Reducing Global Environmental Uncertainties in Reports of Tropical Forest Carbon Fluxes to REDD+ and the Paris Agreement Global Stocktake

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Supplementary Material

1. Information required to evaluate the uncertainties associated with an estimate

a. Spatial uncertainty information may comprise a definition of 'forest' by minimum percentage tree cover; the highest quality data used to make the estimate; the resolution(s) of the remote sensor(s) employed to collect these data; the method used for image interpretation; and the inclusion of spatial forest degradation.

b. Vertical uncertainty information may include a definition of forest degradation; the number of carbon pools included; whether forest ecosystems are stratified, the number of ecosystem types used for this purpose (relative to the corresponding number of ecosystem types for the country in a global ecosystem classification), and the inclusion of specific types, such as dry or wetland forests; the highest quality data used, including the resolution of the remote sensor and/or the number of plots in which inventory data are collected; whether the estimate refers to biomass change net of the biomass of the land cover replacing forest or merely to the gross change; the types of vertical degradation included, e.g. selective logging; and whether the change from primary to secondary forest is reported.

c. Temporal uncertainty information may consist of the frequency of area mapping and whether the resulting areas are reported for evaluation; and the frequencies of biomass mapping and carbon emissions reporting.

2. Supplementary Tables

The remainder of this material consists of Supplementary Tables S1-S14 and Supplementary Figures S1-S3.

Table S1. The Contribution of Land Use Change and Forestry (LUCF) Carbon Fluxes to the Net Carbon Emissions, Reported in the National Greenhouse Gas Inventories of Twelve Tropical Countries and Showing in **Bold** type the Estimate Selected for Uncertainty Coding for Each Country (in MegaTonnes of Carbon Dioxide, and of Carbon Dioxide Equivalent for "All Gases", Per Year).

	DR Congo	Ghana	Nigeria	Tanzania	Cambodia	Indonesia	Laos	Malaysia	Brazil	Costa Rica	Mexico	Peru	Total
Year submitted	(2015)	(2015)	(2014)	(2014)	(2015)	(2011)	(2013)	(2018)	(2016)	(2014)	(2012)	(2016)	
Year of estimate	2010	2012	2000	2000	2000	2000	2000	2014	2010	2010	2010	2012	
Estimates													
1. Deforestation emissions	-	-	94.46	63.53	22.86	945.97	35.08	0.95	-	-	59.14	80.18	1302.17*
2. Deforestation-related emissions													
a. Soil emissions	-	-	-		-	*216.31*	-	-	-	-	*12.59*	*0.41*	-
b. Peat emissions	-	-	-		-	172.00	-	-	-	-	-	-	-
3. Forest degradation emissions													
a. Logging emissions	-	-	-	-	-	-	7.67	32.94	-	-	5.86	18.7	-
b. Other forest degradation emissions	-	-	-	-	-	-	-	-	-	-	-	-	-
Total LUCF CO_2 emissions	201.73	-	94.46	**63.53**	22.86	1117.97	42.76	33.88	-	**-5.26**	65	98.88	1735.81
3. Forest regrowth removals	-	-	-	-	-27.21	-215.15	-	-284.02	-	-		-3.92	-
4. Forestation removals													
a. Land abandonment removals	-	-	-	-	-20.96	-81.64	-2.05	-1.53	-	-	-	-12.3	-
b. Afforestation removals	-	-	-	-	-	-	-	-	-	-	-	-	-
Total LUCF CO_2 removals	-321.66	-	-	-	-48.17	-296.79	-2.05	-285.55	-	-	-18.11	-16.22	-988.55
Net LUCF CO_2 emissions	**-119.93**	-	**97.39**	-	**-25.31**	**821.17**	**40.71**	**-251.67**	**310.76**	(-3.60)	**46.89**	**82.66**	**1002.67****
National net CO_2 emissions	-119.14	-	214.21	66.89	24.91	1055.68	43.81	0	739.67	-	-	-	1959.14**
LUCF share of net CO2 emissions (%)	sk	na	45	na	sk	78	93	sk	42	na	na	na	45
Net LUCF emissions all gases	-	**15.17**	-	-	-24.57	821.25	41.92	-263.83	349.17	(-0.47)	46.89	86.74	1072.74***
National net emissions all gases	-79.56	33.66	220.51	76.77	-0.46	1377.98	50.74	50.48	1271.4	8.79	748.25	171.31	3703.36***
LUCF share of all emissions (%)	na	45	na	na	sk	60	83	sk	27	na	6	51	29
Uncertainty estimate	-	ns	-	-	nq	±75%	±44%	±17%	-	-	-	nq	-
Number of primary fluxes	0	0	1	1	3	3	3	4	0	0	2	4	22
Mean number of primary fluxes	-	-	-	-	-	-	-	-	-	-	-	-	1.8

NB. sk = an LUCF sink means that it is not possible to calculate the LUCF share of all emissions; nq = the uncertainty analysis is not quantified and ns=the uncertainty analysis is not specific to the LUCF sector; (brackets) indicate that the entry is for the Agriculture, Forestry and Other Land Use (AFOLU) sector, not the LUCF sector; *= total for 8 countries (Table 5d); **= total for 7 countries (Table 5a); *** = total for 8 countries (Table 5b); soil emissions in italics are included in estimate of deforestation emissions.

