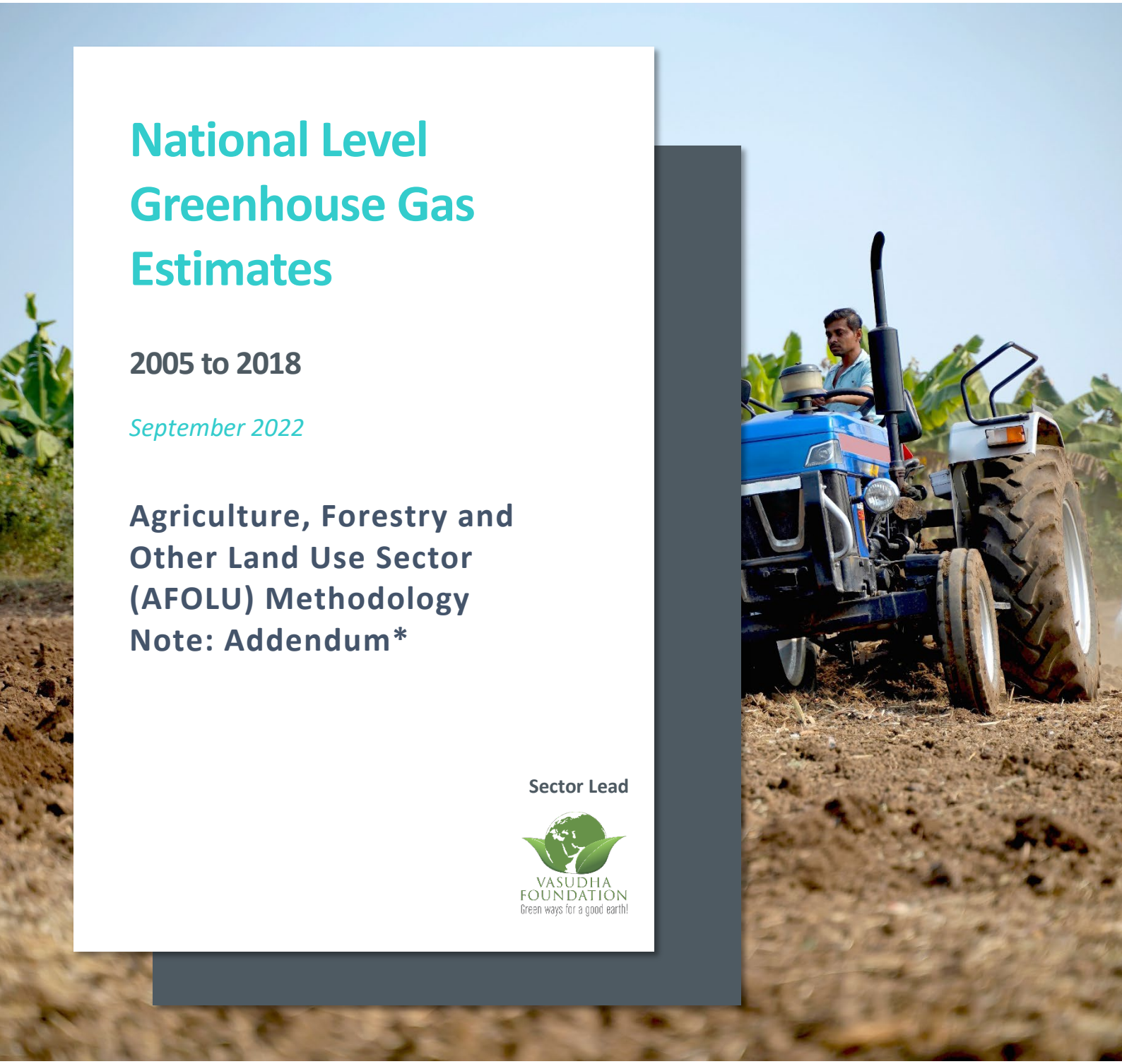
GHG Platform INDIA



National Level Greenhouse Gas Estimates

2005 to 2018

September 2022

Agriculture, Forestry and Other Land Use Sector (AFOLU) Methodology Note: Addendum*

Sector Lead

VASUDHA FOUNDATION
Green ways for a good earth!

