

ANNEX 8.1: CALCULATION OF FOREST REFERENCE LEVEL

The details of data, steps and procedures followed in the calculation of the Forest Reference Level methodology are presented below. For transparency and to assist replication of the calculations, examples of the ER program data and calculations are presented below the respective equations.

The estimates are generated by running a Monte Carlo simulation, where values are sampled at random from the input probability distributions for each variable. Each set of samples is called an iteration, and the resulting outcome from that sample is recorded. The Monte Carlo simulation was run 40,000 times, and the result is a probability distribution of possible outcomes for the FRL. In this way, the Monte Carlo simulation provides a much more comprehensive view of the emissions estimate by estimating what the ERs will be with a confidence interval. As a result of the Monte Carlo simulations the 'final estimates' can be slightly different to the simple multiplication presented in Equations below. The resultant estimate from Equations become the inputs to the Monte Carlo simulation which runs through iterations until it lands on the most likely estimate with a confidence interval. This should be noted when attempting to replicate the numbers as they will vary, somewhat, from the simple linear multiplication of variables as the confidence interval around each individual variable influences the final result.

A8.3.1 Annual Average Gross Emissions

Sources and sub-sources of gross emissions considered in the FRL were:

1. Emissions from deforestation, $\hat{\phi}_{DF}$
2. Emissions from logging in Natural Forest (forest degradation), $\hat{\phi}_{FDem}$
3. Emissions from logging in soft- and hardwood plantations, $\hat{\phi}_{ECem}$
4. Emissions from fire within softwood plantations, $\hat{\phi}_{BSW}$

Gross emissions from all sources considered in the FRL were estimated by:

$$\hat{\phi}_{em} = \hat{\phi}_{DF} + \hat{\phi}_{FDem} + \hat{\phi}_{ECem} \quad (1)$$

Where;

$\hat{\phi}_{em}$ = average annual gross emissions; tCO₂e yr⁻¹

$\hat{\phi}_{DF}$ = average annual emissions from deforestation; tCO₂e yr⁻¹

$\hat{\phi}_{FDem}$ = average annual gross emissions from forest degradation; tC tCO₂e yr⁻¹

$\hat{\phi}_{ECem}$ = average annual gross emissions from enhancement of forest carbon stocks; tC tCO₂e yr⁻¹

A8.3.2 Annual Average Gross Removals

Gross removals linked to the different sinks/sub-sinks considered in the FRL were

1. Removals from growth after logging Natural Forest, $\hat{\phi}_{FDre}$
2. Removals from afforestation/reforestation (AR) and removals from growth in softwood and hardwood plantations, $\hat{\phi}_{ECre}$

Gross removals from all sinks considered in the FRL were estimated by:

$$\hat{\phi}_{re} = \hat{\phi}_{FDre} + \hat{\phi}_{ECre} \quad (2)$$

Where;

$\hat{\phi}_{re}$ = average annual gross removals; tCO₂e yr⁻¹

$\hat{\phi}_{FDre}$ = average annual gross removals from logging in Natural Forest; tCO₂e yr⁻¹

$\hat{\phi}_{ECre}$ = average annual gross removals from afforestation/reforestation and soft- and hardwood plantations; tCO₂e yr⁻¹

A8.3.3 Average Annual Net Emissions

Historical average annual net emissions over the Reference Period in the Accounting Area (i.e. the FRL) were estimated by:

$$\hat{\phi}_{FRL} = \hat{\phi}_{em} + \hat{\phi}_{re} \quad (3)$$

Where;

$\hat{\phi}_{FRL}$ = average annual net emissions over the Reference Period in the Accounting Area; tCO₂e yr⁻¹

$\hat{\phi}_{em}$ = average annual gross emissions; tCO₂e yr⁻¹

$\hat{\phi}_{re}$ = average annual gross removals; tCO₂e yr⁻¹

The average annual net emissions removals during the reference period were estimated to be:

Forest Reference Emission Level	Emission / Removal (tCO ₂ e yr ⁻¹)	Lower Confidence Interval (tCO ₂ e yr ⁻¹)	Upper Confidence Interval (tCO ₂ e yr ⁻¹)
Deforestation	2,696,831	2,143,830	3,373,850
Forest Degradation	310,442	321,925	467,501
Enhancement of Carbon Stocks	-1,370,469	-960,855	-1,791,358
Net FRL	1,636,804	953,458	2,444,030

The equations used and associated activity data and emissions factors applied are outlined by REDD+ Activity in the sections below. Table 1 and Table 2 list the default and national specific variables used in the estimation of emissions and removals.

Table 2: Default variables and values applied in the FRL calculations

Default variable	Description	Value	Units	Source	Uncertainty
η_{CC}	ratio of the molecular weights of CO ₂ and C	$\frac{44}{12}$	tCO ₂ (C) ⁻¹	Default	Small source, not relevant; not included in the quantification of uncertainty.
$T = \{2006, 2016\}$	length of the FRL Reference Period	11	years	ER Program Design	Not relevant; not included in the quantification of uncertainty.

η_{CF}	Conversion factor for biomass to carbon	0.47	C (tB) ⁻¹	IPCC,2006, Vol. 4, Chap. 4, Tab. 4.3	Small source, not relevant; not included in the quantification of uncertainty.
R_{wl}	Root-to-shoot ratio for tropical rainforest	0.37	dimensionless	IPCC, 2006, Vol. 4; Chap. 4; Tab. 4.4	Sampled from a Triangular distribution with lower bound $a = R_{wl} - R_{wl} \times 0$. upper bound $b = R_{wl} + R_{wl} \times 0$. and mode $c = R_{wl}$
R_{dl}	Root-to-shoot ratio for tropical moist deciduous forest < 125 tB ha ⁻¹	0.20	dimensionless	IPCC, 2006, Vol. 4; Chap. 4; Tab. 4.4	Sampled from a Triangular distribution with lower bound $a = 0.09$, upper bound $b = 0.25$, mode $c = 0.20$; a , b and c were taken from IPCC [2006, Vol. 4, Chap. 4, Tab. 4.4].
R_{dlh}	Root-to-shoot ratio for tropical moist deciduous forest > 125 tB ha ⁻¹	0.24	dimensionless	IPCC, 2006, Vol. 4; Chap. 4; Tab. 4.4	Sampled from a Triangular distribution with lower bound $a = 0.22$, upper bound $b = 0.33$, mode $c = 0.24$; a , b and c were taken from IPCC [2006, Vol. 4, Chap. 4, Tab. 4.4].
R_u	shoot ratio for tropical mountain systems	0.27	dimensionless	IPCC, 2006, Vol. 4; Chap. 4; Tab. 4.4	Sampled from a Triangular distribution with lower bound $a = 0.269$, upper bound $b = 0.0.28$, mode $c = 0.27$; a , b and c were taken from IPCC [2006, Vol. 4, Chap. 4, Tab. 4.4].
$BCEF_{AR,I}$	biomass conversion and expansion factor for volume increments in humid tropical natural forests	1.1	tB (m ³) ⁻¹	IPCC [2006, Vol. 4, Chap.4, Tab. 4.5]; (growing stock level 21-40 m ³ ha ⁻¹)	Sampled from a triangular distribution with lower

					bound $a = BCEF_{AR,I} - B$ upper bound $a = BCEF_{AR,I} + B$ and mode $c = BCEF_{AR,I}$
$BCEF_{HW,R}$	biomass conversion and expansion factor for logging;	1.05	tB (m ³) ⁻¹	IPCC [2006, Vol. 4, Chap.4, Tab. 4.5]; (growing stock level >200 m ³ ha ⁻¹)	Sampled from a triangular distribution with lower bound $a = BCEF_{HW,R} - I$, upper bound $a = BCEF_{HW,R} + I$, and mode $c = BCEF_{HW,R}$
$BCEF_{HW,I}$	biomass conversion and expansion factor for increment taken from	1.1	tB (m ³) ⁻¹	IPCC, 2006, Vol.4, Chap. 4, Tab. 4.5; growing stock level 21-40 m ³ ha ⁻¹)	Sampled from a triangular distribution with lower bound $a = BCEF_{HW,I} - E$, upper bound $b = BCEF_{HW,I} + E$, mode $c = BCEF_{HW,I}$
COMF _i	Combustion factor – proportion of prefire fuel biomass consumed)	0.46	dimensionless	(IPCC 2006 Vol. 2, Table 2.6)	Sampled from a Triangular distribution with lower bound a and b were 50% and 150% of the mode c.
G _{g,CO2}		1580	g CO ₂ kg ⁻¹ Dry matter burnt	IPCC 2006 Vol. 4, chapter 2, Table 2.5)	Sampled from a normal distribution N(μ=G _{g,CO2} ; σ ² =902; see Table 2.5 in IPCC, 2006, Vol 4, Chap. 2, Tropical Forest).
G _{g,N2O}		0.2	g N ₂ O kg ⁻¹ Dry matter burnt	(IPCC 2006 Vol. 4, chapter 2, Table 2.5)	Sampled from a Triangular distribution with lower bound a and b were 50% and 150% of the mode c

G_{g,CH_4}		6.8	g CH ₄ kg ⁻¹ Dry matter burnt	IPCC 2006 Vol. 4, chapter 2, Table 2.5)	Sampled from a Triangular distribution with lower bound a and b were 50% and 150% of the mode c
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Table 8.2: Variables with Fiji specific values

Variables with Fiji specific values	Description	Value	Units	Source	Uncertainty
C_{AFTER}	C stock in biomass due to the conversion of Natural Forest to grassland	17.11	tC ha ⁻¹	Rounds [2013]	Lower CI[8.31] Upper CI[25.96]
$C_{BEFORE, Lowland}$	Estimated C stocks stored in AGB and BGB in Lowland Natural Forest	87.86	tC ha ⁻¹	Appendix A2 - Fiji FRL Report, 2018	Lower CI[84.25] Upper CI[93.21]
$C_{BEFORE, Upland}$	Estimated C stocks stored in AGB and BGB in Upland Natural Forest	71.57	tC ha ⁻¹	Appendix A2 - Fiji FRL Report, 2018	Lower CI[66.45] Upper CI[78.58]
EM_{FELL}	carbon loss from the extracted logs, including logging residues	0.69	tC (m ³) ⁻¹	Haas [2015]	Assessed in uncertainty emission factor TEF.
EM_{DAM}	damage to the remaining stand (all killed [snapped and up-rooted] trees 10 cm DBH), crown damage	0.15	tC (m ³) ⁻¹	Haas [2015]	Assessed in uncertainty emission factor TEF.
EM_{INFR}	infrastructure development (all trees 10 cm DBH on logging roads, skid trails and log landings)	0.21	tC (m ³) ⁻¹	Haas [2015]	Assessed in uncertainty emission factor TEF.
δ_{tm}	the length of time interval available for growth on areas conventionally logged in year t	{10,9,..., $\delta_{tm},...1$ }	yrs	Based on Fiji's Reference Period	None

$MAIV_{AR}$	mean annual volume increment for afforestation/reforestation	3.71	$m^3 ha^{-1} yr^{-1}$	Derived from data provided from Fiji Hardwood Corporation Limited	Sampled from a Triangular distribution with lower bound $a = MAIV_{AR} - MAIV_{HW}$, upper bound $b = MAIV_{AR} + MAIV_{HW}$ and mode $c = MAIV_{AR}$
$MAIC_{FD}$	mean annual C increment after logging (above ground and belowground)	0.99	$tC ha^{-1} yr^{-1}$	Personal communication	Triangular distribution with lower bound $a = MAIC_{FD} - MAIC_{SW}$, upper bound $b = MAIC_{FD} + MAIC_{SW}$, mode $c = MAIC_{FD}$
λ_{Pine}	Softwood plantation recovery rate following harvest	0.76	Ratio dimensionless	Waterloo [1994]	Drawn from a Normal distribution with $\mu = \lambda_{Pine}$ and $\sigma^2 = [\lambda_{Pine} \times 0.1]^2$
ρ_{Pine}	Pine tree wood density	0.47	$g cm^{-1}$	Cown [1981]	Drawn from a Normal distribution with $\mu = \rho_{Pine}$ and $\sigma^2 = 0.0031$
$MAIB_{SW}$	mean annual increment of above and belowground biomass in softwood plantations	10	$tB ha^{-1} yr^{-1}$	Waterloo [1994]	Triangular distribution with lower bound $a = MAIB_{SW} - MAIB_{HW}$, upper bound $b = MAIB_{SW} + MAIB_{HW}$, mode $c = MAIB_{SW}$
CC_{SW}	length of the harvest cycle in softwood plantations	20	yrs	Personal communication Fiji Pine Limited (FPL) indicated that most pine plantations are harvested around 20 years ranging between 15 to 25 years.	Sampled from a Triangular distribution with lower bound $a = CC_{SW} - 5$, upper bound $b = CC_{SW} + 5$, mode $c = CC_{SW}$
$\overline{MAIV}_{HW}$	Average mean annual increment in Fiji hardwood plantations	5.85	$m^3 ha^{-1} yr^{-1}$	derived from data provided from Fiji Hardwood Corporation Limited	Sampled from a Triangular distribution with lower bound $a = \overline{MAIV}_{HW} - MAIV_{HW}$, upper bound $b =$

					$\overline{MAIV}_{HW} - \overline{MAIV}_{HW}$, mode $c = \overline{MAIV}_{HW}$
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A8.3.2 Deforestation

Activity Data

The area of deforestation over the Reference Period is generated from an annual time series of forest loss (refer to Annex 8.2 for details of how the data is generated).