Table S2. Evaluation of Land Use Change and Forestry Carbon Fluxes in National Greenhouse Gas Inventories of Twelve Tropical Countries.

	DR Congo	Ghana	Nigeria	Tanzania	Cambodia	Indonesia	Laos	Malaysia	Brazil	Costa Rica	Mexico	Peru
Year submitted	(2015)	(2015)	(2014)	(2014)	(2015)	(2011)	(2013)	(2018)	(2016)	(2014)	(2012)	(2016)
Year of estimate	2010	2012	2000	2000	2000	2000	2000	2014	2010	2010	2010	2012
Spatial Uncertainty Information												
1. Forest definition (% cover)	-	-	-	-	-	-	-	-	-	-	-	-
2. Highest data quality	Maps	Maps	Statistics	Statistics	Statistics	Maps	Statistics	-	Satellite	Satellite	Maps	Satellite
3. Sensor resolution (m)	-	-	-	-	-	-	-	-	30	30	-	30
4. Satellite image interpretation	-	-	-	-	-	-	-	-	Visual	Visual	-	Visual
5. Spatial forest degradation	-	-	-	-	-	-	-	-	-	-	-	-
Vertical Uncertainty Information												
1. Forest degradation definition	-	-	-	-	-	-	-	-	-	-	-	-
2. Carbon pool disaggregation rank	0	H	0	H	0	0	0	0	H	0	0	M
a. Carbon pools included	-	abdl(s)	(s)	abdl(s)	-	sp	-	-	abdl(s)	(s)	s	abs
3. Ecosystem disaggregation rank	m	0	0	0	0	M	0	0	H	0	0	0
a. Ecosystem types included	3	-	-	-	-	3	-	-	6	-	-	-
b. Ecosystem types Eyre	4	2	3	4	2	4	1	2	7	3	9	5
c. Proportion of Eyre types	0.8	-	-	-	-	0.8	-	-	0.9	-	-	-
Dry/wetland forests	dr	-	-	-	-	w	-	-	drw	-	-	-
4. Highest data quality	Statistics	Inventory	-	-	Statistics	Statistics	Statistics	-	Inventory	Inventory	Inventory	-
5. Non-optical sensor used	-	-	-	-	-	-	-	-	-	-	-	-
6. Inventory plots	-	-	-	-	-	-	-	-	-	-	-	-
7. Plot density (Per 1000 ha)	-	-	-	-	-	-	-	-	-	-	-	-
8. Net land cover change	no	no	no	no	no	no	no	no	no	no	no	no
9. Vertical degradation												
a. Types of vertical degradation	-	-	-	-	-	-	L	L	-	-	L	L
b. Primary to secondary forest	-	-	-	-	-	Yes	-	-	-	-	-	Yes
Temporal Uncertainty Information												
1. Area mapping frequency (yrs)	-	-	-	-	-	4	-	-	1	-	-	-
2. Area trends reported	Yes	-	-	-	-	-	-	-	Yes	-	-	-
3. Inventory frequency	-	-	-	-	-	-	-	-	-	-	-	-
4. Emissions frequency (yrs)	1	1	1	-	-	1	-	1	5	-	1	2-5

NB. a= above-ground biomass, b = below-ground biomass, d = deadwood, l = litter, s = soil; L= degradation by selective logging; dr = dry forest, w = wetland forest; (s) = soil flux is included but not listed separately.

Table S3. Forest Reference Emission Levels Reported by Twelve Tropical Countries and Showing in **Bold** type the Estimate Selected for Uncertainty Coding for Each Country (in MegaTonnes of Carbon Dioxide Per Year)

	DR Congo	Ghana	Nigeria	Tanzania	Cambodia	Indonesia	Laos	Malaysia	Brazil	Costa Rica	Mexico	Peru	Total
Year submitted	(2018)	(2017)	(2019)	(2017)	(2017)	(2016)	(2018)	(2018)	(2018)	(2016)	(2015)	(2016)	
Period of estimate	2000-10	2001-15	2006-16	2002-13	2006-14	1990-12	2005-15	2000-14	1996-15	1997-09	2000-10	2001-14	
Title of level	FREL	FRL	FREL	FREL	FRL	FREL	FRL/ (FREL)	FRL	FREL	FRL/ (FREL)	FREL	FREL	
Level reported	Gross	Net	Gross	Gross	Net	Gross	Net	Net	Gross	Net	Gross	Gross	
Reference Level	**483.74**	**60.67**	**32.40**	**43.74**	**78.95**	**351.20**	**33.48**	**-213.05**	**751.78**	**4.37**	**45.07**	**53.37**	**1725.72**
1. **Deforestation CO_2 emissions**	**483.74**	40.30	**32.40**	**43.74**	92.58	293.20	12.00	12.92	**751.78**	8.59	**45.07**	**53.37**	585.28*
2. Deforestation-related emissions													
a. Soil emissions	-	-	-	-	-	-	-	-	-	-	-	-	-
b. Peat emissions	-	-	-	-	-	(217)	-	-	-	-	-	-	-
3. Forest degradation emissions													
a. Logging emissions	-	20.23	-	-	-	58.00	9.19	-	-	-	-	-	-
b. Other forest degradation emissions	-	0.71	-	-	-	-	19.83	-	-	-	-	-	-
Total forest CO_2 emissions	-	61.24	-	-	92.58	**351.20**	41.01	12.92	-	8.59	-	-	-
3. Forest regrowth removals	-	-	-	-	-	-	-4.28	-225.98	-	-	-	-	-
4. Forestation removals													
a. Land abandonment removals	-	-	-	-	-	-		-	-	-	-	-	-
b. Afforestation removals	-	-0.57	-	-	-13.62	-	-3.25	-	-	-	-	-	-
Total forest CO_2 removals	-	-0.57	-	-	-	-	-7.53	-225.98	-	-4.23	-	-	-
Net forest CO_2 emissions	-	**60.67**	-	-	**78.95**	-	**33.48**	**-213.05**	-	**4.37**	-	-	-
Uncertainty estimate (%)	7	11	32	12	ns	16	19	21	ns	-	-	9	-
Number of primary fluxes	1	3	1	1	2	2	4	2	1	1	1	1	20
Mean Number of primary fluxes	-	-	-	-	-	-	-	-	-	-	-	-	1.7