CEEW THE COUNCIL | CIMMYT International Maize and Wheat Improvement Center | STEP CENTER FOR STUDY OF SCIENCE, TECHNOLOGY & POLICY | ICLEI Local Governments for Sustainability | VASUDHA FOUNDATION Green ways for a good earth!

*Phase IV methodology note is an addendum to the detailed methodology note of Phase-III.

Credits

Vasudha Foundation

Team Members

Shivika Solanki
Rini Dutt
Monika Chakraborty
Rahul Menon
Shubhi Gupta

Research Support

Mansi Dalal
Swati Gupta
Vrinda Vijayan

Reviewers

Raman Mehta
Srinivas Krishnaswamy

Editing & Design

Designed and formatted by – Strategic Outreach Team, Vasudha Foundation
Design reviewed by Communications Team (All Partner Organisations), GHG Platform India

Executive Summary[1]

KEY HIGHLIGHTS

- Emissions from the Agriculture, Forestry and Other Land Use (AFOLU) sector arise from three main sub-sectors: Livestock, Land and Aggregate Sources and Non-CO2 Emissions Sources on Land[2].
- The AFOLU sector contributed 170.58 Mt CO_2e (including Land sub-sector) to the total GHG emissions of India in 2018. However, the gross AFOLU emissions were 351.55 Mt CO_2e, these were offset by 180.97 Mt CO_2e removals of the Land sub-sector.
- GHG emissions from the AFOLU sector were dominated by two key source categories, viz., Enteric Fermentation and Rice Cultivation, which together account for approx. 76.60% of the gross GHG emissions from AFOLU (excluding the Land sub-sector) in 2018. However, Land as a whole was responsible for net removal of GHG emissions, removing nearly 51.48% of the gross AFOLU emissions in 2018.
- Emissions from the Livestock sub-sector (the key contributor to AFOLU) increased at a nominal CAGR of 0.007% between 2005 and 2018.
- In 2018, AFOLU sector contributed ~64% to the total economy-wide methane (CH_4) emissions and ~60% to the total N_2O emissions in India. While its share in net economy-wide emissions (in terms of CO_2e) was around 5.78%.

BACKGROUND INFORMATION OF GHG EMISSION ESTIMATES

The detailed emissions of each of the key source categories is given in Table ES1 as per the IPCC format.

Table ES 1: Overview of GHG Emissions Estimates by Gases and Sector for AFOLU sector

IPCC ID	Key Source category	GHG Emissions (2018)			
		Mt CO_2	Mt CH_4	Mt N_2O	Mt CO_2e[3]
3	AFOLU	-180.97	14.10	0.179	170.58
3A	Livestock		10.56	0.002	222.47
3A1	Enteric Fermentation		9.60		201.57
3A2	Manure Management		0.96	0.002	20.90
3B	Land	-180.97			-180.97
3B1	Forest Land	-145.03			-145.03
3B2	Cropland	-27.75			-27.75
3B3	Grasslands	0.58			0.58
3B5	Settlements	-0.22			-0.22
3B6	Other Lands	-8.55			-8.55
3C	Aggregate Sources and Non-CO_2 Emission Sources on land		3.54	0.177	129.07
3C1a	Emissions from biomass burning in forest lands		0.06	0.001	1.51
3C1b	Emissions from biomass burning in croplands		0.25	0.007	7.30
3C4	Direct N_2O emissions from managed soils			0.135	41.93

[1] GHG Platform India (GHGPI), is a collective civil-society initiative providing an independent estimation and analysis of India's greenhouse gas (GHG) emissions across key sectors. In this Phase, GHGPI provides national and state level emissions estimates from 2005 to 2018.

[2] The sub-sector called 'Aggregate Sources and Non-CO_2 Emissions Sources on Land' includes emissions from Rice Cultivation, Agriculture Soils, and Biomass Burning in Cropland and Forestland.

[3] CO_2e is calculated using GWP values as given in IPCC AR2 (as India reports using these values).

