertainty for this parameter are due to:</p> <ol style="list-style-type: none"> 1. Limited number of permanent sampling plots 2. Allometric equations 3. Root:shoot ratio 4. Biomass density 5. Human error in measuring tree diameters
Process for managing and reducing uncertainty associated with this parameter	<i>Increasing number of PSP. The additional PSPs is planned to be established in the forest types will less number of plots, namely swamp and mangrove forest. With the plan to increase the categorization of forest based on level of degradation, the establishment of the new PSPs will also be allocated to this area.</i>
Any comment:	In the secondary forest affected by fire during the

	reference period, the AGB of the fire affected secondary forest will be adjusted to avoid double counting if this fire-affected secondary forest becomes deforested during the ER period. Following the IPCC default factor, the AGB of the fire-affected secondary forest will decrease by 36% of the initial biomass. Thus the AGB of the secondary forest affected by fire during the reference period will be only 64% of the non-affected secondary forest.
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Emission Factors for peat decomposition and mangrove will continue to rely on the same published values used to calculate the RL. Above ground biomass of forest lands will be monitored as part of the NFI program in which the number of PSPs will be increased in East Kalimantan to reduce the uncertainties mentioned above, while for those of non-forest lands will not be monitored to maintain consistency with the EF used in the development of the Reference Level.

9.1.1.2 PEAT AND FOREST FIRES

Parameter:	Area of stable secondary forest affected by fire each year
Description:	Stable Secondary forest (secondary forest in 2016 and in the measurement year) affected by fire is monitored based on hotspot data
Data unit:	Ha/yr
Source of data or measurement/calculation methods and procedures to be applied (e.g. field measurements, remote sensing data, national data, official statistics, IPCC Guidelines, commercial and scientific literature), including the spatial level of the data (local, regional, national, international) and if and how the data or methods will be approved during the Term of the ERPA	Hotspot data will be acquired from NASA FIRMS (https://nrt4.modaps.eosdis.nasa.gov/). The method for estimating the burnt area follows the method that combine the hotspot data with the Landsat image (quick look original with composite band 645) that is able to delineate the burnt area and supervised by other data (e.g. fire control activity and ground check).
Frequency of monitoring/recording:	<i>Annually</i>
Monitoring equipment:	National Forest Monitoring System (NFMS)
Quality Assurance/Quality Control procedures to be applied:	QA/QC are directed to ensure the consistency of the method and approach adopted for estimating burnt area with the one used in the RL development. Result of the estimation of burnt area will be verified

	by BAPLAN
Identification of sources of uncertainty for this parameter	Sources of uncertainty for this parameter are: (i) processing of Hotspot data; (ii) selection of confidence level of the Hotspot data for this analysis, which is >80%; and (iii) sample error
Process for managing and reducing uncertainty associated with this parameter	<i>Developing SOP for the estimation of burnt area using semi-automatic approach which combine the hotspot data with the Landsat image (quick look original with composite band 645) and supervised by other data (e.g. fire control activity and ground check) for minimizing bias.</i>
Any comment:	The semi-automatic approach replaced the MRI (2013) method. Comparison of the two methods is available in Rossita et al. (2019).

Emission Factors for peat and forest fire will not be changed in order to maintain consistency with the EF used in the development of RL (using the IPCC default values).

9.2 Organizational structure for measurement, monitoring and reporting

The ER Program has two sets of organizational structures for measurement, monitoring and reporting of emissions estimates as presented in Figure 9.2