The average annual forest area loss [ha] in stratum i (i.e., Low-and Upland Natural Forest) over the FRL Reference Period was calculated as follows

$$\hat{A}_{DF,i} = \mathcal{T}^{-1} \left(\frac{1}{2} \hat{A}_{DF,2005-2006,i} + \left[\sum_{T_m} \hat{A}_{DF,t_m,i} \right] + \frac{1}{2} \hat{A}_{DF,2016-2017,i} \right) \quad (4)$$

Where;

- $\hat{A}_{DF,i}$ = Average annual area of deforestation in stratum i ; ha yr⁻¹
- $\mathcal{T}$ = Length of the FRL Reference Period $|T| = \mathcal{T} = 11$, where $T = \{2006, 2007, \dots, t, \dots, 2016\}$; yrs
- $\hat{A}_{DF,2005-2006,i}$ = Forest area loss during the interval 2005-2006 in stratum i ; ha
- $\hat{A}_{DF,t_m,i}$ = Forest area loss during the interval t_m in stratum i , where $T_m = \{2006 - 2007, 2007 - 2008, \dots, t_m, \dots, 2015 - 2016\}$; ha
- $\hat{A}_{DF,2016-2017,i}$ = Forest area loss during the interval 2016-2017 in stratum i ; ha

The annual average area of deforestation was found to be:

Annual Average Deforestation	Estimate [ha]	Lower Confidence Interval [ha]	Upper Confidence Interval [ha]
Lowland	8,332	5,531	8,437
Upland	2,682	1,627	2,889

Description of the variable including the time period covered:	$\hat{A}_{DF,Lowland}$ = average annual forest area losses in hectares in the strata Lowland Natural Forest
Explanation for which sources or sinks the variable is used:	This activity data is used on the estimation of emissions from deforestation.
Data unit:	Ha
Value:	8,332
Source of data:	Management Services Division of the Ministry of Forestry
Spatial level:	Sub-National; this data represents forest cover loss in Lowland Natural Forest within the Fijian islands of Viti Levu, Vanua Levu and Taveuni, covering approximately 90% of the land area of the Fijian islands.
Discussion of key uncertainties for this variable:	The key sources of uncertainty relate to errors of omission and commission in the image classification process.

Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	The data are predicted values generated from semi-automated processing of Landsat imagery. The accuracy assessment following the methods of Olofsson et al 2014 is applied to developed error adjusted areas and confidence intervals which are then incorporated into the Monte Carlo simulation. Lower CI[ha] 5,531 Upper CI[ha] 8,437
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Description of the variable including the time period covered:	$\hat{A}_{DF,Upland}$ = average annual forest area losses in hectares in the strata Upland Natural Forest
Explanation for which sources or sinks the variable is used:	This activity data is used on the estimation of emissions from deforestation.
Data unit:	Ha
Value for the variable:	2,682
Source of data:	Management Services Division of the Ministry of Forestry
Spatial level:	Sub-National; this data represents forest cover loss in Lowland Natural Forest within the Fijian islands of Viti Levu, Vanua Levu and Taveuni, covering approximately 90% of the land area of the Fijian islands.
Discussion of key uncertainties for this variable:	The key sources of uncertainty relate to classification errors in the image classification process.
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	The data are predicted values generated from semi-automated processing of Landsat imagery. The accuracy assessment following the methods of Olofsson et al 2014 is applied to developed error adjusted areas and confidence intervals which are then incorporated into the Monte Carlo simulation. Lower CI[ha] 1,627 Upper CI[ha] 2,889

Emissions Factors

Emissions from deforestation were estimated by multiplying the average annual forest area loss by the amount of emissions that are released if one hectare of forest is lost. Emission factors for the source 'deforestation' were estimated from the difference between average C stocks in Lowland Upland Natural Forest [tC ha^{-1}] and the average C stocks in grassland [tC ha^{-1}]. The IPCC default equation was used to compute the C stock change [IPCC;2006, Vol. 4, Chap. 2, Eq. 2.16].

$$\Delta C_{B,i} = \Delta C_G + \Delta C_{CONVERSION,i} + \Delta C_L \quad (5)$$

where;

$\Delta C_{B,i}$ = change in carbon stocks in biomass in Natural Forest stratum I converted to Non-Forest; tC ha^{-1}

ΔC_G = annual increase in carbon stocks in biomass due to growth in Non-Forest; $\text{tC ha}^{-1} \text{ yr}^{-1}$

ΔC_L = annual decrease in carbon stocks in biomass due to disturbances in Non-Forest; $\text{tC ha}^{-1} \text{ yr}^{-1}$

And

$$\Delta C_{CONVERSION,i} = C_{AFTER} - C_{BEFORE_i} \quad (6)$$

$\Delta C_{CONVERSION,i}$ = initial change in carbon stocks in biomass in Natural Forest stratum i converted to Non-Forest; tC ha^{-1}

C_{AFTER} = carbon stocks in biomass in Non-Forest; tC ha⁻¹

C_{BEFORE_i} = carbon stocks in biomass in Natural Forest stratum i ; tC ha⁻¹

ΔC_G and ΔC_L are assumed to be zero; the change in C stock in biomass due to the conversion of Natural Forest to grassland is captured in $\Delta C_{CONVERSION,i}$, hence $\Delta C_{B,i} = \Delta C_{CONVERSION,i}$.

C_{AFTER} is the peak C stock in grassland as estimated by Rounds [2013] to be 17.11 ± 10.81 tC ha⁻¹.

A description of the data and methods used to estimate C_{BEFORE_i} is provided in University of Hamburg (2018). The carbon stock change due to deforestation was computed by:

$$\Delta C_{B,Lowland} = C_{AFTER} - C_{BEFORE,Lowland} \quad (7)$$

$$- 70.74 = 17.11 - 87.85 \quad (\text{Example})$$

$$\Delta C_{B,Upland} = C_{AFTER} - C_{BEFORE,Upland} \quad (8)$$

$$- 54.45 = 17.11 - 71.56 \quad (\text{Example})$$

Where;

$\Delta C_{B,Lowland}$ = change in C stock in biomass in Lowland Natural Forest due to deforestation; tC ha⁻¹

$\Delta C_{B,Upland}$ = change in C stock in biomass in Upland Natural Forest due to deforestation; tC ha⁻¹

C_{AFTER} = average carbon stock in grasslands in Fiji (Rounds, 2013); tC ha⁻¹

$C_{BEFORE,Lowland}$ = average carbon stock in Lowland Natural Forest in Fiji; tC ha⁻¹

$C_{BEFORE,Upland}$ = average carbon stock in Upland Natural Forest in Fiji; tC ha⁻¹

Carbon losses from deforestation are converted to emission factors by:

$$\Psi_{DF,Lowland} = \Delta C_{B,Lowland} \times n_{cc} \quad (9)$$

$$- 259.38 = - 70.74 \times \left(\frac{44}{12}\right) \quad (\text{Example})$$

Where;

$\Psi_{DF,Lowland}$ = emission factor for deforestation in Lowland Natural Forest, tCO₂e ha⁻¹

$\Delta C_{B,Lowland}$ = change in carbon stock in biomass in Lowland Natural Forest due to deforestation; tC ha⁻¹

n_{cc} = ratio of molecular weights of CO₂ and carbon; tCO₂e (tC⁻¹)

$$\Psi_{DF,Upland} = \Delta C_{B,Upland} \times n_{cc} \quad (10)$$

$$- 199.65 = - 54.45 \times \left(\frac{44}{12}\right) \quad (\text{Example})$$

Where;

$\Psi_{DF,Upland}$ = emission factor for deforestation in Upland Natural Forest, tCO₂e ha⁻¹

$\Delta C_{B,Upland}$ = change in carbon stock in biomass Upland Natural Forest due to deforestation; tC ha⁻¹

n_{cc} = ratio of molecular weights of CO₂ and carbon; tCO₂e (tC⁻¹)

Description of the variable including the forest class if applicable:	$\Psi_{DF,Lowland}$ - emission factor for deforestation in Lowland Natural Forest
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Data unit:	tCO ₂ e ha ⁻¹
Value for the variable:	- 259.40
Source of data or description of the assumptions, methods and results of any underlying studies that have been used to determine the variable:	This emissions factor has been calculated from National Forest Inventory Data and National specific studies on Grassland carbon stocks. For a detailed description of the data used and method adopted to estimate this emissions factor see Fiji's Forest Reference Level (University of Hamburg, 2018).
Spatial level:	Nationally relevant emission factor for the conversion of Lowland forest to Grassland.
Discussion of key uncertainties for this variable:	The key uncertainties associated with this emission factor considered in the Monte Carlo simulations relate to: 1. Measurement error (uncertainty in measurements of the DBH of trees); 2. Uncertainties in wood density estimates; 3. Modelling uncertainty (PSP height model and Chave et al.'s [2014] AGB model); 4. Uncertainty in root-to-shoot ratios (IPCC [2006] default values);
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	Lower CI[tCO ₂ e ha ⁻¹] – 226.49 Upper CI[tCO ₂ e ha ⁻¹] – 298.23

Description of the variable including the forest class if applicable:	$\Psi_{DF,Upland}$ - emission factor for deforestation in Lowland Natural Forest
Data unit:	tCO ₂ e ha ⁻¹
Value for the variable:	- 199.68
Source of data or description of the assumptions, methods and results of any underlying studies that have been used to determine the variable:	This emissions factor has been calculated from National Forest Inventory Data and National specific studies on Grassland carbon stocks. For a detailed description of the data used and method adopted to estimate this emissions factor see Fiji's Forest Reference Level (University of Hamburg, 2018).
Spatial level:	Nationally relevant emission factor for the conversion of Lowland forest to Grassland.
Discussion of key uncertainties for this variable:	The key uncertainties associated with this emission factor considered in the Monte Carlo simulations relate to: 1. Measurement error (uncertainty in measurements of the DBH of trees); 2. Uncertainties in wood density estimates; 3. Modelling uncertainty (PSP height model and Chave et al.'s [2014] AGB model); 4. Uncertainty in root-to-shoot ratios (IPCC [2006] default values);
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	Lower CI[tCO ₂ e ha ⁻¹] – 163.00 Upper CI[tCO ₂ e ha ⁻¹] – 241.45

Average annual emissions from deforestation

Average annual emissions from deforestation are first estimated separately by strata using Monte Carlo:

$$\hat{\phi}_{DF,Lowland} = \hat{A}_{DF,Lowland} \times \Psi_{DF,Lowland} \quad (11)$$

$$\hat{\phi}_{DF,Lowland} = 7,914 \times - 259.40 \quad (\text{Example})^1$$

Where;

$\hat{\phi}_{DF,Lowland}$ = average annual emissions from deforestation of Lowland Natural Forest; tCO₂e yr⁻¹

$\hat{A}_{DF,Lowland}$ = average annual loss of Lowland Natural Forest area; ha yr⁻¹

$\Psi_{DF,Lowland}$ = emissions factor for deforestation in Lowland Natural Forest, tCO₂e ha⁻¹

And

$$\hat{\phi}_{DF,Upland} = \hat{A}_{DF,Upland} \times \Psi_{DF,Upland} \quad (12)$$

$$\hat{\phi}_{DF,Upland} = 2,112 \times - 199.68 \quad (\text{Example})$$

Where;

$\hat{\phi}_{DF,Upland}$ = average annual emissions from deforestation of Upland Natural Forest; tCO₂e yr⁻¹

$\hat{A}_{DF,Upland}$ = average annual loss of Upland Natural Forest area; ha yr⁻¹

$\Psi_{DF,Upland}$ = emissions factor for deforestation in Upland Natural Forest, tCO₂e ha⁻¹

Then total average annual emissions from deforestation (Low- and Upland Natural Forest) were estimated by:

$$\hat{\phi}_{DF} = \hat{\phi}_{DF,Lowland} + \hat{\phi}_{DF,Upland} \quad (13)$$

Where;

$\hat{\phi}_{DF}$ = average annual emissions from deforestation; tCO₂e yr⁻¹

$\hat{\phi}_{DF,Upland}$ = average annual emissions from deforestation of Upland Natural Forest; tCO₂e yr⁻¹

$\hat{\phi}_{DF,Lowland}$ = average annual emissions from deforestation of Lowland Natural Forest; tCO₂e yr⁻¹

The average annual emission from deforestation were estimated to be:

Emissions from Deforestation	Emission (tCO ₂ e yr ⁻¹)	Lower Confidence Interval (tCO ₂ e yr ⁻¹)	Upper Confidence Interval (tCO ₂ e yr ⁻¹)
Lowland	2,161,364	1,667,836	2,763,108
Upland	535,466	371,765	739,937
Total	2,696,831	2,143,830	3,373,850

¹ Note because the emissions are estimated using a Monte Carlo approach the final annual average emissions vary (slightly) from the linear calculation presented by virtue of the iterative process undertaken to estimate the most likely value.

