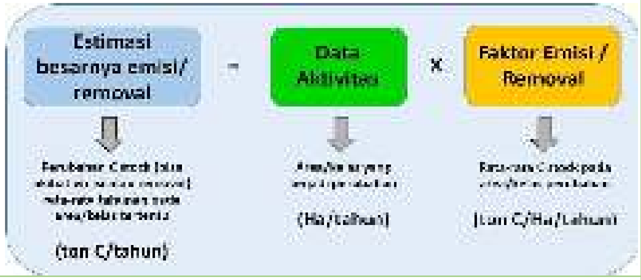
Annex 8.2. References for technical assessment related to carbon accounting

No	Topic	Summary	Page	Link	Book/Journal Title	Author	Years
Carbon Accounting Aspect							
1	Forest definition	Forest is defined as "Land spanning more than 0.25 hectares with trees higher than 5 meters at maturity and a canopy cover of more than 30 percent, or trees able to reach these thresholds in situ". This is the definition of forest stated in the Minister of Forestry Decree No 14/2004 on A/R CDM (MoFor, 2004).	7	http://ditjenppi.menlhk.go.id/kcpi/dokumen/national_frel_final%20revisi_10des.pdf	NATIONAL FOREST REFERENCE EMISSION LEVEL FOR DEFORESTATION AND FOREST DEGRADATION (In the Context of Decision 1/CP.16 para 70 UNFCCC)	Directorate General of Climate Change Ministry of Environment and Forestry Republic of Indonesia	2015
2	Deforestation	The Minister of Forestry No. 30/2009 that stated deforestation as the permanent alteration from forested area into a non-forested area as a result of human activities.	9	http://ditjenppi.menlhk.go.id/kcpi/dokumen/national_frel_final%20revisi_10des.pdf			
3	Forest Degradation	ITTO (2002), defined degraded forest as natural forest which has been fragmented or subjected to forest utilization including for wood and or non-wood forest product harvesting that alters the canopy cover and overall forest structure. According to The Minister of Forestry No. 30/2009, forest degradation is a deterioration of forest cover	9	http://ditjenppi.menlhk.go.id/kcpi/dokumen/national_frel_final%20revisi_10des.pdf			

		quantity and carbon stock during a certain period of time as a result of human activities.					
4	Activity Data and Emission Factors	In order to measure emissions / removals in the land sector, including the forestry sector and peat land, the basic formula is used  	27	http://ditjenppi.menlhk.go.id/reddplus/images/adminppi/dokumen/pedoman_mrv_redd.pdf			
5	FREL	FREL is a benchmark for assessing Indonesia's performance in implementing REDD+, expressed in tons of carbondioxide equivalent per year.	10	http://ditjenppi.menlhk.go.id/kcpi/dokumen/national_frel_final%20revisi_10des.pdf	NATIONAL FOREST REFERENCE EMISSION LEVEL FOR DEFORESTATION AND FOREST DEGRADATION (In the Context of Decision 1/CP.16 para 70 UNFCCC)	Directorate General of Climate Change Ministry of Environment and Forestry Republic of Indonesia	2015
6	Acounting Area Map in East Kalimantan			https://drive.google.com/open?id=1cDTK3NsWLz3_W_W2n_YiYDtdGDxcfskB			

7	Emission factors for deforestation and forest degradation	The total AGB for each plot (per hectare) was then quantified by summing AGB estimates for all trees on the plots in dry weight (expressed in tons (t)) **(Equation 1).** $M_p = \sum_1^n \frac{M_T}{A_P} M_P = \sum_1^n \frac{M_T}{A_P}$ Where MP = AGB of plot expressed as (t ha-1), MT = AGB of measured tree (t), AP = plot area (ha), n = number of trees per plot. The total AGB per hectare for each forest type in the main island were derived by averaging the AGB of the total plots **(Equation 2).** $M_j = \sum_{1=1}^n \frac{M_{Pi}}{n} M_j = \sum_{1=1}^n \frac{M_{Pi}}{n}$ where M_j = mean AGB(t $ha^{-1)}$ of forest type-j, MPi = AGB of plot-i, n= plot number. To estimate the amount of carbon (C) in each forest type, information on carbon fraction is needed. The carbon fraction of biomass (dry weight) was assumed to be 47% (1 tons biomass = 0.47 tons C) following IPCC 2006 Guideline. Conversion of C-stock into carbon dioxide equivalent (CO_2e) was then obtained by multiplying C-stock with a factor of 3.67 (44/12) (Paciornik and Rypdal, 2006).	22-24	http://ditjenppi.menlhk.go.id/kcpi/dokumen/national_frel_final%20revisi_10des.pdf			