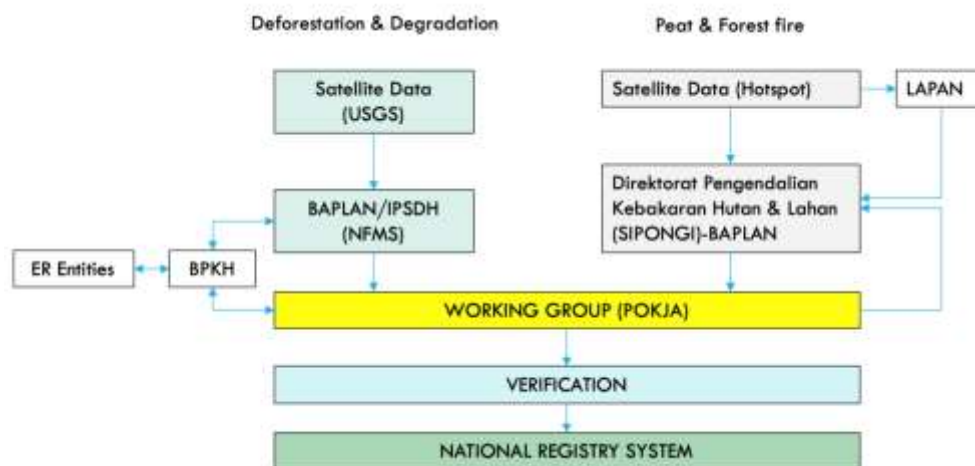


Figure 9.7 Organizational Structure for measurement, monitoring and reporting of the implementation of ER Program

The MMR system of the ER Program will be institutionally integrated with the national forest monitoring system (NFMS; Figure 9.3) as described in Regulation of Director General of Forest Planology Number P.1/VII- IPSDH/2015. The generation of national forest and land cover change data from satellite images is conducted by the Regional Office for the Management of Forest Area (BPKH) in East Kalimantan Province under the direction of the Directorate of Forest Resources Inventory and Monitoring (IPSDH), which is under the Directorate General of Forestry Planning and Environmental Arrangement (BAPLAN). The BPKH will receive satellite data from IPSDH. The satellite data are first acquired by LAPAN, which also does pre-processing of data up to mosaicking before sending the data to the respective institutions (including IPSDH). The visual interpretation is conducted by the BPKH using a standard methodology for land cover mapping (Margono *et al*, 2014, 2016). Results of the processing and ground check by BPKHs are sent back to IPSDH for validation by IPSDH including some necessary edge-matching as appropriate, as part of the QA/QC process. Finally, the accuracy of the interpretation is assessed by comparing the land cover maps to field data from the ground check using a contingency matrix (MoFor, 2012, Margono *et al.*, 2012). There are about 300 points for ground checking in East Kalimantan (MoEF, 2017), which are determined randomly by land cover classes. All the data from the BPKH will be consolidated to generate data on forest cover change.

The ER Program (through the Working Group) will analyze the data from the BPKH to estimate emissions from deforestation and degradation, peat decomposition, and loss of mangrove soil from the conversion of mangrove to aquaculture. Results of the estimation are then submitted to the Environmental Agency for internal verification. The Environmental Agency will then submit the results of the verified estimation to the national registry and verification system.

To facilitate the work of the Working Group, the Government of East Kalimantan has developed a web portal for the Sub-national MRV System for managing all the processed data from the

national and also from local governments. The system can perform calculations of the emissions using the national data & sub-national data. The system is to be operated by the Provincial Environmental Office (DLH) as the East Kalimantan MRV Focal Point. Measurement (data input pages) and Verification (verification purpose pages) sections need a user account but the Reporting section is publicly available to show the Emission Factor (Faktor Emisi), Activity Data (Data Aktivitas) and Emission include Reference Emission Level (Tingkat Emisi Rujukan), Actual Emission after reference period (Emisi Aktual) and Performance of Emission Reduction (Kinerja Penurunan Emisi). This menu is available on the left as an expandable menu. The MRV web portal has been tested using national data and the calculation method is the same with the national FREL. This MRV web portal will increase public participation of OPD to village communities or indigenous people to participate in monitoring the condition of forests and changes in the forest/land that occurs.