A8.3.3 Forest Degradation

Emissions from degradation are estimated as the combination of the net emissions/removals from logging in Natural Forests and the emissions from Fire in Pine Plantations.

A8.3.3.1 Emissions from Logging of Natural Forests

Emissions related to logging practices in natural forest were estimated using the approach proposed by Pearson et al. (2014) which converts volumes extracted during logging operations to total carbon loss including loss from the felled tree itself (AGB and BGB), logging residues of the felled tree, logging damages to the remaining stand (AGB and BGB), and losses due to the establishment of logging infrastructure (e.g., skid trails, logging roads and log landings).

Gross emissions from forest degradation were estimated using the IPCC generic equation (Equation 8.1 above) where the volumes recorded in the Timber Revenue systems served as Activity Data and the Total Emission Factor (TEF) (multiplied by n_{cc}) served as the Emissions Factor.

Average annual gross emissions

Annual carbon loss due to logging in Natural Forest was estimated by:

$$\Delta C_{FD,L,t} = [V_{FD,t} \times TEF] \times (-1) \quad (14)$$

$$-83,454_{FD,L,2006} = [79,480_{FD,2006} \times 1.05] \times (-1) \quad (\text{Example})$$

Year	V_{FD}	$\Delta C_{FD,L,t}$
2006	79,480	-83,454
2007	45,122	-47,378
2008	81,706	-85,791
2009	59,614	-62,595
2010	49,814	-52,305
2011	36,499	-38,324
2012	30,517	-32,043
2013	26,947	-28,294
2014	46,431	-48,752
2015	51,091	-53,645
2016	50,825	-53,366
Sum	478,566	-502,494

Where;

$\Delta C_{FD,L,t}$ = carbon loss in year t due to logging in Natural Forest; tC

$V_{FD,t}$ = wood volume extracted from Natural Forest in year t ; m³

TEF = total emission factor, $TEF = 1.05$ (Haas, 2015); tC (m³)⁻¹

The multiplication of the brackets by -1 is required because carbon losses are always reported with a negative sign.

Average annual gross emissions from forest degradation were estimated by:

$$\hat{\phi}_{FDem} = T^{-1} \left[\sum_T \Delta C_{FD,L,t} \times n_{cc} \right] \quad (15)$$

$$- 168,498 = 11^{-1} \left[- 502,494 \times \left(\frac{44}{12} \right) \right] \quad (\text{Example})$$

Where;

$\hat{\phi}_{FDem}$ = average annual gross emissions from forest degradation; tCO₂e yr⁻¹

T = length of the Reference Period |T| = 11; yrs

$\Delta C_{FD,L,t}$ = carbon loss in year *t* due to logging in Natural Forest; tC

n_{cc} = ratio of molecular weights of CO₂ and carbon; tCO₂e (tC⁻¹)

Average annual gross removals

Removals are computed based on data of areas logged and mean annual increment (MAI) in logged forests in year *t* is estimated by:

$$\Delta C_{FD,G,t} = \delta_t \times A_{FD,t} \times MAIC_{FD} \quad (16)$$

$$1,739_{FD,G,2006} = (0.5)_{2006} \times 3,513_{FD,2006} \times 0.99 \quad (\text{Example})$$

Where;

$\Delta C_{FD,G,t}$ = carbon gains over the Reference Period on areas logged in year *t*; tC

$\delta_t = 2006 - t + 0.5$, i.e. the length of time interval available for growth on areas conventionally logged in year *t*; yrs

$MAIC_{FD}$ = mean annual C increment after logging (above ground and belowground); tC ha⁻¹ yr⁻¹

$A_{FD,t}$ = the area logged in Natural Forest in year *t*; ha

Average annual gross removals on Natural forest areas conventionally logged were estimated by:

$$\hat{\phi}_{FDre} = T^{-1} \left[\sum_T \delta_t \times MAIC_{FD} \times A_{FD,t} \times n_{cc} \right] \times (-1) \quad (17)$$

$$= T^{-1} \left[\sum_T \Delta C_{FD,G,t} \times n_{cc} \right] \times (-1) \quad (18)$$

Where;

$\hat{\phi}_{FDre}$ = average annual gross removals on Natural Forest areas conventionally logged; tCO₂e yr⁻¹

T, T, *t* = length of the Reference Period. i.e. 11 years; yrs

$\delta_t = 2006 - t + 0.5$, i.e. length of time interval available for growth on conventionally logged area in year *t*; yrs

$MAIC_{FD}$ = mean annual carbon increment after logging (AGC and BGC); i.e.

$A_{FD,t}$ = the area logged in Natural Forest in year *t*; ha

n_{cc} = ratio of molecular weights of CO₂ and carbon; tCO₂e (tC⁻¹)

The emissions from Logging in Natural Forest were estimated to be:

Emissions/Removals from Forest Degradation (Logging)	Estimate (tCO ₂ e yr ⁻¹)	Lower Confidence Interval (tCO ₂ e yr ⁻¹)	Upper Confidence Interval (tCO ₂ e yr ⁻¹)
Emissions	195,316	167,487	223,343
Removals	-42,362	-57,222	-27,794
Net Total	152,955	121,701	184,309

Activity Data

Description of the variable including the time period covered:	$V_{FD,t}$ = wood volume extracted from Natural Forest in year t ;																								
Explanation for which sources or sinks the variable is used:	This variable is used in the estimation of emissions from Forest Degradation from the long-term loss of carbon stocks in Natural Forests in Fiji's a result of commercial harvest activities.																								
Data unit:	m ³																								
Value for the variable:	<table> <tr> <th>Year</th><th>V_{FD} (m³)</th></tr> <tr><td>2006</td><td>79,480</td></tr> <tr><td>2007</td><td>45,122</td></tr> <tr><td>2008</td><td>81,706</td></tr> <tr><td>2009</td><td>59,614</td></tr> <tr><td>2010</td><td>49,814</td></tr> <tr><td>2011</td><td>36,499</td></tr> <tr><td>2012</td><td>30,517</td></tr> <tr><td>2013</td><td>26,947</td></tr> <tr><td>2014</td><td>46,431</td></tr> <tr><td>2015</td><td>51,091</td></tr> <tr><td>2016</td><td>50,825</td></tr> </table>	Year	V_{FD} (m ³)	2006	79,480	2007	45,122	2008	81,706	2009	59,614	2010	49,814	2011	36,499	2012	30,517	2013	26,947	2014	46,431	2015	51,091	2016	50,825
Year	V_{FD} (m ³)																								
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2011	36,499																								
2012	30,517																								
2013	26,947																								
2014	46,431																								
2015	51,091																								
2016	50,825																								
Source of data:	Volume data were extracted from Fiji's Timber Revenue System (TRS).																								
Spatial level:	Sub-National; this data represents volume extracted within the Fijian islands of Viti Levu, Vanua Levu and Taveuni. The land area of these three islands makes up approximately 90% of the land area of the Fijian islands.																								
Discussion of key uncertainties for this variable:	The main sources of uncertainty related to the volume relate to systematic and random errors associated with field assessment of extracted volume by the staff (i.e. log-scalers) from the Division of Forest Offices (DFOs).																								
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	Once a licence is issued and the logger has hauled the timber to the log-landings, log-scalers from the Division Forest Offices (DFOs) assess the amount of timber extracted and enter the data into the Timber Revenue System (TRS) database to determine the amount of royalty fees the logger has to transfer to the MoF. As the accuracy of the data is linked to royalties there is confidence in these figures. The uncertainty is considered to be zero.																								

Description of the variable including the time period covered:	$A_{FD,t}$ = area of natural forest logged each year																								
Explanation for which sources or sinks the variable is used:	This variable is used in the estimation of emissions from Forest Degradation from the long-term loss of carbon stocks in Natural Forests in Fiji's a result of commercial harvest activities.																								
Data unit:	Ha																								
Value for the variable:	<table> <tr> <th>Year</th><th>$A_{FD,t}$ (ha)</th></tr> <tr><td>2006</td><td>3,513</td></tr> <tr><td>2007</td><td>2,545.57</td></tr> <tr><td>2008</td><td>3,258.55</td></tr> <tr><td>2009</td><td>1,165.19</td></tr> <tr><td>2010</td><td>1,641.17</td></tr> <tr><td>2011</td><td>905.43</td></tr> <tr><td>2012</td><td>795.66</td></tr> <tr><td>2013</td><td>1,354.02</td></tr> <tr><td>2014</td><td>1,427.76</td></tr> <tr><td>2015</td><td>1,738.04</td></tr> <tr><td>2016</td><td>1,438.37</td></tr> </table>	Year	$A_{FD,t}$ (ha)	2006	3,513	2007	2,545.57	2008	3,258.55	2009	1,165.19	2010	1,641.17	2011	905.43	2012	795.66	2013	1,354.02	2014	1,427.76	2015	1,738.04	2016	1,438.37
Year	$A_{FD,t}$ (ha)																								
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2013	1,354.02																								
2014	1,427.76																								
2015	1,738.04																								
2016	1,438.37																								
Source of data:	Annual data on the areas harvested between 2006 and 2016 were taken from digital logging maps provided by logging companies.																								
Spatial level:	Sub-National; this data represents area of natural forest logged within the Fijian islands of Viti Levu, Vanua Levu and Taveuni. The land area of these three islands makes up approximately 90% of the land area of the Fijian islands.																								
Discussion of key uncertainties for this variable:	These maps were edited by staff from the Management Service Division (MSD). Editing was necessary if the logger provided paper maps, the area of the proposed logging compartment did not match the data collected by MSD/DFO staff during field checks, or the digital maps were poorly edited.																								
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	Small source, highly relevant; included in the quantification of uncertainty. Confidence in the data collected by Ministry staff, however systematic and random errors can occur in mapping of areas. QA/QC checks have found evidence of errors which are considered small. In the Monte Carlo simulation this values is sampled from a triangular distribution with lower bound $a = A_{FD,t} - A_{FD,t} \times 0.25$; upper bound $a = A_{FD,t} + A_{FD,t} \times 0.25$, mode $c = A_{FD,t}$.																								

Emissions Factors

Description of the variable including the forest class if applicable:	TEF - conversion factor for timber volumes extracted to total carbon loss
Data unit:	tC (m ³) ⁻¹
Value for the variable:	1.05

Source of data or description of the assumptions, methods and results of any underlying studies that have been used to determine the variable:	Haas, M., 2015. Carbon Emissions from Forest Degradation caused by Selective Logging in Fiji. Regional project Climate Protection through Forest Conservation in Pacific Island Countries, GIZ, SPC. The TEF derived for Fiji is estimated by: $TEF = EM_{FELL} + EM_{DAM} + EM_{INFR}$ Where; TEF = conversion factor for timber volumes extracted to total carbon loss; tC (m³)⁻¹ EM_{FELL} = carbon loss from the extracted logs, including logging residues; tC (m³)⁻¹ EM_{DAM} = damage to the remaining stand (all killed [snapped and up-rooted] trees 10 cm DBH), crown damage; tC (m³)⁻¹ EM_{INFR} = infrastructure development (all trees _ 10 cm DBH on logging roads, skid trails and log landings), tC (m³)⁻¹ AND EM_{FELL} = 0:69 includes: (i) C loss from the logs and (ii) C loss from timber waste from the felled trees (crown-, bole-, stump-, and below-ground biomass), EM_{DAM} = 0:15 includes: (i) C loss from killed (uprooted and snapped) trees _ 10 cm DBH (AGB and BGB) and (ii) C loss from sever crown damage, EM_{INFR} = 0:21 includes: (i) C loss from clearings of all trees _ 10 cm DBH (AGB and BGB) for logging road construction, (ii) C loss from clearings of all trees _ 10 cm DBH for skid trail construction, and (iii) C loss from all trees _ 10 cm for the construction of log-landings.
Spatial level:	The TEF was derived from data collected at the REDD+ pilot site at Nakavu.
Discussion of key uncertainties for this variable:	The key uncertainties associated with this emission factor considered in the Monte Carlo simulations relate to: 1. Measurement error; 2. Small sample size
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	Large source of uncertainty, highly relevant; included in the quantification of uncertainty.
Description of the variable including the forest class if applicable:	$MAIC_{FD}$ = mean annual C increment after logging (above ground and belowground);
Data unit:	tC ha ⁻¹ yr ⁻¹
Value for the variable:	0.99

Source of data or description of the assumptions, methods and results of any underlying studies that have been used to determine the variable:	(Mussong; personal communication; unpublished data). These data are the only data on carbon growth in logged Natural Forest currently available in Fiji. This value the best (and only) estimate of mean annual carbon increment in natural forest available in Fiji. When compared to default values listed in the IPCC 2006, Table 3A.1.5 suggests that natural regeneration after logging in Asia & Oceania / Insular for Wet to Moist Tropical forest for >20 years ranges from 2.0 - 3.4 t d.m. ha ⁻¹ yr ⁻¹ which is equivalent to between 1 – 1.7 t C ha ⁻¹ yr ⁻¹ . The national figure is comparable and more conservative than applying the default value.
Spatial level:	Data on net C stock gains after logging in Natural Forest have not yet been assessed nationally in Fiji. For the FRL, these data were taken from the REDD+ pilot site at Nakavu. The estimated net carbon gain (AGB and BGB) REDD+ pilot site at Nakavu but considered applicable to Fijian natural forest.
Discussion of key uncertainties for this variable:	The key uncertainties associated with this emission factor considered in the Monte Carlo simulations relate to: 1. Measurement error 2. Small sample size
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	Large source, highly relevant; included in the quantification of uncertainty.