NB. ns = non-specific estimate. *= total for 8 countries: Costa Rica, Indonesia, Laos, Malaysia, Mexico, Nigeria, Peru and Tanzania (Table 5d.

Table S4. Uncertainty Evaluation of Forest Reference Emission Levels Reported by Twelve Tropical Countries.

	DR Congo	Ghana	Nigeria	Tanzania	Cambodia	Indonesia	Laos	Malaysia	Brazil	Costa Rica	Mexico	Peru
Year submitted	(2018)	(2017)	(2019)	(2017)	(2017)	(2016)	(2018)	(2018)	(2018)	(2016)	(2015)	(2016)
Period of estimate	2000-10	2001-15	2006-16	2002-13	2006-14	1990-12	2005-15	2000-14	1996-15	1997-09	2000-10	2001-14
Type of level	FREL	FRL	FREL	FREL	FRL	FREL	FRL/ (FREL)	FRL	FREL	FRL/ (FREL)	FREL	FREL
Spatial Uncertainty Information												
1. Forest definition (% cover)	>30	>15	>15	>10	>10	>30	>20	>30	>10	>70	>10	≥30
2. Highest data quality	Satellite	Satellite	Satellite	Satellite	Satellite	Satellite	Satellite	Satellite	Satellite	Satellite	Satellite	Satellite
3. Sensor resolution (m)	30	30	30	30	30	30	10,5	10	30	30	30,10	30
4. Satellite image interpretation	Visual	-	Visual	Visual	Visual	-Visual	Visual	-	Visual	Digital	Visual	Visual
3. Spatial forest degradation	-	Yes	-	-	-	-	-	-	-	-	-	-
Vertical Uncertainty Information												
1. Forest degradation definition	-	-	-	-	-	-	-	-	-	-	-	-
2. Carbon pool disaggregation rank	L	H	M	M	L	L	L	L	M	M	M	L
a. Carbon pools included	ab	abdls	abd	abd	ab	a	ab	abp	abl	abdl	abdl	ab
3. Ecosystem disaggregation rank	H	H	H	H	H	M	H	H	H	H	M	M
a. Ecosystem types included	4	7	5	7	6	3	3	4	6	6	8	4
Ecosystem types Eyre	4	2	3	4	2	4	1	2	7	3	9	5
% of Eyre types	1.0	3.5	1.7	1.8	3.0	0.8	3.0	2.0	0.9	2.0	0.9	0.8
Dryland/wetland forests	drw	dr	drw	drw	w	w	dr	w	drw	drw	drw	w
4. Highest data quality	Inventory	Inventory	Inventory	Inventory	Inventory	Inventory	Inventory	Inventory	Airborne Radar	Inventory	Inventory	Inventory
Non-optical sensor used	-	-	-	-	-	-	-	-	-	-	-	-
Inventory plots	*89*	600	*116*	30,000	-	*3,900*	679	-	2,292	288	21,811	1,152
Plot density (Per 1000 ha)	0.6	64.3	16.6	651.3	-	42.9	36.2	-	4.6	104.5	330.3	14.4
5. Net land cover change	Yes	Yes	Yes	Yes	-	Yes	-	-	-	-	-	-
6. Vertical forest degradation												
Types of vertical degradation	-	L	-	-	-	L	ffL	-	-	-	-	-
Primary to secondary forest	Yes	-	-	-	-	Yes	-	-	-	Yes	Yes	-
Temporal Uncertainty Information												
1. Area mapping frequency (yrs)*	10.0	3.8	10.0	11.0	2.8	2.6	5.0	2.0	1.0	4.7	5.0	1.0
2. Area trends reported	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	Yes
3. Inventory frequency	-	-	-	-	-	-	-	-	-	-	-	-
4. Emissions frequency (yrs)	1	1	1	-	-	1	-	1	5	-	1	2-5

NB. a= above-ground biomass, b = below-ground biomass, d = deadwood, l = litter, s = soil; *italic numbers* for inventory plots indicates that these numbers refer to plot clusters; ff= degradation to forest fallow, L= degradation by selective logging; dr = dry forest, w = wetland forest;.*Mean frequency over reference period.