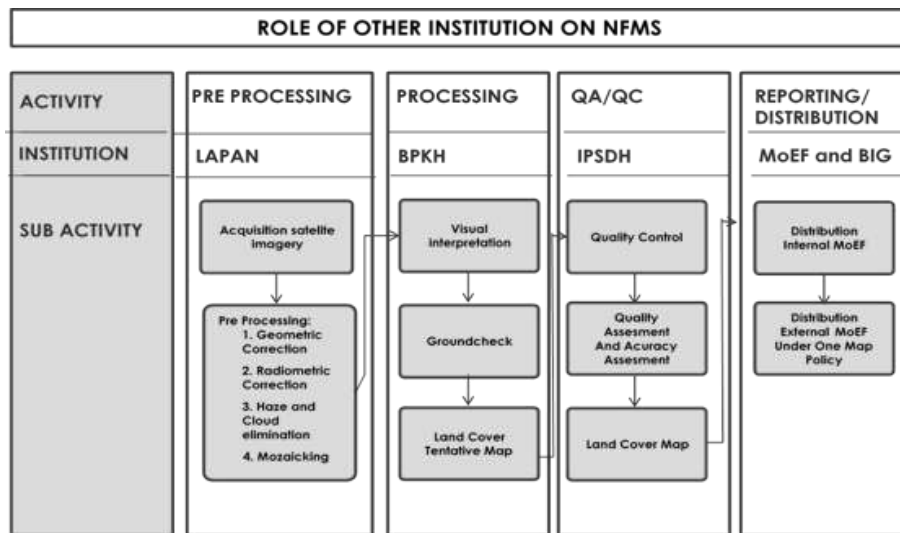


Figure 9.8 Related institutions on NFMS management (MoEF, 2017)

The process of the production of land cover maps will be on an annual basis as defined in the Regulation of the Director General of Forest Planology Number P.1/VII- IPSDH/2015. The timeline of the process is shown in Table 9.2. The collection of the LANDSAT images is conducted throughout the year by LAPAN and the pre-processing of the image is conducted as the data becomes available for producing the mosaic. The mosaic will be available by June to be distributed to IPSDH and to BPKH. BPKH under the supervision of IPSDH will do manual interpretation of the image during the period July-October, while land cover data from field visits (with defined coordinate) are collected in the period March-September. In October, all the results of the interpretation conducted by BPKH will be compiled to the national by IPSDH for QA/QC and accuracy assessment. By December the result of the interpretation is finalized and reported.

Table 9.1 Timeline of land cover change analysis under the current NFMS

9.3 Relation and consistency with the National Forest Monitoring System

As mentioned above, the ER Program will use the data generated by the NFMS, and the East Kalimantan forest inventory data will be integrated to the National Forest Inventory (NFI). The system provides continuous information on activity data and emission factors that can ensure the sustainability of activity data supply needed for estimating emission reductions from the implementation of the ER Program, thus ensuring consistency. The ER Program will continue to apply the sample based area estimation for ER purposes, and will consider whether this approach is also applicable to the NFMS for national reporting purposes.

In addition, the ER Program will also include ground checking activities, as mentioned above, to increase the number of points required for the accuracy assessment. At present, due to limited budget BPKH can only do ground check in a small number of observation points. Through the ER Program, it is planned for ER Entities, as shown in Figure 9.2. This implies an urgent need for capacity building and technical assistance for ER entities.

For the development of capacity of ER entities in the implementation of monitoring and evaluation activities, the ER program will implement a number of capacity building activities. The budget plan is 418,513 USD for the capacity building on monitoring and evaluation and 6,924,317 USD for measurement and reporting of the ER Program (Table 9.2).

Table 9.2 Cost for the implementation of capacity building for monitoring, evaluation, measurement and reporting activities

Year	Implementation of monitoring and evaluation for ER program implementation (USD)	Measurement and Reporting (USD)
2020	63,654	556,415
2021	62,060	593,774
2022	66,226	3,606,316
2023	70,673	676,187
2024	75,418	721,588
2025	80,482	770,037
Total	418,513	6,924,317

12 UNCERTAINTIES OF THE CALCULATION OF EMISSION REDUCTIONS

The process for addressing uncertainty related to the REL and the calculation of emission reductions follows a stepwise process. The process involves the identification of sources of uncertainty, the minimization of uncertainty where feasible and cost effective, and the quantification of the remaining uncertainty through application of Monte Carlo analysis. The ER Program uses the 2006 IPCC Guideline for estimating average annual GHG emissions in the reference period, i.e. multiplication of Activity Data with Emission Factors (AD x EF) as described in Section 8.3.1. Therefore, uncertainty in the emission estimates is linked to the uncertainties of the AD and EF inputs.