A8.3.3.2 Emissions from Fire

Data from Fiji Pine Limited (FPL) were used to estimate emissions from fire in Softwood Plantations. The dataset provided by FPL lists plantation compartments (coupes) that burned between 2015 and 2018. For each compartment the following attributes were provided: the year of burning (year), the area burnt in hectares (ha), and the age in years (yrs) of each compartment, i.e., the time elapsed since planting. Where compartments listed in the FPL dataset had an area of zero, these compartments were dropped from the dataset.

The greenhouse gases (GHGs) included in the estimation of emissions are: carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O). To estimate GHG emissions, the biomass available for combustion in a compartment was estimated first. It is assumed that the entire above-ground biomass (AGB) is available for combustion. AGB in a compartment that burnt in year t_b , with $T_b = \{2015; \dots; t_b; \dots; 2018\}$, was predicted as follows (note that this is the amount of AGB that is available for combustion — it is not to be confused with the AGB that actually burns during a fire).

$$AGB_{l,t_b} = \Lambda_{l,t_b} \times \frac{MAIB_{SW}}{(1 + R_{dll})} \quad (20)$$

Where;

Λ_{l,t_b} = the age of a compartment that burnt in year t_b , $L = \{1; 2; \dots; l; \dots; L\}$

L = the total number of compartments \

$MAIB_{SW}$ = the mean annual total biomass (above-and below-ground biomass) increment [tB ha⁻¹ yr⁻¹]

R_{dll} = root-to-shoot ratio in tropical moist deciduous forest < 125 tAGB ha.

If AGB burns some amount of below-ground biomass (BGB) is also lost, e.g., if the stem and crown of a tree is lost, the BGB of the tree is, in the majority of cases, also lost. It is assumed that only CO₂ is released from the BGB (since it does not burn, or at least only a small fraction of it burns). The amount of BGB available for combustion was predicted as follows:

$$BGB_{l,t_b} = \Lambda_{l,t} \times MAIB_{SW} \times R_{dll}. \quad (21)$$

CO₂ emissions from AGB in compartment that burnt in year *tb* was estimated as follows (cf. IPCC [2006, Vol. 4, Chap. 2, Eq. 2.27])

$$E_{ACO2_{l,t_b}} = A_{l,t_b} \times AGB_{l,t} \times C_f \times G_{ef,CO_2} \quad (22)$$

Where;

A_{l,t_b} = the area burnt [ha] in compartment *l* at time *t_b*,

C_f = the combustion factor, i.e., the proportion of prefire biomass consumed (the value was taken from IPCC 2006, Vol. 4, Chap. 2, Tab. 2.6, young secondary tropical forest (3-5) year)

G_{ef,CO_2} = the emission factor [g kg⁻¹] taken from IPCC [2006, Vol. 4, Chap. 2, Tab. 2.5, Tropical forest].

CO₂ emissions from BGB were estimated by:

$$E_{BCO2_{l,t_b}} = A_{l,t_b} \times BGB_{l,t_b} \times C_f \times \eta_{CF} \times [\eta_{CC} \times -1] \quad (23)$$

Where;

$n_{CF} = 0.47$ and $n_{CC} = 44/12$ are the conversion factors of biomass to carbon and carbon to carbon dioxide equivalents, respectively.

Methane (CH₄) emissions were estimated as follows:

$$E_{CH4_{l,t_b}} = A_{l,t_b} \times AGB_{l,t_b} \times C_f \times G_{ef,CH_4} \times GWP_{CH_4} \quad (24)$$

Where:

G_{ef,CH_4} = the emission factor for CH₄

GWP_{CH_4} = the global warming potential of CH₄, taken from IPCC [2014, Box 3.2, Tab. 1].

Nitrous oxide (N₂O) emissions in compartment *l* that burnt in year *t_b* were estimated by

$$E_{N2O_{l,t_b}} = A_{l,t_b} \times AGB_{l,t_b} \times C_f \times G_{ef,N_2O} \times GWP_{N_2O}. \quad (25)$$

Where:

G_{ef,N_2O} = the emission factor for N₂O

GWP_{N_2O} = the global warming potential of N₂O, taken from IPCC [2014, Box 3.2, Tab. 1].

Total GHG emissions from compartment l were computed by:

$$E_{l,t_b} = E_{ACO2_{l,t_b}} + E_{BCO2_{l,t_b}} + E_{CH4_{l,t_b}} + E_{N2O_{l,t_b}} \quad (26)$$

The sum of GHG emissions from individual compartments was computed for each year:

$$E_{t_b} = \sum_L E_{l,t_b} \quad (27)$$

The average of E_{t_b} was used as an estimate of the average annual GHG emissions from biomass burning in Softwood Plantations [$tCO_2e \text{ yr}^{-1}$] over the Reference Period.

$$\hat{\theta}_{BSW} = \frac{\sum_{T_b} E_{t_b}}{|T_b|} = \frac{\sum_{T_b} E_{t_b}}{4} \quad (28)$$

The emissions from Fire were estimated to be:

Emissions/Removals from Forest Degradation (Fire)	Estimate ($tCO_2e \text{ yr}^{-1}$)	Lower Confidence Interval ($tCO_2e \text{ yr}^{-1}$)	Upper Confidence Interval ($tCO_2e \text{ yr}^{-1}$)
Emissions from fire	157,488	98,855	219,937

Activity Data

Description of the variable including the time period covered:	A_{l,t_b} = Area burnt in softwood plantations at time t .											
Explanation for which sources or sinks the variable is used:	This activity data is used to estimate emissions from fire which contribute to and are reported under Forest Degradation.											
Data unit:	Ha											
Value for the variable:	The values for this variable include a combination of actual and modelled data. Actual data were provided from Fiji Pine Limited for the years 2015 – 2018 (clear cells in table). The average annual area burnt over these 4 years was used to estimate the annual area burnt historically. <table border="1"> <thead> <tr> <th rowspan="2">Year</th><th>Softwood Plantations</th></tr> <tr> <th>Area Burnt</th></tr> </thead> <tbody> <tr> <td>2015</td><td>1447</td></tr> <tr> <td>2016</td><td>830</td></tr> <tr> <td>2017</td><td>2709</td></tr> <tr> <td>2018</td><td>729</td></tr> </tbody> </table>	Year	Softwood Plantations	Area Burnt	2015	1447	2016	830	2017	2709	2018	729
Year	Softwood Plantations											
	Area Burnt											
2015	1447											
2016	830											
2017	2709											
2018	729											
Source of data:	Fiji Pine Limited											
Spatial level:	National - This data is recorded in all Fiji Pine Plantation areas within Fiji											

Discussion of key uncertainties for this variable:	Burnt areas provided by Fiji Pine Limited are measured in the field using a GPS. This data will have measurement errors associated, however as there are no QA/QC or verification processes in place these random and systematic errors cannot be quantified.
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	Large source, highly relevant; included in the quantification of uncertainty.

Emissions Factors

Emissions Factors																		
Description of the variable including the forest class if applicable:	AGB_{l,t_b} Average aboveground biomass stock before burning in softwood plantation at time t;																	
Data unit:	tonnes d.m. ha ⁻¹																	
Value for the variable:	<table><tr><th rowspan="2">Year</th><th colspan="2">Softwood Plantations</th></tr><tr><th>Average age of compartment that burnt in year t_b</th><th>Average aboveground biomass in a compartment that burnt in year t_b</th></tr><tr><td>2015</td><td>17.5</td><td>145.8</td></tr><tr><td>2016</td><td>16.3</td><td>135.8</td></tr><tr><td>2017</td><td>10.2</td><td>85</td></tr><tr><td>2018</td><td>9.8</td><td>81.6</td></tr></table>	Year	Softwood Plantations		Average age of compartment that burnt in year t _b	Average aboveground biomass in a compartment that burnt in year t _b	2015	17.5	145.8	2016	16.3	135.8	2017	10.2	85	2018	9.8	81.6
Year	Softwood Plantations																	
	Average age of compartment that burnt in year t _b	Average aboveground biomass in a compartment that burnt in year t _b																
2015	17.5	145.8																
2016	16.3	135.8																
2017	10.2	85																
2018	9.8	81.6																
Source of data or description of the assumptions, methods and results of any underlying studies that have been used to determine the variable:	The data are sourced from Fiji Pine Limited and the variable is calculated according to Equation 20: An example is presented below: $AGB_{l,2015} = 17.5 \times \frac{10}{1.2} = 145.8$																	
Spatial level:	National Data																	
Discussion of key uncertainties for this variable:	The key areas of uncertainty that relate to the estimates of available aboveground biomass are the measurement errors and modelling errors relating to the estimate of annual increment in Pine plantations (Waterloo, 1994) as well as the uncertainty in the use of default root:shoot ratios for adjusting the mean annual increment.																	
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	The measurement and modelling uncertainty related to the mean annual biomass increment were considered to be medium and probability functions for the Monte Carlo runs adopted as outlined in Annex 12.1																	

Description of the variable including the forest class if applicable:	BGB_{l,t_b} Average belowground biomass stock before burning in softwood plantation at time t;
Data unit:	tonnes d.m. ha ⁻¹
Value for the variable:	

		Softwood Plantations	
		Average age of compartment that burnt in year t_b	Average belowground biomass in a compartment that burnt in year t_b
	Year		
	2015	17.5	35
	2016	16.3	32.6
	2017	10.2	20.4
	2018	9.8	19.6
Source of data or description of the assumptions, methods and results of any underlying studies that have been used to determine the variable:	The data are sourced from Fiji Pine Limited and the variable is calculated according to Equation 21: An example is presented below: $BGB_{l,2015} = 17.5 \times 10 \times 0.2 = 35$		
Spatial level:	National Data		
Discussion of key uncertainties for this variable:	The key areas of uncertainty that relate to the estimates of available aboveground biomass are the measurement errors and modelling errors relating to the estimate of annual increment in Pine plantations (Waterloo, 1994) as well as the uncertainty in the use of default root:shoot ratios for adjusting the mean annual increment.		
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	The measurement and modelling uncertainty related to the mean annual biomass increment were considered to be medium and probability functions for the Monte Carlo runs adopted as outlined in Annex 12.1		

Average annual net emissions from forest degradation

Average annual net emissions from forest degradation were estimated by:

$$\hat{\phi}_{FD} = \hat{\phi}_{FDem} + \hat{\phi}_{BSW} + \hat{\phi}_{FDre} \quad (29)$$

where

$\hat{\phi}_{FD}$ = average annual net emissions from forest degradation; tCO₂e yr⁻¹

$\hat{\phi}_{FDem}$ = average annual gross emissions from forest degradation; tCO₂e yr⁻¹

$\hat{\phi}_{BSW}$ = average annual gross emissions from fire in softwood plantations; tCO₂e yr⁻¹

$\hat{\phi}_{FDre}$ = average annual gross removals from forest degradation; tCO₂e yr⁻¹

Note: Gross removals are added to gross emissions because gross removals always have a negative sign.

The emissions from Forest Degradation were estimated to be:

Emissions/Removals from Forest Degradation	Estimate (tCO ₂ e yr ⁻¹)	Lower Confidence Interval (tCO ₂ e yr ⁻¹)	Upper Confidence Interval (tCO ₂ e yr ⁻¹)

Emissions from Logging	195,316	167,487	223,343
Removals from re-growth on logged areas	-42,362	-57,222	-27,794
Emissions from Fire	157,488	98,855	219,937
Net Total	310,442	321,925	467,501

A8.3.4 Enhancement of Forest Carbon Stocks

The sink “enhancement of forest carbon stocks” includes removals from afforestation/reforestation (AR), as well as gross emissions and removals from forest plantation management.