8	Emission Calculation from deforestation and Forest Degradation	Emissions from deforestation were derived from the total loss of forest biomass regardless biomass gain, or gross deforestation. Procedures for emissions calculation from deforestation and forest degradation, as follow : Step 1 : Generate deforestation and forest degradation for each interval period. Step 2: The generated deforestation and forest degradation polygons were multiplied by associated emission factors to calculate emissions from deforestation and forest degradation for each interval period.Later the result was divided by number of years for each interval period, to generate annual emissions from deforestation and forest degradation. CO_2 emissions (GE_{ij}) from a deforested or degraded forest area-i (A_{ij}), was calculated by multiplying the area (in ha) with emission factor of the associated forest cover change type-j (EF_j). A conversion factor from C to CO_2 was further multiplied to derived emissions in tCO_2 equivalent **(Equation 3).** $$GE_{ij} = A_{ij} \times EF_j \times (\frac{44}{12})$$ where GE_{ij} = CO_2 emissions from deforested or forest degradation area-i at forest change class-j, in tCO_2e. A_{ij} = deforested or forest degradation area-i in forest change class j, in hectare (ha). EF_j =	27-29	http://ditjenppi.menlhk.go.id/kcpi/dokumen/national_frel_final%20revisi_10des.pdf			

		Emission Factor from the loss of carbon stock from change of forest class-j, due to deforestation or forest degradation; in tons carbon per ha (tC ha^{-1}). (44/12) is conversion factor from tC to tCO_2e. Emission from gross deforestation and forest degradation at period t (GEt), was estimated using **(Equation 4).** $GE_t \sum_{i=1}^{N} \sum_{j=1}^{P} GE_{ij}$ where, GE_t is in tCO_2, GE_{ij} is emission from deforested or degraded forest area-i in forest classes j, expressed in tCO_2. N is number of deforested or degraded forest area unit at period t (from t_0 to t_1), expressed without unit. P is number of forest classes which meet natural forest criterion. Mean emissions from deforestation and forest degradation from all period P (MGE_P) were calculated using **(Equation 5).** $MGE_p = \frac{1}{T} \sum_{t=1}^{p} GE_t$ Where, MGEP is expressed in tCO_2yr^{-1}. GE_t is total emissions from gross deforestation and forest degradation at year t and expressed in tCO_2. T is number of years in period P.					

9	Emission Calculation from Peat Decomposition	Land emission from peat decomposition is calculated by multiplying the transition matrix of land cover changein forested peat land and the transition matrix of emission factor within the subsequent land cover (see Annex 7). The calculation is used is **(Equation 6).** $$PDE_{ijt} = A_{ijt} \times EF_j$$ Where PDE is CO_2 emission (tCO_2 yr_{-1}) from peat decomposition in peat forest area-i changed into land cover type-j within time period-t. A is area-i of peat forest changed into land cover type-j within time period-t. EF is the emission factor from peat decomposition of peat forest changed into land cover class-j (tCO_2 ha^{-1} yr^{-1}). Procedures for annual peat emissions calculation from deforestation and forest degradation, were as follows: Step 1 : Define natural forest over peat land. Step 2 : Generate land cover change from each interval year to define transition area matrix for the associated year of interval. Step 3 : Calculate total annual emmision by multyplying transition matrix of both areas and associated emission factors. Emission factor from the areas of change is half of total emission factor, because of time averaged. For example, emission factor of secondary forest is 19 tCO_2 ha^{-1} y^{-1} and emission factor of bare ground is 51 tCO_2 ha^{-1} y^{-1}, so that emission factor of the change from secondary forest to bare ground is 35 tCO_2 ha^{-1} y^{-1}.		http://ditjenppi.menlhk.go.id/kcpi/dokumen/national_frel_final%20revisi_10des.pdf			

10	Measuring Emissions from Peat Fires	According to the IPCC Supplement for Wetland (Hiraishi et al.,2014), emissions from organic soil fires are calculated with the following formula : $L_{fire} = A \times MB \times CF \times G_f$	86	http://ditjenppi.menlhk.go.id/kcpi/dokumen/national_frel_final%20revisi_10des.pdf			