12.1 Identification of sources of uncertainty of AD

The activity data used to estimate the emissions of deforestation, forest degradation, peat decomposition, and mangrove soil came from the national land cover maps produced by MoEF. The land cover map consists of 23 land cover classes derived by remote sensing data analysis (Landsat at 30-meter spatial resolution). The object identification is purely based on the appearance on the images. Manual-visual classification through an on-screen digitizing technique based on key elements of image/photo-interpretation was applied as the interpretation/classification method. Several ancillary data sets (including concession boundaries of logging and plantation, forest area boundaries) were utilized during the process of delineation, to integrate additional information valuable for classification. The detailed explanation on the method for generating the activity data can be accessed from <https://nfms.menlhk.go.id/> and <https://jurnal.ugm.ac.id/ijg/article/view/12496/9041>

Manual classification is time-consuming and labor intensive (Margono et al., 2012, Margono et al., 2014). It involves staff from district and provincial levels to manually interpret and digitize the satellite images, to exploit their local knowledge. Data validation was carried out by comparing the land cover maps with field data. Stratified random sampling is the selected approach to verify the classification map to the field reality. Compilation of several field visit data within a specific year interval was exercised for accuracy assessment. Comparison of results was performed on a table of accuracy (contingency matrix MoFor, 2012, Margono *et al.*, 2012).

Emissions from peat decomposition are estimated using the activity data derived from the peatland map, which is separated from land cover maps produced by MoEF. The development of the peatland map in Indonesia is closely related to soil mapping projects for agricultural development programs, conducted by the Ministry of Agriculture. Indonesia has developed a procedure for peatland mapping based on remote sensing at a scale of 1:50,000 (SNI 7925:2013). The map of Indonesia's peat land has been updated and released several times due to the dynamics of data availability. The latest Peatland Map version 2011 at a scale of 1:250,000 (national scale) is used for the emission estimation.

Based on the above practices, there are a number of main sources of uncertainty for the Activity Data used for estimating the emission from deforestation, degradation, peat decomposition, and mangrove soil. The AD for forest cover and forest cover changes used in the estimation of emissions from deforestation, degradation, peat decomposition and mangrove soils have at least three sources of uncertainty, namely quality of the satellite images, interpretation procedure, and sampling error that is related to the process of ground truthing.

Sources of uncertainty	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
Activity Data				
<i>Measurement</i>	<ul style="list-style-type: none"> There are two sources of error related to the Landsat images. First stripping problem that leads to a loss of some data from the images and the need for manipulation using different images. Second, Indonesia almost always has a lot of cloud cover. The cloud's shadows and cloud coverage will affect the quality of the images as it generates data gaps. These constraints affect the image interpretation process. Interpretation of satellite images to produce land cover maps is done by trained interpreters who use manual or visual interpretation digitization technique. Standard Operating Procedures (SOPs) and manuals are provided to guide the interpreters to do the satellite image interpretation 	<i>L (random)</i>	YES	NO
<i>Representativeness</i>	The ground truthing uses stratified random sampling. Compilation of several ground truthing results within a specific year interval was used for accuracy assessment that will provide level of accuracy of the land cover classes interpretation.	<i>L (bias)</i>	YES	NO
<i>Sampling</i>	The number of points to represent land cover categories will determine the level of accuracy of the assessment. Ground truthing will reflect the accuracy of the interpretation with real condition. It helps to determine the accuracy of the satellite interpretation results. Therefore, the number of points of ground check will significantly affect the level of uncertainty. The number of sampling plots will be increased in order to reduce the uncertainty rate.	<i>H (random / bias)</i>	YES	YES
<i>Extrapolation</i>	MoEF land cover data which has 23 classes and is reclassified into 5 (five) classes of land cover change, namely deforestation, forest degradation, forest gain (forest growth), stable forest (fixed/unchanged forest cover) and stable non-forest (non-forest cover that remains / does not change).	<i>H (bias)</i>	YES	NO
<i>Approach 3</i>	The approach is carried out by only calculating deforestation from forested areas from the beginning of the reference period until the	<i>L (bias)</i>	YES	NO