A8.3.4.1 Afforestation/Reforestation

Afforestation/Reforestation is defined as the conversion of land in the land-use sub-category Non-Forest to land in the sub-category Natural Forest (Low- or Upland) and Plantations (Softwood and Hardwood). Afforestation/reforestation if the crown-cover percent on a patch of land (min. 0.5 ha) reaches or exceeds the threshold value of 10%. Afforestation/reforestation cannot occur within lands defined as plantations as this land is classified as Forest Land regardless of canopy cover as it primarily land use is forest. It is assumed that afforestation/reforestation always has anthropogenic causes in Fiji.

Initial carbon stocks on land afforested/reforested is considered to be zero. Carbon gains on afforestation/reforestation land were estimated by taking the average forest area gain in each sub-period and multiply the average by the mean annual carbon increment for the forest strata.

Afterwards annual carbon gains were available for each year (t). These carbon gains for each year are subsequently multiplied by the time elapsed since conversion to estimate carbon gains over the FRL Reference Period for each year. Finally, the average annual carbon gain over the Reference Period was estimated by taking the average of the carbon gains of each year over the Reference Period.

Average annual gross removals

To compute the average annual removals from forestation, the removals over the Reference Period for each time interval were computed first. The area of reforestation over the Reference Period is generated from an annual time series of forest gain (see Annex 8.2 for detail on how this data is generated).

For the first time interval 2005-2006 it was assumed that half of the area was afforested (or reforested) during the first half of 2006.

$$A_{AR,2006} = \frac{1}{2} A_{AR,2005-2006} \quad (30)$$

where

$A_{AR,2005-2006}$ is the total area that was afforested/reforested during the interval 2005-2006 (including Low-and Upland Natural Forest), i.e., from mid 2005 to mid 2006. It is assumed that this area is not deforested during the FRL Reference Period.

The area $A_{AR,2006}$ is assumed to grow for 10.75 years. That is, from the mid of the first half of 2006 until the end of the Reference Period.

For example for the interval 2005-2006 (i.e., mid 2005 to mid 2006) there is a forest area gain of 4,841 ha. Only half of this is considered (i.e., $4,841/2 = 2,420$ ha), since it is assumed that half of the area was afforested/reforested in the second half of the year 2005 (which is not covered by the FRL

Reference Period). Hence, there are 2,420 ha of forest area gain in the 'first half of 2006'. It is assumed that the 2,420 ha were afforested/reforested in the mid of the first half of 2006 (i.e., April 1, 2006). If these 2,420 ha grow from April 1, 2006 to December 31, 2016, they grow for 10.75 years.

The total carbon gains on AAR_{2006} over the Reference Period were calculated as follows:

$$\Delta C_{AR,2006} = A_{AR,2006} \times 10.75 \times MAIC_{AR} \quad (31)$$

Carbon gains for the last time interval 2016-2017 were estimated in a similar way.

$$A_{AR,2016} = \frac{1}{2} A_{AR,2016-2017} \quad (32)$$

However, AAR_{2016} does not grow for 10.75 years but for 0.25 years (mid of the second half of 2016 until the end of the FRL Reference Period, i.e., from October 1, 2016 on).

$$\Delta C_{AR,2016} = A_{AR,2006} \times \frac{1}{4} MAIC_{AR} \quad (33)$$

Carbon gains for year t_1 generated over the rest of the FRL Reference Period were estimated by

$$\Delta C_{AR,t_m} = \delta_{t_m} \times A_{AR,t_m} \times MAIC_{AR} \quad (34)$$

Where;

$\Delta C_{AR,t_1}$ = carbon gains for the year t_1 generated over the Reference Period; tC

$\delta_{t_1} = \{10, 9, \dots, \delta t_m, \dots, 1\}$, yrs

$MAIC_{AR}$ = mean annual carbon increment for afforestation/reforestation (above ground and belowground); tC ha⁻¹ yr⁻¹

A_{AR,t_m} = forest area gain in each interval t_b , ha

Total carbon gains over the Reference Period were calculated using:

$$\Delta C_{AR} = \Delta C_{AR,2006} + \left[\sum_{T_m} \Delta C_{AR,t_m} \right] + \Delta C_{AR,2016} \quad (35)$$

Activity Data

Description of the variable including the time period covered:	A_{AR,t_m} = forest area gain This area represents the total area afforested/reforested.
Explanation for which sources or sinks the variable is used:	This variable is used in the estimation of removals from afforestation/reforestation activities.
Data unit:	Ha
Value for the variable:	6,180
Source of data:	Management Services Division of the Ministry of Forestry
Spatial level:	Sub-National; this data represents areas of afforestation/reforestation within the Fijian islands of Viti Levu, Vanua Levu and Taveuni. The land

	area of these three islands makes up approximately 90% of the land area of the Fijian islands.
Discussion of key uncertainties for this variable:	The key sources of uncertainty relate to errors of omission and commission in the image classification process.
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	The data are predicted values generated from semi-automated processing of Landsat imagery. The accuracy assessment following the methods of Olofsson et al 2014 is applied to developed error adjusted areas and confidence intervals which are then incorporated into the Monte Carlo simulation. Lower CI[ha] 4,415 Upper CI[ha] 8,124

Emissions Factors

Description of the variable including the forest class if applicable:	$MAIC_{AR}$ = mean annual carbon increment for afforestation/reforestation (above ground and belowground)
Data unit:	tC ha ⁻¹ yr ⁻¹
Value for the variable:	2.63
Source of data or description of the assumptions, methods and results of any underlying studies that have been used to determine the variable:	$MAIC_{AR}$ was calculated from estimates of mean annual volume increments reported by Fiji Hardwood Corporation Limited as follows: $MAIC_{AR} = MAIV_{AR} \times BCEF_{AR,I} \times (1 + R_{wl}) \times \eta_{CF}$ $2.63 = 3.71 \times 1.1 \times (1 + 0.37) \times 0.47$

	Where; $MAIC_{AR}$ = mean annual carbon increment for forestation including C in AGB and BGB; tC ha⁻¹ yr⁻¹ $MAIV_{AR}$ = mean annual volume increment for forestation derived from data from FHCL; m³ ha⁻¹ yr⁻¹ $BCEF_{AR,I}$ = biomass conversion and expansion factor for volume increments in humid tropical natural forests (growing stock level 11-20 m³ ha⁻¹) taken from IPCC [2006, Vol. 4, Chap.4, Tab. 4.5]; to be 1.1 tB (m³)⁻¹ R_{wl} = root-to-shoot ratio for tropical rainforest (see Table A.9); dimensionless η_{CF} = biomass to carbon conversion factor (IPCC default); C (tB)⁻¹
Spatial level:	Nationally relevant
Discussion of key uncertainties for this variable:	The sources of uncertainty with this emissions factor include: 1. Volumes provided by FHCL considered to be a large source 2. Uncertainty in root-to-shoot ratios (IPCC [2006] default values); 3. Uncertainty in biomass expansion factor (IPCC [2006] default values); 4. Uncertainty in root:shoot ratio (IPCC [2006] default values);
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	lower CI[tC ha⁻¹ yr⁻¹]: 1.61 upper CI[tC ha⁻¹ yr⁻¹]: 3.66

Average annual net removals from Afforestation/Reforestation

Total carbon gains were converted to tCO₂e and annualized:

$$\hat{\theta}_{ECAR} = \mathcal{T}^{-1} \left[\Delta C_{AR} \times \eta_{CC} \right] \quad (36)$$

Where;

$\hat{\theta}_{ECAR}$ = average annual removals from afforestation/reforestation; tCO₂e yr⁻¹

ΔC_{AR} = average annual carbon gains from afforestation / reforestation over the Reference Period; tC yr⁻¹

η_{CC} = conversion factor C to CO₂; tCO₂ (tC)⁻¹

The removals from Afforestation / Reforestation were estimated to be:

Removals from A/R	Estimate (tCO ₂ e yr ⁻¹)	Lower Confidence Interval (tCO ₂ e yr ⁻¹)	Upper Confidence Interval (tCO ₂ e yr ⁻¹)
	-327,541	-470,832	-202,971

8.3.4.2 Forest Plantation Management

Fiji's forest definition lists two types of Forest Plantations, namely Hardwood Plantations and Softwood (or Pine) Plantations. By definition, deforestation and afforestation/reforestation are not possible within Forest Plantations. Forest Plantations remain in the land-use category Forest Land even if the crown-cover is completely removed following harvest, e.g., temporarily unstocked.

For the FRL it was assumed that field data, i.e., records on the current stocking, volumes and areas harvested and areas planted available at FPL and FHCL, would provide more reliable estimates of emissions and removals from Forest Plantations. As spatial data on the extent of Hard- and Softwood Plantations was available, the methods used may still be considered to follow IPCC Approach 3.

To estimate gross emissions from Forest Plantations, records on the timber volumes extracted in the years 2006 to 2016 provided by the plantation management companies were used. Timber volumes extracted were converted to total tree biomass, to total carbon and finally to CO₂ emissions. The conversion from logging to emissions was calculated differently for Hardwood and Softwood Plantations as described below.

Removals from Forest Plantations were estimated based on the mean annual increment (MAI) reported for Hard- and Softwood Plantations. Removals originate from areas that were planted during the FRL Reference Period and plantations that were planted before the start year 2006 and were not harvested until the end of the Reference Period.

Average annual gross emissions from softwood plantations

Emissions from logging in softwood plantations were estimated from data on extracted volumes provided by Fiji Pine Limited (FPL) for the years of the Reference Period.

$$AGB_{SW,L,t} = V_{SW,L,t} \times \frac{1}{\lambda_{Pine}} \times \rho_{Pine} \quad (37)$$

Where;

$AGB_{SW,L,t}$ = aboveground biomass loss in year t in softwood plantations; tAGB

$V_{SW,L,t}$ = wood volumes harvested in softwood plantations in year t ; m³

λ_{Pine} = recovery rate in softwood plantations; dimensionless

ρ_{Pine} = wood density of pine wood harvested in softwood plantations; g cm⁻³

Total biomass loss was estimated by:

$$TB_{SW,L,t} = AGB_{SW,L,t} \times (1 + R_{dlh}) \quad (38)$$

Where;

$T_{SW,L,t}$ = total biomass loss in year t in Softwood Plantations; tB

$AGB_{SW,L,t}$ = aboveground biomass loss in softwood plantations; tB

R_{dlh} = root-to-shoot ratio for tropical moist deciduous forest >125 tB ha⁻¹, taken from IPCC, 2006,

Vol.4, Chap. 4, Tab. 4.4; dimensionless

Carbon loss due to harvest in softwood plantations was estimated by:

$$\Delta C_{SW,L,t} = [TB_{SW,L,t} \times \eta_{CF}] \times (-1) \quad (39)$$

Where;

$\Delta C_{SW,L,t}$ = carbon loss in softwood plantations in year t due to logging; tC

$TB_{SW,L,t}$ = total biomass loss in year t in softwood plantation; tB

η_{CF} = conversion factor for dry matter to C; tC (tB)⁻¹

Average annual gross emissions from softwood plantations were estimated by:

$$\hat{\phi}_{ECS_{em}} = T^{-1} \left[\sum_T \Delta C_{SW,L,t} \times \eta_{CC} \right] \quad (40)$$

Where;

$\hat{\phi}_{ECS_{em}}$ = average annual gross emissions from softwood plantations; tCO₂e yr⁻¹

T = length of the FRL Reference Period, i.e. 11 years; yrs

$\Delta C_{SW,L,t}$ = carbon loss in softwood plantations in year t due to logging; tC

η_{CC} = conversion factor C to CO₂e; (tCO₂ (C)⁻¹)

Average annual gross removals from softwood plantations

Average annual gross removals from softwood plantations were estimated based on the mean annual increment of above and belowground biomass, $MAIB_{SW}$ (taken from Waterloo [1994]), areas planted during the Reference Period and growth on areas that were planted before 2006 and were either harvested or not harvested before the end of the Reference Period.

Fiji Pine Limited provided inventory data from which growth curves for volume could have been derived. However, the data were erroneous and a reliable estimate could not be obtained. Spatial data on areas planted and areas harvested per year were provided by Fiji Pine Limited, however, data on areas harvested were erroneous and could not be used. For example, for the year 2012 Fiji Pine Limited reported that about 158,214 m³ of pine wood were harvested. The area reported as harvest in 2012 was, however, zero hectares. As the area harvested was needed to estimate the area on which removals were generated in Softwood Plantations these data were estimated using data on harvested volumes.