11	Peat Fire Definition	Are calculated not only at the time deforestation occurred, but it continues over longer periods until organic contents/organic peats are fully decomposed. This current analysis only deals with emissions related to drainage (emissions from peat decomposition). Although drainage and burning are the major sources of GHG emissions in peat land, emission from peat fires are excluded since the generation of the activity data for the latter is complicated and highly uncertain (Agus et al., 2013).	16	http://ditjenppi.menlhk.go.id/kcpi/dokumen/national_frel_final%20revisi_10des.pdf			
12	Uncertainty Calculation	Uncertainty (U) was calculated following the IPCC 2006 Guidelines, volume 1. Chapter 3. If EA is uncertainty from Activity Data and EE is uncertainty from emission factor from i forest cover class and activity j, the combined uncertainty is calculated using **(Equation 7).** $$Uij = \sqrt{EAij^2 + EEij^1}$$ A proportion of accuracy contribution (C_{ij}) was calculated from activity j that occurs in forest cover class i, by involving the uncertainty (U_{ij}), total emissions occurred in the corresponding forest cover classes and activities (E_{ij}) and total emission from the corresponding year (E). **(Equation 8)** $$C_{ij} = \frac{(E_{ij} * U_{ij})^2}{E}$$	31-32	http://ditjenppi.menlhk.go.id/kcpi/dokumen/national_frel_final%20revisi_10des.pdf			

		(Equation 9) $$TU = \sqrt{\Sigma} C_{ij}$$ Total uncertainty of each year (TU), was derived from a square root of sum C_{ij}.					
		The project proponent must justify the selection of uncertainty propagation in the project documents. If Uij ≤ 0.15 then no deduction will result for uncertainty. If Uij >0.15 then the amount of greenhouse gas emission credits associated with IFM activities will be deducted as follows : $$CREDIT = GHG_{credits\|LtPF} * (1 - Uij)$$ Where: $CREDIT$ = Total greenhouse gas credits adjusted for uncertainty for each year t in the project crediting period $GHG_{credits\|LtPF}$ = Project greenhouse gas credits associated with the implementation of improved forest management (IFM) activities in the project scenario, tCO2e·year-1 Uij = Total uncertainty for LtPF Project, dimensionless	52	http://ditjenppi.menlhk.go.id/kcpi/dokumen/national_frel_final%20revisi_10des.pdf			

13	Uncertainty of Activity Data for Peat Decomposition	For peat decomposition, uncertainty of activity data derived from the overall accuracy of peat land mapping (80%) (Ritung et al. 2011), while for uncertainty values of peat emission factors were derived from Hiraishi et al.,(2014) default values.	98	http://ditjenppi.menlhk.go.id/kcpi/dokumen/national_frel_final%20revisi_10des.pdf			
14	Total Tree Biomass for National Measurement	In order to estimate total tree biomass, field measurement data (DBH, species and tree height) were converted using allometric equation. The availability of local allometric models specific for six forest types were not all represented in seven main islands of Indonesia so this generalized allometric model of Chave et al. (2005) was selected, instead. $AGB = Exp\ (-1.499 + 2.148(lnDBH) + 0.207(lnDBH)^3 - 0.0281(lnDBH)^3) * WD$	84	http://ditjenppi.menlhk.go.id/reddplus/images/adminppi/dokumen/pedoman_mrv_redd.pdf			

		Where, AGB is above ground biomass of individual tree. DBH is diameter at breast height and WD is the wood density. This model has been found to perform equally well as local models in the Indonesian tropical forests (Rutishauser et al., 2013; Manuri et al., 2014).					
15	Summary of GHG Emission Reduction and/or Removals in National Measurement	Net GHG emission reductions are calculated as : $$GHG_{CREDITS\|LtPF,t8} = GHG_{NET\|BSL,t*} - GHG_{NET\|PRJ,t8} - GHG_{LK\|LtPF,t*}$$ Where : $GHG_{CREDITS\|LtPF,t8}$ = project greenhouse gas credits associated with the implementation of improved forest management (IFM) activities in the year t* since the start of the project activity, in the project scenario, tCO_2e $GHG_{NET\|BSL,t*}$ = net greenhouse gas emissions in the baseline scenario in the year t* since the start of the project activity, tCO_2e $GHG_{NET\|PRJ,t8}$ = net greenhouse gas emissions in the project scenario in the year t* since the start of the project activity, tCO_2e $GHG_{LK\|LtPF,t*}$ = total greenhouse gas emissions due to leakage arising outside the project boundary as a result of the implementation of improved forest management (IFM) activities in the year t* since the start of the project activity, in the project scenario, tCO_2e	51	http://ditjenppi.menlhk.go.id/kcpi/dokumen/national_frel_final%20revisi_10des.pdf	VM0010 Methodology for Improved Forest Management: Conversion from Logged to Protected Forest. (Version 1.3)	VCS	2016