3C5	Indirect N_2O emissions from managed soils			0.034	10.63
3C7	Rice Cultivation		3.22		67.70

SUMMARY OF GHG SOURCES AND SINKS

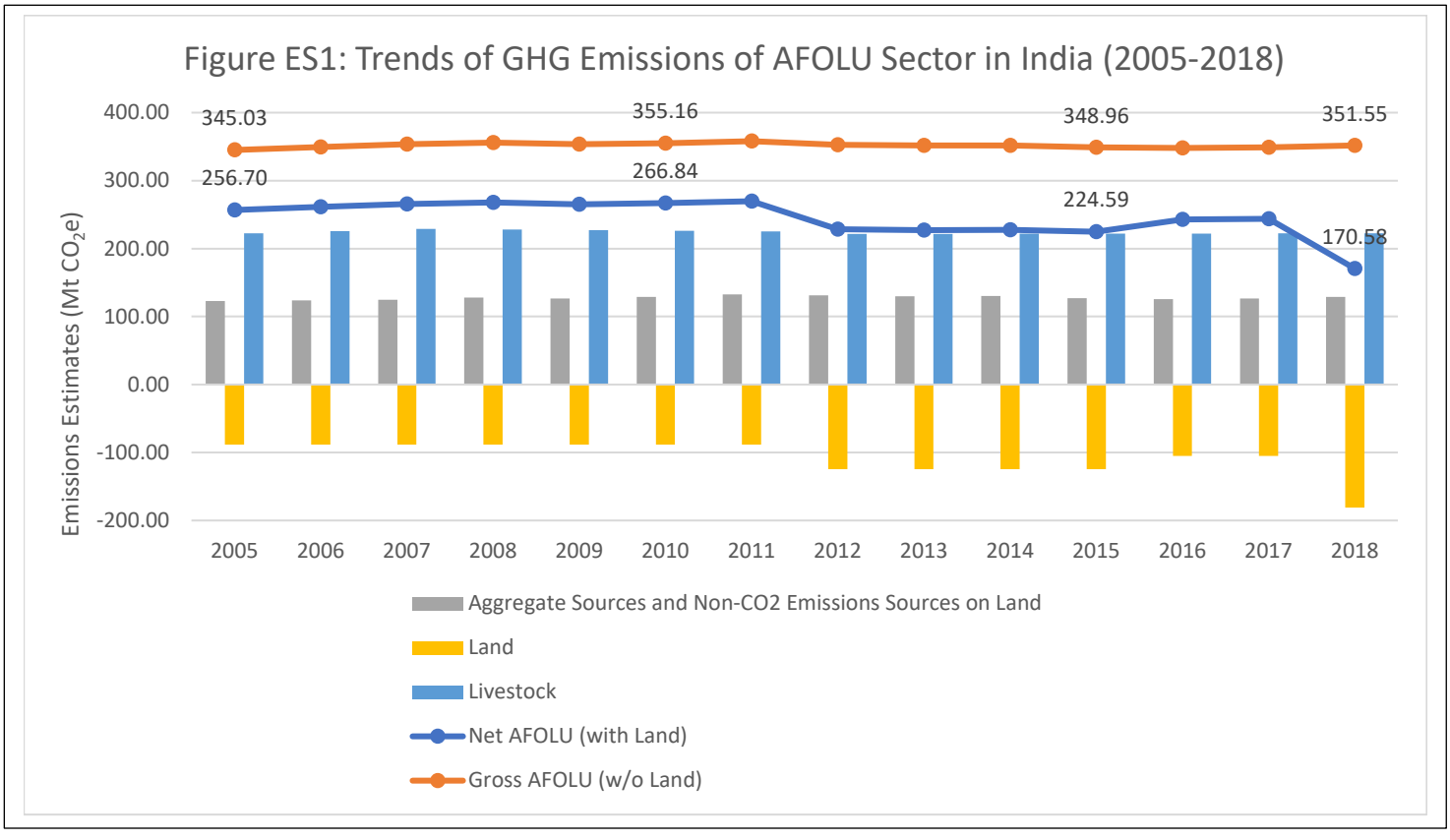
GHG emissions of the AFOLU sector mainly arise from three sub-sectors namely, Livestock, Land and Aggregate Sources and Non-CO_2 Emissions Sources on Land. Notably, the Land sub-sector was a net remover of GHGs while the other two sub-sectors were net emitters. In 2018, Livestock was the major contributor, representing 63.28% emissions, while Aggregate Sources and Non-CO_2 Emissions Sources on Land represented 36.72% of the gross AFOLU emissions (excluding Land sub-sector). India has a large cattle population in terms of both density and absolute numbers, which explains why the Livestock sub-sector is the leading contributor to AFOLU emissions.