Sources of uncertainty	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High / Low)	Addressed through QA/QC?	Residual uncertainty estimated?
	measurement year, after which it changes to non-forested areas, while degradation is calculated in primary forested areas from the beginning of the reference period until the calculation year.			
<i>DBH measurement</i>	Measurement officers in the field have gone through a training process and are provided with technical instructions for measuring, which are accompanied by a process of supervision and QA/QC.	<i>L (random)</i>	YES	NO
<i>H measurement</i>		<i>L (random)</i>	YES	NO
<i>Plot delineation</i>		<i>L(random)</i>	YES	NO
<i>Wood density estimation</i>	The calculation of wood density is carried out through a laboratory measurement approach on the species in the sample plot.	<i>L (random)</i>	YES	NO
<i>Biomass allometric model</i>	The sample tree data used to construct biomass allometric models is still relatively limited to trees of a certain size. Standard errors are also documented in the allometric model process.	<i>L(random)</i>	YES	NO
<i>Sampling</i>	Determination of the location of the sample is done based on proportional random based on forest class area.	<i>H (random)</i>	YES	YES
<i>Carbon Fraction</i>	Carbon fraction uses the values listed in Table 4.3 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4: Agriculture, Forestry and Other Land Use https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_04_Ch4_Forest_Land.pdf	<i>H (bias / random)</i>	YES	YES
<i>Root-to-shoot ratio)</i>	Root shoot ratio using the IPCC GPG LULUCF Table 3A.1.8 - https://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Chp3/Anx_3A_1_Data_Tables.pdf	<i>H (bias / random)</i>	YES	YES
<i>Representativeness</i>	Representative sample by purposive sample in each land cover class	<i>L (bias)</i>	YES	NO
<i>Model</i>	The combination of AD & EF does not necessarily need to result in additional uncertainty. QA/QC carried out by the MMR East Kalimantan team	<i>L (bias)</i>	YES	NO
<i>Integration</i>	This source of error is linked to the lack of comparability between the transition classes of the Activity Data and those of the Emission Factors. QA/QC carried out by the MMR East Kalimantan team	<i>L (bias)</i>	YES	NO

Steps to minimize uncertainty

The minimization of error of interpretation that normally results in systematic error, as required by Indicator 8.1 of MF of the FCPF, is through the implementation of a consistent and comprehensive set of standard operating procedures (SOP), including a set of quality assessment and quality control processes, and that of sampling error is through increased sampling. The implementation of QA/QC procedure will be enhanced, through the consistent use of the SOPs for the interpretation and training procedures. The consistency checks will be conducted by interpreters that were not involved in the original classification. Following the provisions on verification provided in Chapter 3 – Volume 1 of the 2006 IPCC GL, QA/QC measures will be complemented with verification, i.e. through an accuracy assessment. The verification will be conducted by a third party, which will serve to confirm the acceptable quality of the estimates and will enable the correction of biases and respective uncertainties. The accuracy assessment is conducted using Olofsson *et al.* (2014) with stratified reference data. The assessment is not only to assess accuracy but to also calculate the sample based estimates of areas and to quantify the degree of uncertainty for analysis purposes. In applying Olofsson *et al.* (2014) for the estimation of the accuracy of land cover change and the calculation of the sample based estimates of areas, Indonesia used a reference data set of 880 observations.