16	Reference Period in National Level	The main guide for establishing FREL must refer to the attachment to FCCC / CP / 2013/10 / Add. 1 (Guidelines and procedures for submission of technical assessments from the Parties regarding the proposed forest reference emission level and / or forest reference level). A period span from 1990 to 2012 was used for FREL reference period. The period selection has been considered the following aspects: (1) availability of land cover data that is transparent, accurate, complete and consistent, (2) reflects the general condition of the forest transition in Indonesia, and (3) the length of time that could reflect the national circumstances, policy dynamics and impacts (biophysical, social, economic growth, political and spatial planning), as well as associated carbon emission. The land cover maps during the period of 1990 - 2000 were produced only twice for epochal data from 1990 and 1996; for 2000 - 2009 were produced every 3 years, and since 2011 the maps were generated annually. So that emission calculation from deforestation, forest degradation and peat decomposition, were based on the periods of 1990 - 1996; 1996 - 2000; 2000 - 2003; 2003 - 2006; 2006 - 2009; 2009 - 2011 and 2011-2012.	26-27	http://ditjenppi.menlhk.go.id/kcpi/dokumen/national_frel_final%20revisi_10des.pdf	NATIONAL FOREST REFERENCE EMISSION LEVEL FOR DEFORESTATION AND FOREST DEGRADATION (In the Context of Decision 1/CP.16 para 70 UNFCCC)	Directorate General of Climate Change Ministry of Environment and Forestry Republic of Indonesia	2015

17	Reference Emission Calculation for National Level	Reference emission was calculated by using average annual emission from 1990 to 2012, i.e. from historical emission from deforestation and forest degradation. The advantage of this approach is the simplicity in capturing highly dynamic activities in the past. Historical emission from peat decomposition was calculated from the same base period as deforestation and forest degradation. Once deforestation or forest degradation occurs in particular peat land areas, GHGs will be emitted and calculated on annual basis, and continue to emit GHG subsequently as inherited emission. The emission was reported inaverage of the total period of calculation.	27	http://ditjenppi.menlhk.go.id/kcpi/dokumen/national_frel_final%20revisi_10des.pdf			
18	Emission Calculation (1990-2012) National Level	**Table Annex 5. Detail calculation on emission from deforestation forest degradation and the associated peat decomposition (1990-2012) National Level**	91-95	http://ditjenppi.menlhk.go.id/kcpi/dokumen/national_frel_final%20revisi_10des.pdf			
			Reporting and Verification				
19	REPORTING	Reporting REDD + is collecting and provising data and information related to the results of the calculation of the achievement of mitigation GHG emissions reduction actions under the REDD + mechanism.	32	http://ditjenppi.menlhk.go.id/reddplus/images/adminppi/dokumen/pedoman_mrv_redd.pdf			

20	VERIFICATION	REDD + verification is a verification activity carried out to ensure the higher truths conveyed by REDD + implementers (and / or sub-national (provincial) REDD + management institutions) are correct and adhere to the principles of transparency, accuracy, completeness, consistency and entertainment of calculation double (double counting). The verification process of REDD + activity reports is successful after the REDD + event is received by the Ministry of Environment and Forestry c. q. Directorate General of Climate Change Control from REDD + implementers or sub-national (provincial) REDD + management institutions through SRN.	35	http://ditjenppi.menlhk.go.id/reddplus/images/adminppi/dokumen/pedoman_mrv_redd.pdf			
21	LEAKAGE	Since the applicability conditions do not allow for changes in harvest levels, it can be conservatively assumed that leakage is zero because there is no difference in harvest levels between the baseline and project scenarios.	15	https://verra.org/wp-content/uploads/2018/03/VM0035-RIL-C-Methodology-v1.0.pdf	VM0035 Methodology for Improved Forest Management through Reduced Impact Logging (Version 1.0)	VCS	2016
22	Activity Shifting Leakage	There may be no leakage due to activity shifting. Where the project proponent controls multiple parcels of land within the country the project proponent must demonstrate that the management plans and/or land-use designations of other lands they control have not materially changed as a result of the planned project (designating new lands as timber concessions or increasing harvest rates in lands already managed	48	https://verra.org/methodology/vm0010-methodology-for-improved-forest-management-conversion-from-logged-to-protected-forest-v1-3/	VM0010 Methodology for Improved Forest Management: Conversion from Logged to Protected Forest. (Version 1.3)	VCS	2016