To estimate C accumulation on areas planted during the Reference Period and areas that have been planted before 2006 (and were not harvested until the end of the Reference Period), the $MAIB_{SW}$ was converted to C increment by:

$$MAIC_{SW} = [MAIB_{SW} \times \eta_{CF}] \quad (41)$$

$MAIC_{SW}$ = mean annual C increment in Softwood Plantations; tC ha⁻¹ yr⁻¹

$MAIB_{SW}$ = mean annual biomass increment (AGB + BGB) in Softwood Plantations; tB ha⁻¹ yr⁻¹

η_{CF} = conversion factor biomass to C; dimensionless

Using the same methods as for Hardwood Plantations, C gains on areas planted during the Reference Period were estimated for each year (over the Reference Period) by:

$$\Delta C_{SW,G,t} = \delta_t \times A_{SE,PL,t} \times MAIC_{SW} \quad (42)$$

$\Delta C_{SW,G,t}$ = carbon gains for year t in Softwood Plantations over the Reference Period; tC

$\delta_t = 2016 - t + 0.5$; yrs

$A_{SE,PL,t}$ = area planted in Softwood Plantations in year t; ha

$MAIC_{SW}$ = mean annual C increment in Softwood Plantations; tC ha⁻¹ yr⁻¹

To estimate C gains on areas that were planted before 2006 and were not harvested until the end of the Reference Period, data on these areas were needed. As Fiji Pine Limited did not report on the area stocked with trees at the beginning of the Reference Period, these areas were estimated from data on harvested volumes and data on areas planted. As no reliable data for the area harvested were provided by Fiji Pine Limited, these areas harvested were estimated first. To estimate harvested areas, data on the $MAIC_{SW}$, the cutting cycle (CC_{SW} ; currently 20 years in Softwood Plantations and ii) the C loss due to harvests in each year were used. The area logged in year t was estimated by:

$$\hat{A}_{SW,LG,t} = [CC_{SW} \times MAIC_{SW}]^{-1} \times \Delta C_{SW,L,t} \quad (43)$$

Where;

$\hat{A}_{SW,LG,t}$ = area logged in Softwood Plantations in year t; ha

CC_{SW} = length of the cutting cycle in Softwood Plantations; yrs

$MAIC_{SW}$ = mean annual C increment in Softwood Plantations; tC ha⁻¹ yr⁻¹

$\Delta C_{SW,L,t}$ = carbon loss in Softwood Plantations in year t due to logging; tC

— For 2006, FPL reported a stocking area of 49,503 ha (December 31, 2006). The stocking area at the start of the Reference Period was estimated by

$$\hat{A}_{SW,S,2005} = A_{SW,S,2006} + \hat{A}_{SW,LG,2006} - A_{SW,PL,2006} \quad (44)$$

Where;

$\hat{A}_{SW,S,2005}$ = stocking area of Softwood Plantations in 2005; ha

$A_{SW,S,2006}$ = stocking area of Softwood Plantations in 2006; ha

$\hat{A}_{SW,LG,2006}$ = area harvested in Softwood Plantations in 2006; ha

$A_{SW,PL,2006}$ = area planted in FPL's plantation lease area in 2006; ha

The area that was planted before 2006 and was not harvested until end of 2016 was estimated by:

$$\hat{A}_{SW,S,GR} = \hat{A}_{SW,S,2005} - \sum_T \hat{A}_{SW,LG,t} \quad (45)$$

$\hat{A}_{SW,S,GR}$ = stocking area in Softwood Plantations that was planted before 2006 and was not harvested until the end of the Reference Period; ha

$\hat{A}_{SW,S,2005}$ = stocking area of Softwood Plantations in 2005; ha
 $\hat{A}_{SW,LG,t}$ = area harvested in Softwood Plantations in year t; ha

The average annual C gain on $\hat{A}_{SW,S,GR}$ were computed by:

$$\Delta C_{SW,GR} = \hat{A}_{SW,S,GR} \times MAIC_{SW} \quad (46)$$

$\Delta C_{SW,GR}$ = average annual C gain on areas that were planted before 2006 and were not harvested until the end of the Reference Period; tC yr⁻¹

$\hat{A}_{SW,S,GR}$ = stocking area in Softwood Plantations that was planted before 2006 and was not harvested until the end of the Reference Period; ha

$MAIC_{SW}$ = mean annual C increment in Softwood Plantations; tC ha⁻¹ yr⁻¹

Average annual removals on compartments in Softwood Plantations that were harvested during the Reference Period were estimated as follows:

$$\Delta C_{SW,GRH} = T^{-1} \left[\sum_T \delta_t \times \hat{A}_{SW,LG,t} \times MAIC_{SW} \right] \quad (47)$$

$\Delta C_{SW,GRH}$ = average annual C gain on areas that were planted before 2006 and harvested during the Reference Period; tC yr⁻¹

δ_t = the time a compartment logged in year t grew during the Reference Period, $\delta_t = t - 2016 + 10.5$, i.e., the reversal of δ_t ; yrs

$\hat{A}_{SW,LG,t}$ = area logged in Softwood Plantations in year t; ha

$MAIC_{SW}$ = mean annual C increment in Softwood Plantations; tC ha⁻¹ yr⁻¹

Total average annual C gain, including gains on areas planted during the Reference Period, areas harvested during the Reference Period and areas that were planted before 2006 and were not harvested until the end of the Reference Period, was computed by:

$$\Delta C_{SW,G} = \left[T^{-1} \sum_T \Delta C_{SW,G,t} \right] + \Delta C_{SW,GRH} + \Delta C_{SW,GR} \quad (48)$$

Where;

$\Delta C_{SW,G}$ = total average annual C gains including gains from areas that were planted in Softwood Plantations during the Reference Period, areas that were harvested during the Reference Period, and areas that were planted before 2006 and were not harvested until the end of the Reference Period; tC yr⁻¹

$\Delta C_{SW,G,t}$ = carbon gains for year t in Softwood Plantations over the Reference Period; tC

$\Delta C_{SW,GRH}$ = average annual C gain on areas that were planted before 2006 and harvested during the Reference Period; tC yr⁻¹

$\Delta C_{SW,GR}$ = average annual C gain on areas that were planted before 2006 and were not harvested until the end of the Reference Period; tC yr⁻¹

Estimated total average annual carbon gains in softwood plantations were converted to average annual removals by:

$$\hat{\phi}_{ECS_{re}} = \Delta C_{SW,G} \times \eta_{CC} \quad (49)$$

Where;

$\hat{\phi}_{ECS_{re}}$ = average annual gross removals from softwood plantations; tCO₂e yr⁻¹

$\Delta C_{SW,G}$ = total average annual carbon gains including gains from areas that were planted before 2006 and were not harvested until the end of the Reference Period and areas that were planted in softwood plantations during the Reference Period; tC yr⁻¹

η_{CC} = carbon to carbon dioxide equivalents conversion factor; (tCO₂ (C)⁻¹)

Activity Data

Description of the variable including the time period covered:	$V_{SW,L,t}$ = wood volumes harvested in softwood plantations in year t																										
Explanation for which sources or sinks the variable is used:	Emissions from logging in softwood plantations estimated from data on extracted volumes.																										
Data unit:	m ³																										
Value for the variable:	<table><tr><th>Year</th><th>$V_{SW,L}$</th></tr><tr><td>2006</td><td>282,102</td></tr><tr><td>2007</td><td>294,685</td></tr><tr><td>2008</td><td>265,046</td></tr><tr><td>2009</td><td>249,769</td></tr><tr><td>2010</td><td>256,040</td></tr><tr><td>2011</td><td>306,684</td></tr><tr><td>2012</td><td>158,214</td></tr><tr><td>2013</td><td>668,833</td></tr><tr><td>2014</td><td>393,519</td></tr><tr><td>2015</td><td>544,902</td></tr><tr><td>2016</td><td>259,301</td></tr></table>			Year	$V_{SW,L}$	2006	282,102	2007	294,685	2008	265,046	2009	249,769	2010	256,040	2011	306,684	2012	158,214	2013	668,833	2014	393,519	2015	544,902	2016	259,301
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Source of data:	Provided by Fiji Pine Limited (FPL) for the years of the Reference Period.																										
Spatial level:	Sub-National; this data represents volumes extracted from softwood plantations within the Fijian islands of Viti Levu, Vanua Levu and Taveuni. The land area of these three islands makes up approximately 90% of the total land area of the Fijian islands.																										
Discussion of key uncertainties for this variable:	Small source of uncertainty; not included in the quantification of total uncertainty. Note that the data are census data (i.e., no sampling error). Data are census data (i.e., no sampling error). High confidence in the data collected by Ministry staff as systematic and random errors are considered nil due to QA/QC checks and training and strong links to Ministry revenues.																										
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of	None.																										

assumptions/methodology in the estimation:	
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Description of the variable including the time period covered:	$A_{SW,PL,t}$ = area planted in softwood plantations in year t																								
Explanation for which sources or sinks the variable is used:	Carbon gains on areas planted with softwood plantations during the Reference Period																								
Data unit:	ha																								
Value for the variable:	<table> <tr> <th>Year</th><th>$A_{SW,PL}$</th></tr> <tr><td>2006</td><td>1,477.80</td></tr> <tr><td>2007</td><td>2.87</td></tr> <tr><td>2008</td><td>14.09</td></tr> <tr><td>2009</td><td>16.70</td></tr> <tr><td>2010</td><td>177.40</td></tr> <tr><td>2011</td><td>273.12</td></tr> <tr><td>2012</td><td>871.02</td></tr> <tr><td>2013</td><td>12.51</td></tr> <tr><td>2014</td><td>201.71</td></tr> <tr><td>2015</td><td>1,031.91</td></tr> <tr><td>2016</td><td>0.00</td></tr> </table>	Year	$A_{SW,PL}$	2006	1,477.80	2007	2.87	2008	14.09	2009	16.70	2010	177.40	2011	273.12	2012	871.02	2013	12.51	2014	201.71	2015	1,031.91	2016	0.00
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Discussion of key uncertainties for this variable:	The area planted is used as a proxy for stocked plantations growing in the estimation of removals. The uncertainty related to this figure relates to systematic and random errors in recording the area planted as well as the uncertainty arising from failed areas which are not captured in this dataset.																								
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	The uncertainty of this data on planted area being used in the context of growing plantations is considered medium and relevant and as such is included in the quantification of uncertainty.																								

Description of the variable including the time period covered:	$A_{SW,LG,t}$ = area logged in softwood plantations in year t;								
Explanation for which sources or sinks the variable is used:	Carbon gains on areas planted with softwood plantations during the Reference Period								
Data unit:	ha								
Value for the variable:	<table> <tr> <th>Year</th><th>$A_{SW,LG}$</th></tr> <tr><td>2006</td><td>1,081.64</td></tr> <tr><td>2007</td><td>1,129.88</td></tr> <tr><td>2008</td><td>1,016.24</td></tr> </table>	Year	$A_{SW,LG}$	2006	1,081.64	2007	1,129.88	2008	1,016.24
Year	$A_{SW,LG}$								
2006	1,081.64								
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	<table><tr><td>2009</td><td>957.67</td></tr><tr><td>2010</td><td>981.71</td></tr><tr><td>2011</td><td>1,175.89</td></tr><tr><td>2012</td><td>606.63</td></tr><tr><td>2013</td><td>2,564.45</td></tr><tr><td>2014</td><td>2,089.27</td></tr><tr><td>2015</td><td>1,508.83</td></tr><tr><td>2016</td><td>994.21</td></tr></table>	2009	957.67	2010	981.71	2011	1,175.89	2012	606.63	2013	2,564.45	2014	2,089.27	2015	1,508.83	2016	994.21
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Source of data:	Areas stocked with trees at the beginning of the Reference Period were not available from Fiji Pine Limited records or the remote sensing data and therefore were estimated from data on harvested volumes and data on areas planted. To estimate harvested areas, data on the $MAIC_{SW}$, the cutting cycle (CC_{SW}; currently 20 years in Softwood Plantations and the carbon loss due to harvests in each year were used. The area logged in year t was estimated by: $\hat{A}_{SW,LG,t} = [CC_{SW} \times MAIC_{SW}]^{-1} \times \Delta C_{SW,L,t}$ Where: $\hat{A}_{SW,LG,t}$ = area logged softwood plantations in year t; ha CC_{SW} = length of the cutting cycle in softwood plantations; yrs $MAIC_{SW}$ = mean annual carbon increment in softwood plantations; tC ha⁻¹ $\Delta C_{SW,L,t}$ = carbon loss in softwood plantations in year t due to logging; tC The stocked area at the start of the Reference Period was estimated by: $\hat{A}_{SW,S,2006} = A_{SW,S,2006} + \hat{A}_{SW,LG,2006} - A_{SW,PL,2006}$ Where; $\hat{A}_{SW,S,2006}$ = stocked area of softwood plantations in 2005; ha $A_{SW,S,2006}$ = stocked area of softwood plantations in 2006; ha $\hat{A}_{SW,LG,2006}$ = area of softwood plantations harvested in 2006; ha $A_{SW,PL,2006}$ = area of softwood plantations planted in 2006; ha The area planted before 2006 and not harvested until the end of 2016 was estimated by: $\hat{A}_{SW,GR} = \hat{A}_{SW,S,2005} - \sum_T \hat{A}_{SW,LG,t}$ Where; $A_{SW,GR}$ = stocked area of softwood plantations that was planted before 2006 and was not harvested until the end of the Reference Period; ha $A_{SW,S,2005}$ = stocked area of softwood plantations in 2005; ha $A_{SW,LG,t}$ = areas of softwood plantation harvested in year t; ha																

	<table> <tr> <th>Year</th><th>$\hat{A}_{SW,S}$</th></tr> <tr><td>2006</td><td>49,503.00</td></tr> <tr><td>2007</td><td>47,979.83</td></tr> <tr><td>2008</td><td>48,104.68</td></tr> <tr><td>2009</td><td>48,165.88</td></tr> <tr><td>2010</td><td>48,302.52</td></tr> <tr><td>2011</td><td>48,204.06</td></tr> <tr><td>2012</td><td>49,371.23</td></tr> <tr><td>2013</td><td>46,554.90</td></tr> <tr><td>2014</td><td>47,219.28</td></tr> <tr><td>2015</td><td>48,629.91</td></tr> <tr><td>2016</td><td>48,112.62</td></tr> </table>	Year	$\hat{A}_{SW,S}$	2006	49,503.00	2007	47,979.83	2008	48,104.68	2009	48,165.88	2010	48,302.52	2011	48,204.06	2012	49,371.23	2013	46,554.90	2014	47,219.28	2015	48,629.91	2016	48,112.62
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Discussion of key uncertainties for this variable:	The key uncertainties related to area logged relate to the = length of the cutting cycle in softwood plantations (CC_{SW}) and the mean annual carbon increment in softwood plantations ($MAIC_{SW}$).																								
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	Refer to the probability density functions of the key variables [(CC_{SW}) and $MAIB_{SW}$, used to estimate $MAIC_{SW}$] which were applied in the Monte Carlo simulations.																								