The Land sub-sector, consisting of emissions/removals from Forest Land, Cropland, Grassland, Settlements and Other Lands, removed 51.48% of the gross AFOLU emissions in 2018.

SUMMARY OF GHG TRENDS

In general, during the period of estimation, the GHG emissions from AFOLU sector decreased, primarily due to increased removals from the Forest Land category of the Land sub-sector. The national GHG emissions have been calculated by adding up the state values for the categories.

The major trends of this sector are depicted in Figure ES1.



1. Introduction and Background

1.1 Context

The AFOLU GHG estimates reported in this document are part of a collaborative effort by *GHG Platform India* to create year-on-year estimates by aggregating and interpreting public data. The platform contributes to ongoing GHG estimating efforts by addressing data gaps and data accessibility concerns, expanding beyond national inventories, and improving analytics and policy debate on India's GHG emissions sources, profile, and related policies.

The greenhouse gases (GHG) accounted for in the AFOLU sector are *Carbon Dioxide (CO_2)*, *Methane (CH_4)* and *Nitrous Oxide (N_2O).* The *Carbon Dioxide equivalent (CO_2e)* emissions are calculated using global warming potential (GWP) and global temperature potential (GTP) from Intergovernmental Panel on Climate Change (IPCC) Assessment Reports: Second Assessment Report (SAR or AR2), 2007 and Sixth Assessment Report (AR6), 2021 (see Table 1.1).

Table 1.1: Global warming potential and global temperature potential as per IPCC assessment reports

Name of the gas	Formula	GWP		GTP	
		SAR	AR6	SAR	AR6
Carbon dioxide	CO_2	1	1	1	1
Methane	CH_4	21	27.90	5	5.38
Nitrous oxide	N_2O	310	273	270	233

Source: SEEG Website, SAR (IPCC 2006); AR6 (IPCC, 2021)

In this study, emissions were estimated from 2005 to 2018. 2005 was selected as the base year for these calculations since it is also the base year for India's NDC pledges. Due to lack of public data availability for the years post 2018, the current estimates are till 2018.

It may be noted that emissions from categories 3C1a Biomass Burning in Forestland and 3C1b Biomass Burning in Cropland were limited to the methodology available in NATCOM II in this assessment. Further, the following key source categories were excluded from the present GHG estimates due to lack of activity data and emission factors specific to IPCC 2006 methodology guidance:

- 3B4 Wetlands
- 3C1c Emissions from Biomass Burning in Grassland
- 3C1d Emissions from Biomass Burning in Other Land
- 3C2 Liming
- 3C3 Urea Fertilization
- 3C6 Indirect N_2O emissions from Manure Management

2. Trends analysis of GHG emissions from AFOLU

2.1 Overview of the sector

Emissions estimates for the AFOLU sector are as provided in Table 2.1, for the base year (2005) and the reporting year (2018):

Table 2.1: GHG emissions estimates for base year and current year (in Mt CO_2e)

IPCC ID	Source Category	GWP – SAR			GWP – AR6		
		2005	2018	% Change	2005	2018	% Change
3A	**Livestock**	222.26	222.50	0.10%	295.06	295.26	0.07%
3B	**Land**	-88.32	-180.97	104.89%	-88.32	-180.97	104.89%
3C	**AggregateSources and non- CO_2 emissions sources on land**	122.77	129.07	5.14%	143.15	146.93	2.64%