Table S5. Completeness in including totals and sub-totals of fluxes of: (a) Carbon dioxide (CO_2) and all greenhouse gases linked to Land Use Change and Forestry (LUCF) and all economic sectors in the National Greenhouse Gas Inventories (various dates, 2000-2014) of twelve tropical countries [54-65]; (b) CO_2 in Forest Reference Emission Level reports (various dates, 1990-2016) of twelve tropical countries [66-77].

a. National Greenhouse Gas Inventories

	Deforestation	**Total LUCF CO_2**		**Net CO_2 emissions**		**All greenhouse gases Net emissions**	
	CO_2 emissions	**Emissions**	**Removals**	**LUCF**	**National**	**LUCF**	**National**
DR Congo	-	Y	Y	Y	Y	-	Y
Ghana	-	-	-	-	-	Y	Y
Nigeria	Y	-	-	Y	Y	-	Y
Tanzania	Y	Y	-	-	Y	-	Y
Cambodia	Y	Y	Y	Y	Y	Y	Y
Indonesia	Y	Y	Y	Y	Y	Y	Y
Laos	Y	Y	Y	Y	Y	Y	Y
Malaysia	Y	Y	Y	Y	Y	Y	Y
Brazil	-	-	-	Y	Y	Y	Y
Costa Rica	-	Y	-	-	-	Y	Y
Mexico	Y	Y	-	Y	-	Y	Y
Peru	Y	Y	Y	Y	-	Y	Y

NB. Y = inclusion of total; - = total is not included.

b. Forest Reference Emission Level reports

	Deforestation emissions	**Total forest emissions**	**Total forest removals**	**Net forest emissions**
DR Congo	Y	-	-	-
Ghana	Y	-	-	Y
Nigeria	Y	-	-	-
Tanzania	Y	-	-	-
Cambodia	Y	Y	-	Y
Indonesia	Y	Y	-	-
Laos	Y	Y	Y	Y
Malaysia	Y	Y	Y	Y
Brazil	Y	-	-	-
Costa Rica	Y	Y	Y	Y
Mexico	Y	-	-	-
Peru	Y	-	-	-

NB. Y = inclusion of total; - = total is not included.

Table S6. Estimates of gross deforestation emissions (Mt CO_2 a^{-1}) and corresponding deforestation rates (1,000 ha a^{-1}) in the National Greenhouse Gas Inventories (NGGIs) and Forest Reference Emission Level (FREL) reports of eight tropical countries. The estimated NGGI deforestation rate is taken from information in the country's FREL report, since none of the NGGIs includes this information. The two rates are compared with estimates for the periods concerned (FRA) which have been submitted by the government to the latest FAO Global Forest Resources Assessment 2015 [53].

	Carbon emissions				Deforestation rate					
	NGGI Emissions	Year	FREL Emissions	Period	NGGI rate (estimated)	FREL rate	NGGI rate (FRA)	Period	FREL rate (FRA)	Period
Nigeria	94.5	2000	32.4	2006-16	*163.4*	163.4	409.7	1990-00	409.6	2005-15
Tanzania	63.5	2000	43.7	2002-13	*512.8*	512.8	400.0	1990-00	390.7	2000-15
Cambodia	22.9	2000	92.6	2006-14	96.3	289.9	139.8	1990-00	127.4	2005-15
Indonesia	729.7	2000	293.2	1990-12	2200.0	918.7	1913.6	1990-00	1205.7	1990-10
Laos	35.1	2000	12	2005-15	60.2	62.0	111.9	1990-00	-189.2	2005-15
Malaysia	0.95	2014	12.9	2000-14	2.8	55.0	78.5	2010-15	-40.3	2000-15
Mexico	46.6	2010	45.1	2000-10	-	-	-	-	-	-
Peru	79.8	2012	53.4	2001-14	149.5	127.2	167.6	2010-15	144.9	2000-15
Total	**1072.86**		**585.3**		**3185.0**	**2129.0**	**3221.1**		**2048.8**	
Share			0.55			0.67			0.64	

NB. The NGGI rate (estimated) uses data for the same year in the corresponding FREL report, except for Nigeria and Tanzania, where the rates (in italics) are assumed to be the same as in the FREL report.

Table S7. Information on spatial terminological difficulties and systematic errors associated with estimates of forest carbon fluxes included in the National Greenhouse Gas Inventories (NGGIs) and Forest Reference Emission Level (FREL) reports of twelve tropical countries [54-65, 66-77].

	Forest definition (% tree cover)	**Highest data quality**	**Sensor resolution** (m)	**Image interpretation method**
NGGIs				
DR Congo	-	Maps	-	-
Ghana	-	Maps	-	-
Nigeria	-	Statistics	-	-
Tanzania	-	Statistics	-	-
Cambodia	-	Statistics	-	-
Indonesia	-	Maps	-	-
Laos	-	Statistics	-	-
Malaysia	-	-	-	-
Brazil	-	Satellite	30	Visual
Costa Rica	-	Satellite	30	Visual
Mexico	-	Maps	-	-
Peru	-	Satellite	30	Visual
FREL reports				
DR Congo	>30	Satellite	30	Visual
Ghana	>15	Satellite	30	Visual
Nigeria	>15	Satellite	30	Visual
Tanzania	>10	Satellite	30	Visual
Cambodia	>10	Satellite	30	Visual
Indonesia	>30	Satellite	30	Visual
Laos	>20	Satellite	10,5	Visual
Malaysia	>30	Satellite	10	-
Brazil	>10	Satellite	30	Visual
Costa Rica	>70	Satellite	30	Digital
Mexico	>10	Satellite	30,10	Visual
Peru	>30	Satellite	30	Visual

Table S8. Vertical understructuralization uncertainties: coverage of carbon pools, ecosystem types and land cover change in estimates of forest carbon fluxes in the National Greenhouse Gas Inventories (NGGIs) and Forest Reference Emission Level (FREL) reports of twelve tropical countries [54-65, 66-77].