		for timber) because such changes could lead to reductions in carbon stocks or increases in GHG emissions. This must be demonstrated through: • Historical records showing trends in harvest volumes paired with records from the with- project time period showing no deviation from historical trends; • Forest management plans prepared ≥24 months prior to the start of the project showing harvest plans on all owned/managed lands paired with records from the with-project time period showing no deviation from management plans. At each verification, documentation must be provided covering the other lands controlled by the project proponent where leakage could occur, including, at a minimum, their location(s), area and type of existing land use(s), and management plans. Where activity shifting occurs or a project proponent is unable to provide the necessary documentation at first and subsequent verification, the project must not meet the requirements for verification. Therefore, the project must be subject to the conditions described in the VCS AFOLU Guidance Document on projects which fail to submit periodic verification after the commencement of the project. The project proponent may optionally choose to submit a methodology deviation with their future verifications to address activity shifting leakage.					

		Where the project proponent has control only over resource use in the project area and has no access to other forest resource, then the only type of leakage emissions calculated is GHG emissions due to market effects that result from project activity.					
23	Market Leakage	Leakage due to market effects is equal to the net emissions from planned timber harvest activities in the baseline scenario multiplied by an appropriate leakage factor : **(Equation 1)** $$GHG_{LK\|LtPF.t*} = LF_{ME} * GHG_{NET\|BS,t*L}$$ Where : $GHG_{LK\|LtPF.t*}$= Total market leakage as a result of IFM LtPF activities, in the year t* since the start of the project activity, tCO_2e; LF_{ME} = Leakage factor for market-effects calculations, dimentionless; $GHG_{NET\|BS,t*L}$ = Net greenhouse gas emissions in the baseline scenario in the year t* since the start of the project activity, tCO_2e. The leakage factor is thus defined as a dimensionless number with values between 0 and 1 assigned ex ante on the basis of a comparison between the ratio of merchantable biomass to total biomass across all strata in the base year, and the ratio of merchantable biomass to total biomass	49	https://verra.org/methodology/vm0010-methodology-for-improved-forest-management-conversion-from-logged-to-protected-forest-v1-3/			

		of the country's forest estate where harvesting would likely be displaced to.					
24	Leakage Factor Calculation	The leakage factor is determined by considering where in the country logging will be increased as a result of the decreased supply of the timber caused by the project. If the areas liable to be logged have a higher ratio of merchantable biomass to total biomass higher than the project area it is likely that the proportional leakage is higher and vice versa : Therefore, $$LF_{ME} = 0$$ if it can be demonstrated that no market-effects leakage will occur within national boundaries, that is if no new concessions are being assigned AND annual extracted volumes cannot be increased within existing national concessions AND illegal logging is absent (or de minimis) in the host country. The amount of leakage is determined by where in the country's forest estate harvesting would likely be displaced. Therefore, each project must calculate within each stratum the ratio of merchantable biomass to total	49-50	https://verra.org/methodology/vm0010-methodology-for-improved-forest-management-conversion-from-logged-to-protected-forest-v1-3/			

		biomass (PMPi). This shall then be compared to the ratio of merchantable biomass to total biomass for each forest type (PML_{FT}). The following deduction factors (LFME) shall be used : PML_{FT} is equal (± 15%) to PMP_i LF_{ME} = 0.4 PML_{FT} is > 15% less than PMP_i LF_{ME} = 0.7 PML_{FT} is > 15% greater than PMP_i LF_{ME} = 0.2 Where: PML_{FT} = merchantable biomass as a proportion of total aboveground tree biomass for each forest type, %; PMP_i = merchantable biomass as a proportion of total aboveground tree biomass for stratum i within the project boundaries, %; and LF_{ME} = Leakage factor for market-effects calculations; dimensionless. If the ratio of merchantable biomass to total biomass is higher in the project area, it is likely that additional logging will be performed in these areas as a result of reduced logging in the project area in the project scenario. Where sufficient variation exists in PMP_i relative to PML_{FT} that multiple values of LF_{ME} result, then an area weighted final value for LF_{ME} shall be calculated. The area of stratum i as a proportion of the total project area shall be multiplied by LFME.					

		All values are then summed to arrive at the area weighted final value of LF_{ME}.					
25	Activity Shifting Leakage	Activity-shifting leakage occurs when the actual agent of deforestation and/or forest or wetland degradation moves to an area outside of the project boundary and continues its deforestation or degradation activities elsewhere.	80	https://verra.org/wp-content/uploads/2018/03/VM0035-First-Assessment-Report-ESI.pdf	RIL-C IFM METHODOLOGY ELEMENT/RIL-C NORTH AND EAST KALIMANTAN PERFORMANCE METHOD MODULE FIRST ASSESSMENT REPORT	Environmental Services, Inc.	2015