Emissions Factors

Description of the variable including the forest class if applicable:	$MAIC_{SW}$ = mean annual carbon increment in softwood plantations;
Data unit:	tC ha ⁻¹ yr ⁻¹
Value for the variable:	4.7
Source of data or description of the assumptions, methods and results of any underlying studies that have been used to determine the variable:	To estimate carbon accumulation on areas planted during the Reference Period and areas that have been planted before 2006 (and were not harvested until the end of the Reference Period), the $MAIB_{SW}$ was converted to C increment by: $MAIC_{SW} = MAIB_{SW} \times \eta_{CF}$ Where; $MAIC_{SW}$ = mean annual carbon increment in softwood plantations; tC ha⁻¹ $MAIB_{SW}$ = mean annual increment of above and belowground biomass; tB ha⁻¹ yr⁻¹ η_{CF} = conversion factor for biomass to carbon; tC (tB)⁻¹

Spatial level:	Sub-National; this data represents volumes extracted from softwood plantations within the Fijian islands of Viti Levu, Vanua Levu and Taveuni. The land area of these three islands makes up approximately 90% of the total land area of the Fijian islands.
Discussion of key uncertainties for this variable:	The two key variables applied in the estimation of this emissions factor had the following uncertainty ranking: η_{CF} = small source, not relevant; not included in the quantification of uncertainty. $MAIB_{SW}$ = large source, highly relevant; included in the quantification of uncertainty.
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	Refer to the probability density functions of the variables [η_{CF} and ($MAIB_{SW}$)] which were applied in the Monte Carlo simulations.

Average annual net emissions from Softwood plantations

Average annual net emissions from softwood plantations were estimated by:

$$\hat{\phi}_{ECS} = \hat{\phi}_{ECS_{em}} + \hat{\phi}_{ECS_{re}} \quad (50)$$

Where;

$\hat{\phi}_{ECS}$ = average annual net emission from softwood plantations; tCO₂e yr⁻¹

$\hat{\phi}_{ECS_{em}}$ = average annual gross emissions from softwood plantations; tCO₂e yr⁻¹

$\hat{\phi}_{ECS_{re}}$ = average annual gross removals from softwood plantations; tCO₂e yr⁻¹

Average annual removals are added to the average annual emissions because removals have a negative sign.

The net emissions from Softwood Plantations were estimated to be:

Emissions/Removals from Softwood Plantations	Estimate (tCO ₂ e yr ⁻¹)	Lower Confidence Interval (tCO ₂ e yr ⁻¹)	Upper Confidence Interval (tCO ₂ e yr ⁻¹)
Emissions from Softwood Plantations	442,001	363,766	543,364
Removals from Softwood Plantations	- 774,225	-929,732	-620,622
Net	- 332,224	-501,514	-135,751

Average annual gross emissions from hardwood plantations

Gross emissions from hardwood plantations utilise annual logged volume data reported by Fiji Hardwood Corporation Limited (FHCL).

$$AGB_{HW,L,t} = V_{HW,L,t} \times BCEF_{HW,R} \quad (51)$$

Where;

$AGB_{HW,L,t}$ = aboveground biomass removed in hardwood plantations in year t ; tAGB

$V_{HW,L,t}$ = volume of hardwood extracted in year t ; m³

$BCEF_{HW,R}$ = biomass conversion and expansion factor for logging; tAGB m⁻³

Aboveground biomass is converted to total biomass (above- and belowground biomass) by:

$$TB_{HW,L,t} = (AGB_{HW,L,t} \times (1 + R_{wl})) \quad (52)$$

Where;

$TB_{HW,L,t}$ = total biomass loss due to harvesting in hardwood plantations in year t ; tB

$AGB_{HW,L,t}$ = aboveground biomass removed in softwood plantations in the year of harvest; tAGB yr⁻¹

R_{wl} = root-to-shoot ratio for tropical rainforests; dimensionless

Extracted total biomass was converted to carbon loss by:

$$\Delta C_{HW,L,t} = [TB_{HW,L,t} \times \eta_{CF}] \times (-1) \quad (53)$$

Where;

$\Delta C_{HW,L,t}$ = carbon loss in hardwood plantations in year t due to logging; tC

$TB_{SW,L,t}$ = total biomass loss in year t in hardwood plantation; tB

η_{CF} = conversion factor for dry matter to C; tC (tB)⁻¹

Average annual gross emissions from hardwood plantations were estimated by:

$$\hat{\phi}_{ECH_{em}} = T^{-1} \left[\sum_T \Delta C_{HW,L,t} \times \eta_{CC} \right] \quad (54)$$

Where;

$\hat{\phi}_{ECH_{em}}$ = average annual gross emissions from hardwood plantations; tCO₂e yr⁻¹

T = length of the FRL Reference Period, i.e. 11 years; yrs

$\Delta C_{SW,L,t}$ = carbon loss in hardwood plantations in year t due to logging; tC

η_{CC} = conversion factor C to CO₂e; (tCO₂ (C)⁻¹)

Average annual gross removals from hardwood plantations

Removals within hardwood plantations were estimated based on mean annual volume increments on areas planted during the reference period (i.e. between 2006 and 2016) and growth on areas that were planted before 2006 and were either harvested or not harvested before the end of the Reference Period.

$$MAIAGB_{HW} = \overline{MAIV}_{HW} \times BCEF_{HW,I} \quad (55)$$

$$6.44 = 5.85 \times 1.1 \quad (\text{Example})$$

Where;

$MAIAGB_{HW}$ = mean annual AGB increment in Hardwood Plantations; tB ha⁻¹ yr⁻¹

$\overline{MAIV}_{HW}$ = average mean annual increment in Hardwood Plantations; m³ ha⁻¹ yr⁻¹

$BCEF_{HW,I}$ = biomass conversion and expansion factor for increment taken from IPCC, 2006, Vol. 4, Chap. 4. Tab. 4.5; $BCEF_I$ for humid tropical natural forest; growing stock level 21-40 m³ ha⁻¹; tB (m³)⁻¹

Total carbon increment, including both aboveground and belowground, was estimated by:

$$MAIC_{HW} = [MAIAGB_{HW} \times (1 + R_{wl})] \times \eta_{CF} \quad (56)$$

Where;

$MAIC_{HW}$ = mean annual carbon increment in Hardwood Plantations; tB ha⁻¹ yr⁻¹

$MAIAGB_{HW}$ = mean annual biomass increment; tB ha⁻¹ yr⁻¹

Carbon gains over the Reference Period on areas that were planted between 2006 and 2016 in FHCL's lease area were estimated for each year by:

$$\Delta C_{HW,G,t} = \delta_t \times A_{HW,PL,t} \times MAIC_{HW} \quad (57)$$

Where;

$\Delta C_{HW,G,t}$ = carbon gains for year t in hardwood plantations over the Reference Period; tC

$\delta_t = 2016 - t + 0.5$; yrs

$A_{HW,PL,t}$ = area planted in hardwood plantations in year t ; ha

$MAIC_{HW}$ = mean annual carbon increment in hardwood plantations; tC ha⁻¹ yr⁻¹

For the year 2011, FHCL reported a stocking area of $A_{HW,S,2011} = 56,652$ ha. The stocking area is the area of the plantation lease area that was stocked with trees. No data were provided for a date prior to 2011. The area stocked at the end of 2005 was calculated by:

$$A_{HW,S,2005} = A_{HW,S,2011} + \sum_{t=2006}^{2010} A_{HW,LG,t} - \sum_{t=2006}^{2010} A_{HW,PL,t} \quad (58)$$

Where;

$A_{HW,S,2005}$ = stocking area in Hardwood Plantations in 2005; ha

$A_{HW,S,2011}$ = stocking area in Hardwood Plantations in 2011; ha

$A_{HW,LG,t}$ = area logged in Hardwood Plantations in year t ; ha

$A_{HW,PL,t}$ = area planted in Hardwood Plantations in year t ; ha

The total of the areas harvested between 2006 and 2016 was subtracted from the stocking area of 2005, $A_{HW,S,2005}$ to obtain the area that accumulated C during the Reference Period, i.e., the area that was neither planted nor harvested during the Reference Period,

$$A_{HW,GR} = A_{HW,S,2005} - \sum_T A_{HW,PL,t} \quad (59)$$

Where;

$A_{HW,GR}$ = stocking area in Hardwood Plantations that was planted before 2006 and was not harvested until the end of the Reference Period; ha

$A_{HW,S,2005}$ = stocking area in Hardwood Plantations in 2005; ha

$A_{HW,LG,t}$ = area logged in Hardwood Plantations in year t; ha

The average annual C gain on hardwood plantation was estimated by:

$$\Delta C_{HW,GR} = A_{HW,GR} \times MAIC_{HW} \quad (60)$$

Where;

$\Delta C_{HW,GR}$ = average annual carbon gain on areas that were planted before 2006 and were not harvested until the end of the Reference Period; tC yr⁻¹

$A_{HW,GR}$ = stocking area in hardwood plantations that was planted before 2006 and not harvested during the Reference Period; ha

$MAIC_{HW}$ = mean annual C increment in hardwood plantations; tC ha⁻¹ yr⁻¹

Carbon also accumulated on plantation compartments that were harvested during the FRL Reference Period. For example, a plantation compartment that was harvested in 2010 accumulated C in 2006, 2007, 2008, 2009 and half of 2010. When the compartment is harvested in 2010 all carbon stored in the compartment is emitted to the atmosphere. This includes the C that was sequestered during the years 2006 to mid of 2010. However, since the C was sequestered during the Reference Period, these removals have to be accounted for. Average annual removals on compartments that were harvested during the Reference Period were estimated as follows:

$$\Delta C_{HW,GRH} = T^{-1} \left[\sum_T \delta_t \times A_{HW,LG,t} \times MAIC_{HW} \right] \quad (61)$$

Where;

$\Delta C_{HW,GRH}$ = average annual C gain on areas that were planted before 2006 and harvested during the Reference Period; tC yr⁻¹

δ_t = the time a compartment logged in year t grew during the Reference Period, $\delta_t = t - 2016 + 10.5$, i.e., the reversal of δt ; yrs

$A_{HW,LG,t}$ = area logged in Hardwood Plantations in year t; ha

$MAIC_{HW}$ = mean annual C increment in Hardwood Plantations; tC ha⁻¹ yr⁻¹

T = duration of the Reference Period (i.e. 11 years); yrs

Total average annual C gain, including gains on areas planted during the Reference Period, areas harvested during the Reference Period and areas that were planted before 2006 and were not harvested until the end of the Reference Period, was computed by:

$$\Delta C_{HW,G} = \left[T^{-1} \sum_T \Delta C_{HW,G,t} \right] + \Delta C_{HW,GRH} + \Delta C_{HW,GR} \quad (62)$$

Where;

$\Delta C_{HW,G}$ = total average annual C gains including gains from areas that were planted in Hardwood Plantations during the Reference Period, areas that were harvested during the Reference Period, and areas that were planted before 2006 and were not harvested until the end of the Reference Period; tC yr⁻¹

$\Delta C_{HW,G,t}$ = carbon gains for year t in Hardwood Plantations over the Reference Period; tC

$\Delta C_{HW,GRH}$ = average annual C gain on areas that were planted before 2006 and harvested during the Reference Period; tC yr⁻¹

$\Delta C_{HW,GR}$ = average annual C gain on areas that were planted before 2006 and were not harvested until the end of the Reference Period; tC yr⁻¹

Estimated total average annual carbon gains in hardwood plantations were converted to average annual removals by:

$$\hat{\phi}_{ECHre} = \Delta C_{HW,G} \times \eta_{CC} \quad (63)$$

Where;

$\hat{\phi}_{ECHre}$ = average annual gross removals from hardwood plantations; tCO₂e yr⁻¹

$\Delta C_{HW,G}$ = total average annual carbon gains including gains from areas that were planted before 2006 and were not harvested until the end of the Reference Period and areas that were planted in hardwood plantations during the Reference Period; tC yr⁻¹

η_{CC} = conversion factor C to CO₂e; (tCO₂ (C)⁻¹)

The net emissions from Hardwood Plantations were estimated to be:

Emissions/Removals from Hardwood Plantations	Estimate (tCO ₂ e yr ⁻¹)	Lower Confidence Interval (tCO ₂ e yr ⁻¹)	Upper Confidence Interval (tCO ₂ e yr ⁻¹)
Emissions from Hardwood Plantations	154,194	127,106	181,684
Removals from Hardwood Plantations	- 864,898	-1,239,892	-541,863
Net	-710,705	-1,086,703	-385,590

Activity Data

Description of the variable including the time period covered:	$V_{HW,L}$ = wood volumes harvested in hardwood plantations in year t;
Explanation for which sources or sinks the variable is used:	Emissions from logging in hardwood plantations estimated from data on extracted volumes.