	Carbon pools		**Number of ecosystem types**	**Proportion of Eyre ecosystem types**	**Dry or wetland forests**	**Net land cover change**
	Types	Number				
NGGIs						
DR Congo	-	0	3	0.8	d	-
Ghana	abdls	5	-	-	-	-
Nigeria	s	1	-	-	-	-
Tanzania	abdls	5	-	-	-	-
Cambodia	-	0	-	-	-	-
Indonesia	sp	2	3	0.8	w	-
Laos	-	0	-	-	-	-
Malaysia	-	0	-	-	-	-
Brazil	abdls	5	6	0.9	dw	-
Costa Rica	s	1	-	-	-	-
Mexico	s	1	-	-	-	-
Peru	abs	3	-	-	-	-
FREL reports						
DR Congo	ab	2	4	1	dw	Y
Ghana	abdls	5	7	3.5	d	Y
Nigeria	abd	3	5	1.7	dw	Y
Tanzania	abd	3	7	1.8	dw	Y
Cambodia	ab	2	6	3	w	-
Indonesia	a	1	3	0.8	w	Y
Laos	ab	2	3	3	d	-
Malaysia	abp	3	4	2	w	-
Brazil	abl	3	6	0.9	dw	-
Costa Rica	abdl	4	6	2	dw	-
Mexico	abdl	4	8	0.9	dw	-
Peru	ab	2	4	0.8	w	-

NB. Carbon pools: a = above-ground biomass; b = below-ground biomass; d = deadwood; l = litter; s = soil; p = peat. Forest types: d = dry forest; w = wetland forest. Y = inclusion of net land cover change; - = gross change.

Table S9. Information on vertical systematic errors associated with estimates of forest carbon fluxes included in the National Greenhouse Gas Inventories (NGGIs) and Forest Reference Emission Level (FREL) reports of twelve tropical countries [54-65, 66-77]. Plot clusters are shown in italics.

	Highest data quality	**Non-optical sensor**	**Number of forest plots**	**Plot density per 1,000 ha**
NGGIs				
DR Congo	Stats	-	-	-
Ghana	Inventory	-	-	-
Nigeria	-	-	-	-
Tanzania	-	-	-	-
Cambodia	Stats	-	-	-
Indonesia	Stats	-	-	-
Laos	Stats	-	-	-
Malaysia	-	-	-	-
Brazil	Inventory	-	-	-
Costa Rica	Inventory	-	-	-
Mexico	Inventory	-	-	-
Peru	-	-	-	-
FREL reports				
DR Congo	Inventory	-	*89*	*0.6*
Ghana	Inventory	-	600	64
Nigeria	Inventory	-	*116*	*16.6*
Tanzania	Inventory	-	30,000	651
Cambodia	Inventory-	-	-	-
Indonesia	Inventory	-	*3,900*	*42.9*
Laos	Inventory	-	678	36
Malaysia	Inventory	-	-	-
Brazil	Airborne	Radar	2,292	4.6
Costa Rica	Inventory	-	288	105
Mexico	Inventory	-	21,811	330
Peru	Inventory	-	1,152	14

Table S10. Information on temporal uncertainties associated with estimates of forest carbon fluxes included in the National Greenhouse Gas Inventories (NGGIs) and Forest Reference Emission Level (FREL) reports of twelve tropical countries [54-65, 66-77].

	Area mapping frequency for estimate (yrs)	Latest area mapping frequency (yrs)	Area trends reported	Emissions frequency (yrs)
NGGIs				
DR Congo	-	-	Y	1
Ghana	-	-	-	1
Nigeria	-	-	-	-
Tanzania	-	-	-	-
Cambodia	-	-	-	-
Indonesia	4.0	4.0	-	1
Laos	-	-	-	-
Malaysia	-	-	-	1
Brazil	1.0	1.0	Y	5
Costa Rica	-	-	-	-
Mexico	-	-	-	1
Peru	-	-	-	-
FREL reports				
DR Congo	10.0	10.0	Y	1
Ghana	3.8	3.0	Y	1
Nigeria	10.0	10.0	Y	1
Tanzania	11.0	11.0	Y	-
Cambodia	4.0	4.0	Y	-
Indonesia	2.8	1.0	Y	1
Laos	5.0	5.0	Y	-
Malaysia	2.0	2.0	Y	1
Brazil	1.0	1.0	Y	5
Costa Rica	4.7	2.0	Y	-
Mexico	5.0	5.0	-	1
Peru	1.0	1.0	Y	2-5

Table S11. The Uncertainty Fingerprints of estimates of forest carbon fluxes in: (a) National Greenhouse Gas Inventories (NGGIs); and (b) Forest Reference Emission Level (FREL) reports of twelve tropical countries (the partial group is in italics) [54-65, 66-77].