2.2 Trend of aggregated GHG emissions

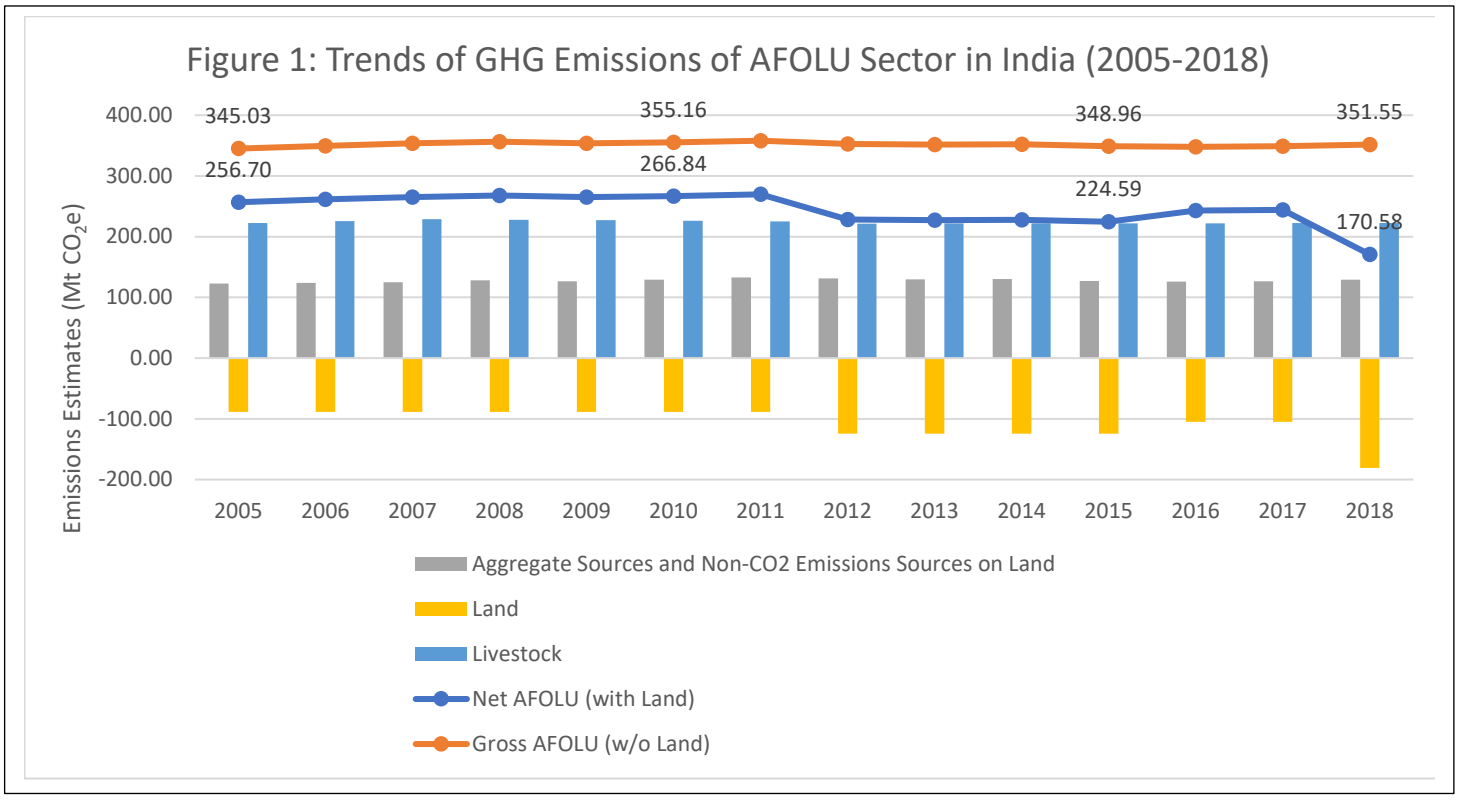
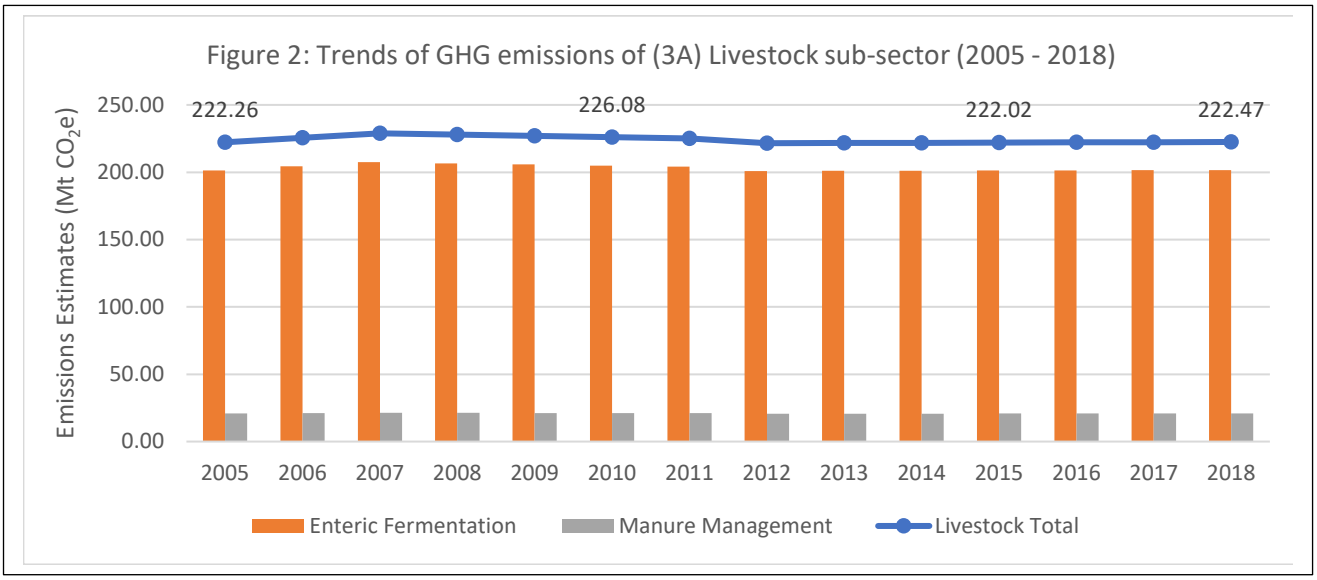