Data unit:	m ³																								
Value for the variable:	<table> <tr> <th>Year</th><th>$V_{HW,L}$</th></tr> <tr><td>2006</td><td>37,216</td></tr> <tr><td>2007</td><td>5,0092</td></tr> <tr><td>2008</td><td>79,869</td></tr> <tr><td>2009</td><td>63,758</td></tr> <tr><td>2010</td><td>92,283</td></tr> <tr><td>2011</td><td>91,025</td></tr> <tr><td>2012</td><td>53,737</td></tr> <tr><td>2013</td><td>63,251</td></tr> <tr><td>2014</td><td>58,542</td></tr> <tr><td>2015</td><td>54,568</td></tr> <tr><td>2016</td><td>39,854</td></tr> </table>	Year	$V_{HW,L}$	2006	37,216	2007	5,0092	2008	79,869	2009	63,758	2010	92,283	2011	91,025	2012	53,737	2013	63,251	2014	58,542	2015	54,568	2016	39,854
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Source of data:	Data on recovered (extracted) volumes from hardwood plantations was provided by Fiji Hardwood Corporation Limited for the years of the FRL Reference Period.																								
Spatial level:	Sub-National; this data represents volumes extracted from hardwood plantations within the Fijian islands of Viti Levu, Vanua Levu and Taveuni. The land area of these three islands makes up approximately 90% of the total land area of the Fijian islands.																								
Discussion of key uncertainties for this variable:	Small source, not relevant; not included in the quantification of uncertainty. Note that the data are census data (i.e., no sampling error).																								
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	None																								

Description of the variable including the time period covered:	$A_{HW,PL,t}$ = area planted in hardwood plantations in year t																								
Explanation for which sources or sinks the variable is used:	Carbon gains on areas planted with hardwood plantations during the Reference Period																								
Data unit:	Ha																								
Value for the variable:	<table> <tr> <th>Year</th><th>$A_{HW,PL}$</th></tr> <tr><td>2006</td><td>305.03</td></tr> <tr><td>2007</td><td>305.03</td></tr> <tr><td>2008</td><td>305.03</td></tr> <tr><td>2009</td><td>305.03</td></tr> <tr><td>2010</td><td>305.03</td></tr> <tr><td>2011</td><td>228.00</td></tr> <tr><td>2012</td><td>1000.00</td></tr> <tr><td>2013</td><td>0</td></tr> <tr><td>2014</td><td>0</td></tr> <tr><td>2015</td><td>0</td></tr> <tr><td>2016</td><td>300.00</td></tr> </table>	Year	$A_{HW,PL}$	2006	305.03	2007	305.03	2008	305.03	2009	305.03	2010	305.03	2011	228.00	2012	1000.00	2013	0	2014	0	2015	0	2016	300.00
Year	$A_{HW,PL}$																								
2006	305.03																								
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2011	228.00																								
2012	1000.00																								
2013	0																								
2014	0																								
2015	0																								
2016	300.00																								

Source of data:	Fiji Hardwood Corporation Limited did not report on the areas planted for each year between 2006 and 2010, only aggregated data for the time interval 2001 to 2010 were reported (3050.3 ha). For the years 2006 to 2010, the average, i.e., $3050.3 \text{ ha} / 10 \text{ years} = 305.03 \text{ ha yr}^{-1}$, was used. For the years 2011 to 2016 FHCL reported on areas planted in each year.
Spatial level:	Sub-National; this data represents volumes extracted from hardwood plantations within the Fijian islands of Viti Levu, Vanua Levu and Taveuni. The land area of these three islands makes up approximately 90% of the total land area of the Fijian islands.
Discussion of key uncertainties for this variable:	Large source, highly relevant; included in the quantification of uncertainty. Note that $A_{HW,PL}$ was only considered highly uncertain for the years 2006-2010, i.e., the years for which the annual average of the time interval 2001 to 2010 was used. For the remaining years 2011 to 2016, the uncertainty was considered small (and was ignored).
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	To obtain random draws of the area planted in the years 2006 to 2010, $z = 10$ realizations were drawn from a Uniform distributions with lower bound $a = 0$ and upper bound $b = 3050.3$, where b is the entire area planted between 2001 and 2010.

Description of the variable including the time period covered:	$A_{HW,LG,t}$ = area logged in hardwood plantations in year t ;																								
Explanation for which sources or sinks the variable is used:	Carbon gains on areas planted with hardwood plantations during the Reference Period																								
Data unit:	Ha																								
Value for the variable:	<table> <tr> <th>Year</th><th>$A_{HW,LG}$</th></tr> <tr><td>2006</td><td>212.40</td></tr> <tr><td>2007</td><td>278.00</td></tr> <tr><td>2008</td><td>736.30</td></tr> <tr><td>2009</td><td>164.60</td></tr> <tr><td>2010</td><td>432.30</td></tr> <tr><td>2011</td><td>132.00</td></tr> <tr><td>2012</td><td>110.00</td></tr> <tr><td>2013</td><td>310.00</td></tr> <tr><td>2014</td><td>394.00</td></tr> <tr><td>2015</td><td>375.00</td></tr> <tr><td>2016</td><td>172.00</td></tr> </table>	Year	$A_{HW,LG}$	2006	212.40	2007	278.00	2008	736.30	2009	164.60	2010	432.30	2011	132.00	2012	110.00	2013	310.00	2014	394.00	2015	375.00	2016	172.00
Year	$A_{HW,LG}$																								
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Source of data:	Fiji Hardwood Corporation Limited																								
Spatial level:	Sub-National; this data represents volumes extracted from hardwood plantations within the Fijian islands of Viti Levu, Vanua Levu and Taveuni. The land area of these three islands makes up approximately 90% of the total land area of the Fijian islands.																								

Discussion of key uncertainties for this variable:	The key areas of uncertainty related to the area harvested arise from random and systematic errors as a result of data collected by the Ministry of Forestry staff in their patrols of the harvested areas. As the staff are well trained, subjected to QA/QC checks and the data is linked to Ministry revenues the data is considered of high quality and low uncertainty.
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	Small source, relevant; considered a small source of uncertainty in the quantification of uncertainty. Note that the data for the areas logged are census data (i.e., no sampling error).

Emissions Factors

Description of the variable including the forest class if applicable:	$MAIC_{HW}$ = mean annual C increment in hardwood plantations
Data unit:	tC ha ⁻¹ yr ⁻¹
Value for the variable:	1.50
Source of data or description of the assumptions, methods and results of any underlying studies that have been used to determine the variable:	Total carbon increment, including above- and belowground was estimated from mean annual increment values provided by Fiji Hardwood Corporation Limited (FHCL) as follows: $MAIAGB_{HW} = \overline{MAIV}_{HW} \times BCEF_{HW,I}$ Where; $MAIAGB_{HW}$ = mean annual AGB increment in hardwood plantations; tB ha⁻¹ yr⁻¹ $\overline{MAIV}_{HW}$ = average mean annual volume increment in hardwood plantations; m³ ha⁻¹ yr⁻¹; calculated as a weighted mean estimate as 6.44 m³ ha⁻¹ yr⁻¹ $BCEF_{HW,I}$ = biomass conversion and expansion factor for increment for humid tropical natural forest; growing stock level 21-40 m³ ha⁻¹; tB (m³)⁻¹ Total carbon increment, including above- and belowground was estimated by: $MAIC_{HW} = [MAIAG_{HW} \times (1 + R_{wl})] \times \eta_{CF}$ Where; $MAIC_{HW}$ = mean annual carbon increment in hardwood plantations; tB ha⁻¹ yr⁻¹ $MAIAG_{HW}$ = mean annual increment tB ha⁻¹ yr⁻¹ R_{wl} = root-to-shoot ration for tropical rainforest taken from IPCC, 2006, Vol.4, Chap. 4, Tab. 4.4; dimensionless η_{CF} = biomass to carbon conversion factor; tC (tB)⁻¹

Spatial level:	Sub-National; this data represents volumes extracted from softwood plantations within the Fijian islands of Viti Levu, Vanua Levu and Taveuni. The land area of these three islands makes up approximately 90% of the total land area of the Fijian islands.
Discussion of key uncertainties for this variable:	The key variables applied in the estimation of this emissions factor had the following uncertainty ranking: Π_{CF} = small source, not relevant; not included in the quantification of uncertainty. R_{wl} = large source, relevant; included in the quantification of uncertainty. $MAIAG_{HW}$ = large source, highly relevant; included in the quantification of uncertainty.
Estimation of accuracy, precision, and/or confidence level, as applicable and an explanation of assumptions/methodology in the estimation:	Refer to the probability density functions of the variables [Π_{CF} , R_{wl} and $MAIAG_{HW}$] which were applied in the Monte Carlo simulations.

Average annual net emissions from hardwood plantations

Average annual net emissions from hardwood plantations were estimated by:

$$\hat{\phi}_{ECH} = \hat{\phi}_{ECH_{em}} + \hat{\phi}_{ECH_{re}} \quad (64)$$

Where;

$\hat{\phi}_{ECH}$ = average annual net emission from hardwood plantations; tCO₂e yr⁻¹

$\hat{\phi}_{ECH_{em}}$ = average annual gross emissions from hardwood plantations; tCO₂e yr⁻¹

$\hat{\phi}_{ECH_{re}}$ = average annual gross removals from hardwood plantations; tCO₂e yr⁻¹

Average annual removals are added to the average annual emissions because removals have a negative sign.

Average annual net emissions from plantations

Average annual gross emission from forest plantations were estimated by:

$$\hat{\phi}_{ECHS_{em}} = \hat{\phi}_{ECH_{em}} + \hat{\phi}_{ECS_{em}} \quad (65)$$

Where;

$\hat{\phi}_{ECHS_{em}}$ = average annual gross emissions from forest plantations; tCO₂e yr⁻¹

$\hat{\phi}_{ECH_{em}}$ = average annual gross emissions from hardwood plantations; tCO₂e yr⁻¹

$\hat{\phi}_{ECS_{em}}$ = average annual gross emissions from softwood plantations; tCO₂e yr⁻¹

Average annual gross removals from forest plantations were estimated by:

$$\hat{\phi}_{ECHS_{re}} = \hat{\phi}_{ECH_{re}} + \hat{\phi}_{ECS_{re}} \quad (66)$$

Where;

$\hat{\phi}_{ECHS_{re}}$ = average annual gross removals from forest plantations; tCO₂e yr⁻¹

$\hat{\phi}_{ECH_{em}}$ = average annual gross removals from hardwood plantations; tCO₂e yr⁻¹

$\hat{\phi}_{ECS_{em}}$ = average annual gross removals from softwood plantations; tCO₂e yr⁻¹

Average annual net emissions from forest plantations were estimated by:

$$\hat{\phi}_{ECHS} = \hat{\phi}_{ECH} + \hat{\phi}_{ECS} \quad (67)$$

Where;

$\hat{\phi}_{ECHS}$ = average annual net emissions from forest plantations; tCO₂e yr⁻¹

$\hat{\phi}_{ECH}$ = average annual net emissions from hardwood plantations; tCO₂e yr⁻¹

$\hat{\phi}_{ECS}$ = average annual net emissions from softwood plantations; tCO₂e yr⁻¹

The net emissions from Forest Plantations were estimated to be:

Emissions/Removals from Forest Plantations	Estimate (tCO ₂ e yr ⁻¹)	Lower Confidence Interval (tCO ₂ e yr ⁻¹)	Upper Confidence Interval (tCO ₂ e yr ⁻¹)
Emissions from Plantations	596,195	513,925	701,282
Removals from Plantations	-1,639,123	-2,034,655	-1,279,843
Net Total	-1,042,928	-1,445,834	-656,927