		Uncertainty Score
NGGIs		
DR Congo	Ct_{sp},usp_{spa},usp_{spdg},usp_{v}, ust_{pool},ust_{lc}; Mr, sy_{sp}, sy_{v}; T_{sp},Tv	11
Ghana	Ct_{sp},usp_{spa},usp_{spdg},usp_{v}, ust_{ecol},ust_{lc}; Mr,sy_{sp}; T_{sp},Tv	10
Nigeria	Ct_{sp},usp_{spa},usp_{spdg},usp_{v},ust_{pool},ust_{ecol},ust_{lc}; Mr,sy_{sp},sy_{v}; T_{sp},Tv	12
Tanzania	Ct_{sp}, usp_{spa},usp_{spdg},usp_{v}, ust_{ecol},ust_{lc}; Mr,sy_{sp},sy_{v}; T_{sp},T_{v}	11
Cambodia	Ct_{sp},usp_{spa},usp_{spdg},usp_{v},ust_{pool}, ust_{ecol},ust_{lc}; Mr,sy_{sp},sy_{v}; T_{sp},T_{v}	12
Indonesia	Ct_{sp}, usp_{spa},usp_{spdg},usp_{v},ust_{pool},ust_{lc}; Mr,sy_{sp},sy_{v}; T_{sp},Tv	11
Laos	Ct_{sp},t_{v},usp_{spa},usp_{spdg},usp_{v},ust_{pool},ust_{ecol},ust_{lc},pr_{log}; Mr,sy_{sp},sy_{v}; T_{sp},T_{v}	14
Malaysia	Ct_{sp},t_{v},usp_{spa},usp_{spdg},ust_{pool},ust_{ecol},ust_{lc},pr_{log}; Mr,sy_{sp},sy_{v}; T_{sp},Tv	13
Brazil	Ct_{sp},usp_{spa},usp_{spdg},usp_{v},ust_{lc}; Mr,sy_{vis}; T_{v}	8
Costa Rica	Ct_{sp},usp_{spa},usp_{spdg},usp_{v},ust_{pool},ust_{ecol},ust_{lc}; Mr,sy_{vis}; T_{sp},T_{v}	11
Mexico	Ct_{sp},t_{v},usp_{spa},usp_{spdg},usp_{v},ust_{pool},ust_{ecol},ust_{lc},pr_{log}; Mr,sy_{sp}; T_{sp},Tv	13
Peru	Ct_{sp},t_{v}, usp_{spa},usp_{spdg},ust_{pool},ust_{ecol},ust_{lc},pr_{log}; Mr,sy_{v},sy_{vis}; T_{sp},T_{v}	13
Mean		**11.6**
FREL reports		
DR Congo	$Cust_{pool}$; Mr,sy_{vis}; T_{sp},T_{v}	5
Ghana	Ct_{v},usp_{spa},usp_{v},pr_{log}; Mr,sy; T_{sp},T_{v}	8
Nigeria	$Cust_{pool}$; Mr,sy_{vis}; T_{sp},T_{v}	5
Tanzania	$Cust_{pool}$; Mr,sy_{vis}; T_{sp},T_{v}	5
Cambodia	C usp_{spa},usp_{spdg},usp_{v},ust_{pool},ust_{lc}; Mr,sy_{vis}; T_{sp},T_{v}	9
Indonesia	Ct_{v},usp_{spdg},usp_{v},ust_{pool},pr_{log}; Mr,sy_{vis}; T_{v}	8
Laos	Ct_{v},usp_{spdg},ust_{pool},ust_{lc},pr_{log}; Mr,sy_{vis}; T_{sp},T_{v}	9
Malaysia	$Cusp_{spa}$,usp_{spdg},usp_{v},ust_{pool},ust_{lc}; Mr,sy; T_{v}	8
Brazil	$Cust_{pool}$,ust_{lc}; Mr,sy_{vis}; T_{v}	5
Costa Rica	Ct_{sp},usp_{spa},usp_{spdg},usp_{v},ust_{pool},ust_{lc}; Mr,sy; T_{sp},T_{v}	10
Mexico	$Cust_{pool}$,ust_{lc}; Mr,sy_{vis}; T_{sp},T_{v}	6
Peru	$Cust_{pool}$,ust_{lc}; Mr,sy_{vis}; T_{v}	5
Mean		**6.9**

NB. t_{sp}, spatial terminological difficulties; t_{v}, vertical terminological difficulties; usp_{spa}, spatial area underspecification; usp_{spdg}, spatial degradation underspecification; usp_{v}, vertical underspecification; ust_{pool}, understructuralization by carbon pools; ust_{ecol}, understructuralization by ecosystem type, ust_{lc}, understructuralization by land cover change; sy_{sp}, spatial systematic errors; sy_{v}, vertical systematic errors; sy_{vis}, systematic errors due to use of visual image analysis; sy, general systematic errors; r, random errors; T_{sp}, temporal spatial uncertainties; T_{v}, temporal vertical uncertainties. The Uncertainty Score is the total number of uncertainties in each fingerprint.

Table S12. Uncertainty Scores for the National Greenhouse Gas Inventories (NGGIs) and Forest Reference Emission Level (FREL) reports of the comprehensive and partial groups of Countries, and the Group of 8 Countries in Table 5b [54-65, 66-77].