Similar to activity data, the uncertainty in Emission Factors is reduced through strengthening the consistency in the use of SOP including through trainings, and through increasing the number of samples. Indonesia plans to increase the number of sample plots in different categories of secondary forest based on tree cover density of secondary forests and shrubs (Annex 9.3). The implementation of this effort will involve FMUs. Activities to be implemented for reducing the uncertainty of the emission factors will include the following activities:

- Developing and improving the monitoring protocol;
- integrating the monitoring protocol into the curriculum of the national forest training center to produce skilled staff within FMUs in east Kalimantan. The training should be conducted periodically by inviting key related field staff from FMUs; and
- providing proper supporting tools/equipment to make the monitoring processes more efficient.

12.2 Quantification of Uncertainty in the Reference Emission Level

Parameter included in the model	Parameter values	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
Project Area	12,734,692 ha			ER program document
Length of reference period	10 years			ER program document
Carbon Fraction	0.47	Measurement	Triangular (lower bound = 0.44, upper bound = 0.49, mode = 0.47)	IPCC 2006

Parameter included in the model	Parameter values	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
Ratio of molecular weights of CO ₂ and C	44/12			Default
Root shoot ratio	See sheet 'EF_EKJERP' excel file fcpf_ekjerp_ermr1_MC_26Juli2022c.xlsx			2006 IPCC GPG LULUCF Table 3A.1.8.
AGB sample	See sheet 'EF_EKJERP' excel file fcpf_ekjerp_ermr1_MC_26Juli2022c.xlsx	Sampling	Normal distribution	
Activity data	See sheet 'UncertaintyAD' excel file fcpf_ekjerp_ermr1_MC_26Juli2022c.xlsx	Sampling	Non-parametric bootstrapping	

Quantification of the uncertainty of the estimate of the Reference level

	Deforestation	Forest degradation	Enhancement of carbon stocks
A Median	23,910,110.75	3,499,907.39	
B Upper bound 90% CI (Percentile 0,95)	21,692,563.78	2,360,708.84	
C Lower bound 90% CI (Percentile 0,05)	26,214,647.70	4,732,375.53	
D Half Width Confidence Interval at 90% (B – C / 2)	2,261,041.96	1,185.833.35	
E Relative margin (D / A)	0.09	0.34	%
F Uncertainty discount	9.46	33.88	%

Sensitivity analysis and identification of areas of improvement of MRV system

Sensitivity Test	Median	Lower bound (5th percentile)	Upper bound (95th percentile)	Half-width confidence interval at 90%	Relative Margin	Uncertainty (%)
All on	35,404,709.61	31,595,294.53	39,343,003.80	3,873,854.63	0.10	10.94
R:S Uncertainty	35,471,602.13	35,001,607.79	35,949,894.69	474,143.45	0.01	1.34
CF Uncertainty	35,463,547.88	34,959,756.78	35,968,679.38	504,461.30	0.01	1.42
Sampling uncertainty	35,479,001.24	33,736,204.15	37,220,024.41	1,741,910.13	0.05	4.91
Emission Factor uncertainty	35,447,106.81	33,535,207.34	37,352,701.23	1,908.746.94	0.05	5.38

Activity Data	35,476,198.51	32,158,638.15	38,852,025.32	3,346,693.58	0.09	9.43
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The sensitivity analysis was done using Monte Carlo approach by removing one estimation parameter at a time, i.e.:

No	Parameter Used	Approach
1	All on	Using the uncertainty for Root shoot ratio, Carbon Fraction, Sampling uncertainty AGB, and Activity Data
2	R:S Uncertainty	Using the uncertainty for Root shoot ratio, and other uncertainty parameter near zero.
3	CF Uncertainty	Using the uncertainty for carbon fraction ratio, and other uncertainty parameter near zero
4	Sampling uncertainty	Using the uncertainty for AGB biomass sampling, and other uncertainty parameter near zero
5	Emission Factor uncertainty	Using the uncertainty for Root shoot ratio, carbon fraction, and AGB biomass sampling, but uncertainty for activity data near zero
6	Activity Data	Using the uncertainty for activity data (AD), and other parameter near zero