Figure 1 shows that the net AFOLU sector emissions declined at a CAGR of 3.09 per cent, from 256.70 MtCO_2e in 2005 to 170.58 Mt CO_2e in 2018. A slight decline in the net emissions was observed in the years 2011 and 2012, which can be attributed to the decrease in emissions from the Grasslands category of the Land sub-sector. Post 2012, emissions from Grasslands category remained steady, as reflected in the curve till 2015. Next, a slight increase in net AFOLU emissions observed in the years 2016 and 2017 can be attributed to the decline in removals from the Forest Land – caused by relatively smaller changes in forest area and reduction in carbon stock densities, as reported by FSI, 2019. In

2018, a significant reduction was observed in the net emissions from the sector. This decrease can be attributed to a significant increase in removals, caused by a relatively higher increase in the forest area as well as a marked increase in the overall carbon stock density in India as reported by FSI, 2021. Additionally, the highest contributor to AFOLU emissions i.e., the Livestock sub-sector showed nominal growth with CAGR of 0.008% and the growth in Aggregate Sources sub-sector was sluggish as well. Table 2.2 summarises emissions growth in sub-sectors between 2005 and 2018.

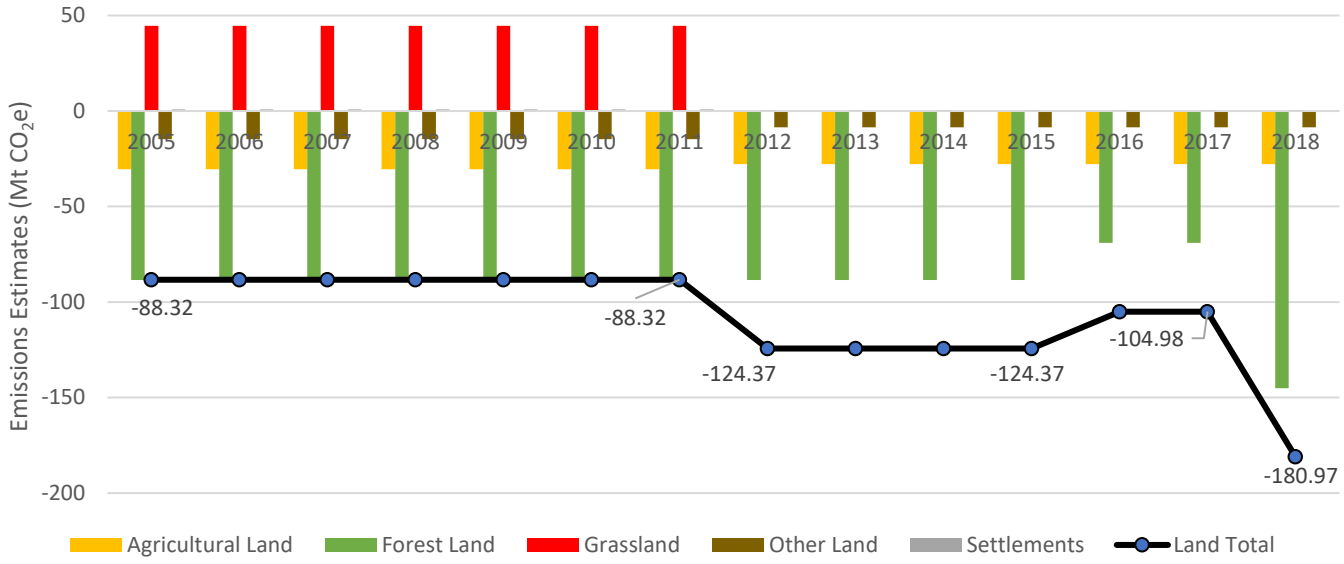
Table 2.2: AFOLU sector trend of GHG emissions estimates by sub-sector