NGGIs		**FREL reports**	
Comprehensive Group	Score	*Comprehensive Group*	Score
Cambodia	12	Cambodia	9
Costa Rica	11	Costa Rica	10
Ghana	10	Ghana	8
Indonesia	11	Indonesia	8
Laos	14	Laos	9
Malaysia	13	Malaysia	8
Means	**11.8**		**8.7**
Partial Group		*Partial Group*	
Brazil	8	Brazil	5
Democratic Republic of Congo	11	Democratic Republic of Congo	5
Mexico	13	Mexico	6
Nigeria	12	Nigeria	5
Peru	13	Peru	5
Tanzania	11	Tanzania	5
Means	**11.3**		**5.2**
Means for All 12 Countries	**11.6**		**6.9**
Eight Countries Reporting Gross Deforestation Emissions (Table 5b)			
Cambodia	9	Cambodia	6
Indonesia	8	Indonesia	4
Laos	9	Laos	6
Malaysia	9	Malaysia	5
Mexico	8	Mexico	6
Nigeria	9	Nigeria	5
Peru	9	Peru	5
Tanzania	8	Tanzania	5
Means	**8.6**		**5.3**

Table S13. Mean completeness and disaggregation rankings for the National Greenhouse Gas Inventories (NGGIs) and Forest Reference Emission Level (FREL) reports of twelve tropical countries [54-65, 66-77].

	Completeness	**Disaggregation**			
	Primary fluxes	Carbon pools	Ecosystem types	Land cover change	Total
NGGIs					
Comprehensive group					
Cambodia	3	0	0	0	0
Costa Rica	0	0	0	0	0
Ghana	0	3	0	0	3
Indonesia	3	0	2	0	2
Laos	3	0	0	0	0
Malaysia	4	0	0	0	0
Means	**2.2**				**0.8**
Partial group					
Brazil	0	3	3	0	6
Democratic Republic of Congo	0	0	2	0	2
Mexico	2	0	0	0	0
Nigeria	1	0	0	0	0
Peru	4	2	0	0	2
Tanzania	1	3	0	0	3
Means	**1.3**				**2.2**
Overall Means	**1.8**				**1.5**
FREL reports					
Comprehensive group					
Cambodia	2	1	3	0	4
Costa Rica	1	2	2	0	4
Ghana	4	3	3	1	7
Indonesia	2	1	2	1	4
Laos	5	1	3	0	4
Malaysia	2	1	3	0	4
Means	**2.7**				**4.5**

Table S13 (Continued.....)

	Completeness	**Disaggregation**			
	Primary fluxes	Carbon pools	Ecosystem types	Land cover change	Total
Partial group					
Brazil	1	2	3	0	5
Democratic Republic of Congo	1	1	3	1	5
Mexico	1	2	2	0	4
Nigeria	1	2	3	1	6
Peru	1	1	2	0	3
Tanzania	1	2	3	1	6
Means	**1.0**				**4.8**
Overall Means	**1.8**				**4.7**

NB. The Disaggregation ranking and scoring method is described in Section 4.4.

Table S14. Uncertainty Assessments included in the National Greenhouse Gas Inventories (NGGIs) and Forest Reference Emission Level (FREL) reports of seven tropical countries and their Uncertainty Scores in this paper [59-61, 68, 70-72, 76-77].

	NGGI Uncertainty estimate %	**Uncertainty Score**	**FREL report Uncertainty estimate** %	**Uncertainty Score**
Democratic Republic of Congo	-	11	±7	5
Ghana	-	10	±11	8
Indonesia	-	11	±16	8
Laos	±44	14	±19	9
Malaysia	±20	13	-	8
Peru	-	13	±9	5
Tanzania	-	11	±12	5

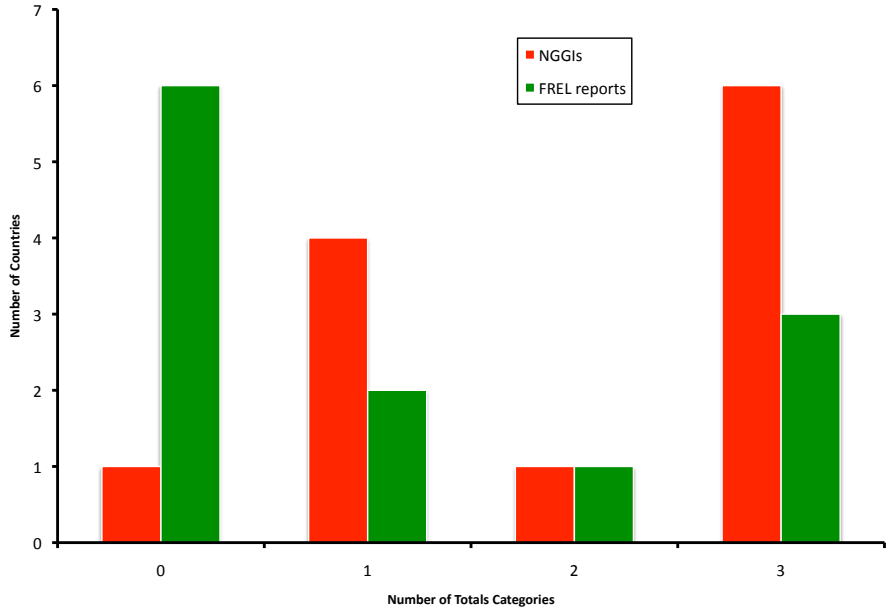


Figure S1. Completeness in reporting forest carbon fluxes to the UN Framework Convention on Climate Change in National Greenhouse Gas Inventories (NGGIs) and Forest Reference Emission Level (FREL) reports of twelve tropical countries [54-65, 66-77]: the number of total CO_2 reporting categories for the Land Use Change and Forestry (LUCF) sector (up to a maximum of three) reported by different numbers of countries.

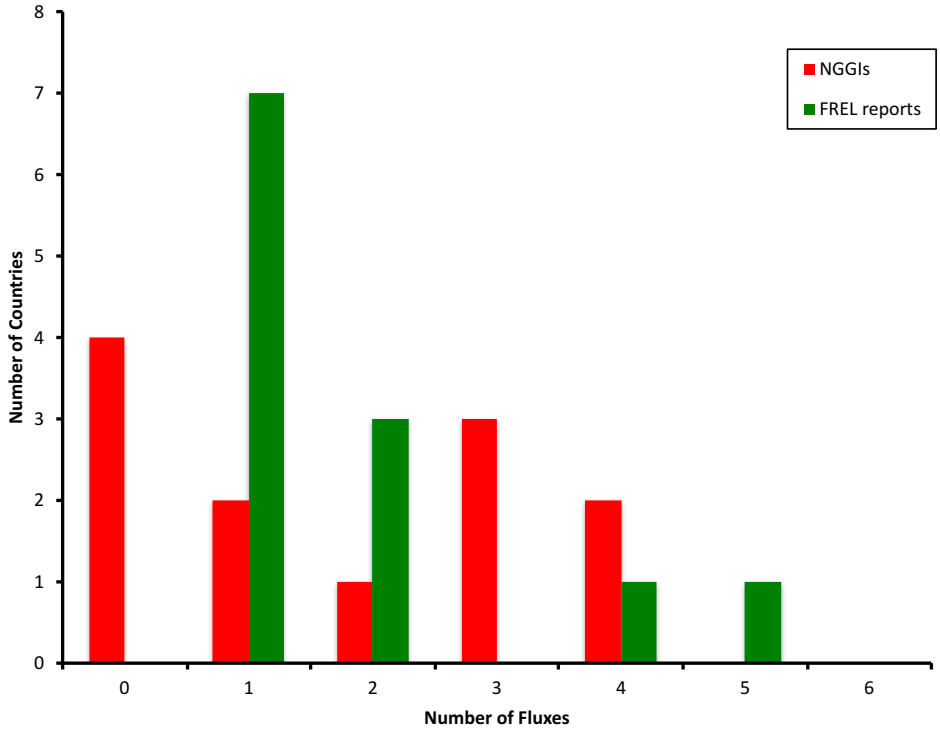
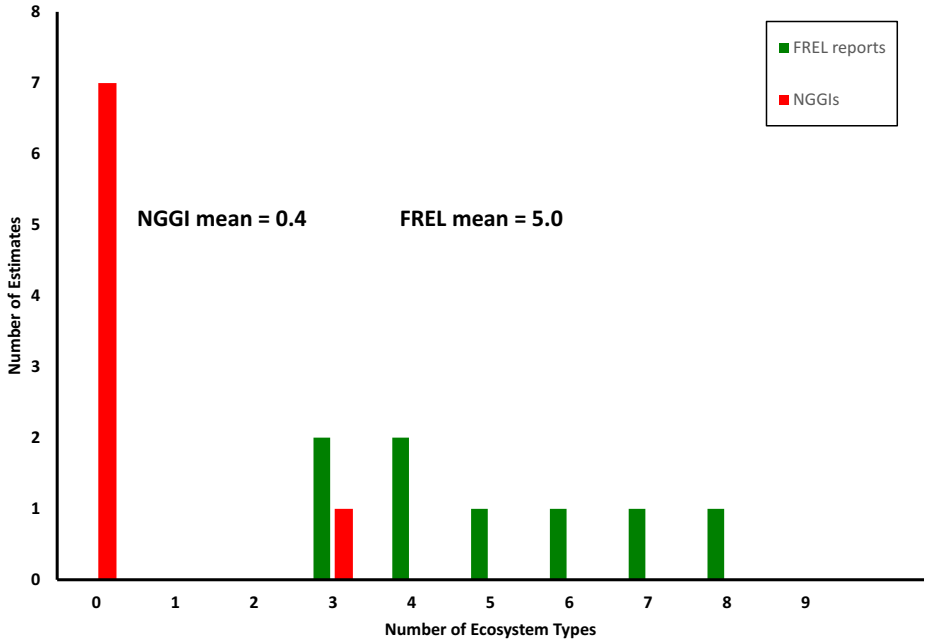


Figure S2. Completeness in reporting forest carbon fluxes to the UN Framework Convention on Climate Change in National Greenhouse Gas Inventories (NGGIs) and Forest Reference Emission Level (FREL) reports of twelve tropical countries [54-65, 66-77]: the number of forest carbon fluxes (up to a maximum of six) reported by different numbers of countries.



b. Number of ecosystem types in estimates

Figure S3. Understructuralization: the total numbers of (a) carbon pools and (b) ecosystem types in estimates of forest carbon emissions in the National Greenhouse Gas Inventories (NGGIs) and Forest Reference Emission Level (FREL) reports of eight tropical countries (see Table 5b) [67, 69-77].