Sub-sector	Emissions in Mt CO_2e (AR2)				% Change		
	2005	2010	2015	2018	2005-2010	2005-2015	2005-2018
Aggregate Sources and Non-CO_2 Emissions Sources on Land	122.77	129.08	126.94	129.07	5.14	3.40	5.14
Land	-88.32	-88.32	-124.37	-180.97	0.00	40.81	104.89
Livestock	222.26	226.08	222.02	222.47	1.72	-0.11	0.10



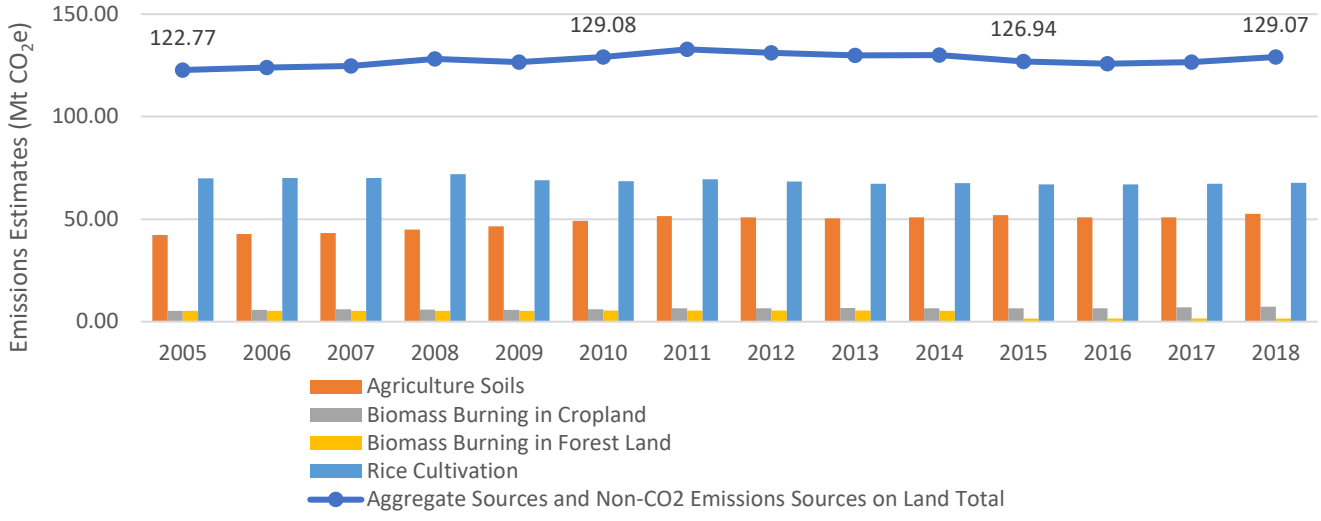
Emissions from the Livestock sub-sector arise from Enteric Fermentation and Manure Management. Emissions from this sub-sector were quite steady through the reference period. A marginal increase in emissions from this sector was observed in 2007 after which they decreased due to a decline in the livestock population. Overall emissions from the Livestock sub-sector grew at a CAGR of 0.007 per cent from 222.26 Mt CO_2e in 2005 to 222.47 Mt CO_2e in 2018. Out of the two categories in this sub-sector, Enteric Fermentation was the key source of emissions, contributing to 90.6 per cent of Livestock emissions in 2018 (see Figure 2).

Figure 3: Trends of GHG emissions of (3B) Land sub-sector (2005-2018)



As seen in Figure 3, CO_2 removals from the Land sub-sector increased at a CAGR of 5.67 per cent between 2005 and 2018. The removals from Land sub-sector were steady between 2005 and 2011. Post this, the removals increased from ~88 Mt CO_2e in 2011 to ~124 Mt CO_2e in 2012. This can be attributed to decline in emissions from Grassland category. Following this, the overall removals from the Land sub-sector decreased in the years 2016 and 2017 to ~105 Mt CO_2e. In 2018, the removals then grew rapidly to ~181 Mt CO_2e. This increase in removals in 2018 can be attributed to Forest Land category – due to the quantum of increase in forest area as well as changes in reported carbon stock densities. Forest Land accounted for 80.14 or 73.24 (removals only) per cent of this sub-sector's removals in 2018.

Figure 4: Trends of GHG emissions of (3C) Aggregate Sources and Non-CO_2 Emission Sources on Land sub-sector (2005-2018)



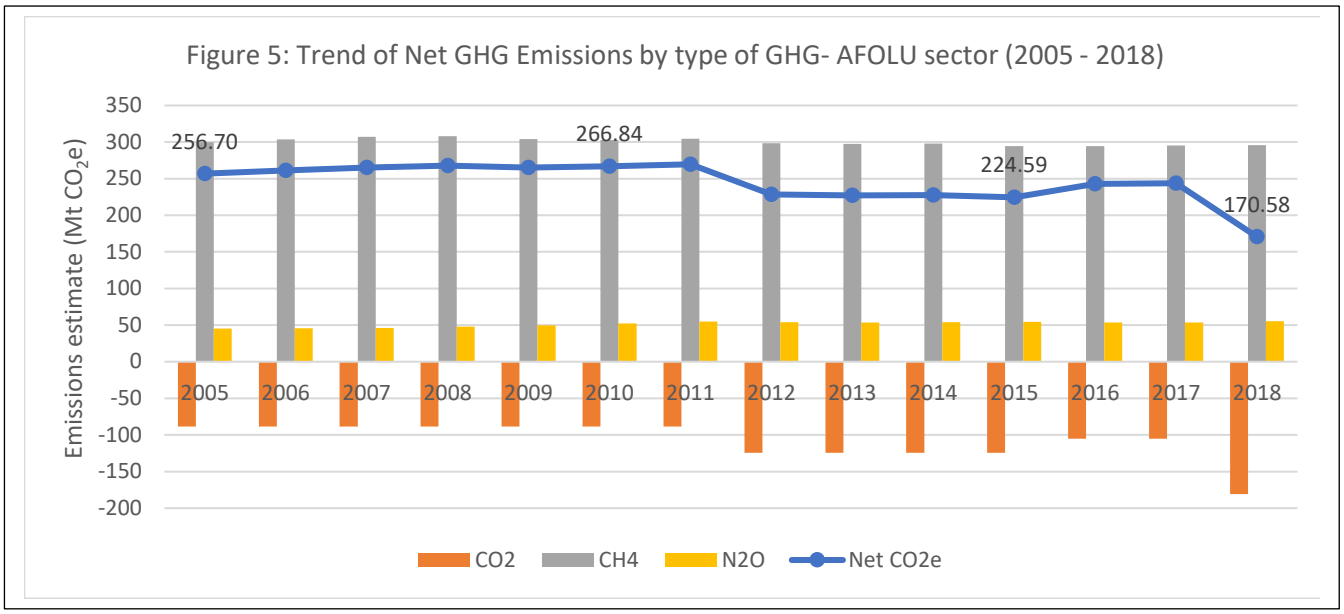
The overall emissions from Aggregate Sources and Non-CO_2 Emission Sources on Land sub-sector

increased marginally over the years with a CAGR of 0.39 per cent from 122.77 Mt CO_2e in 2005 to 129.07 Mt CO_2e in 2018. Rice cultivation contributed a major share of 51.20 per cent of the total emissions of this sub-sector followed by emissions from the Agriculture Soils (~42 per cent) in the year 2018 (see Figure 4).

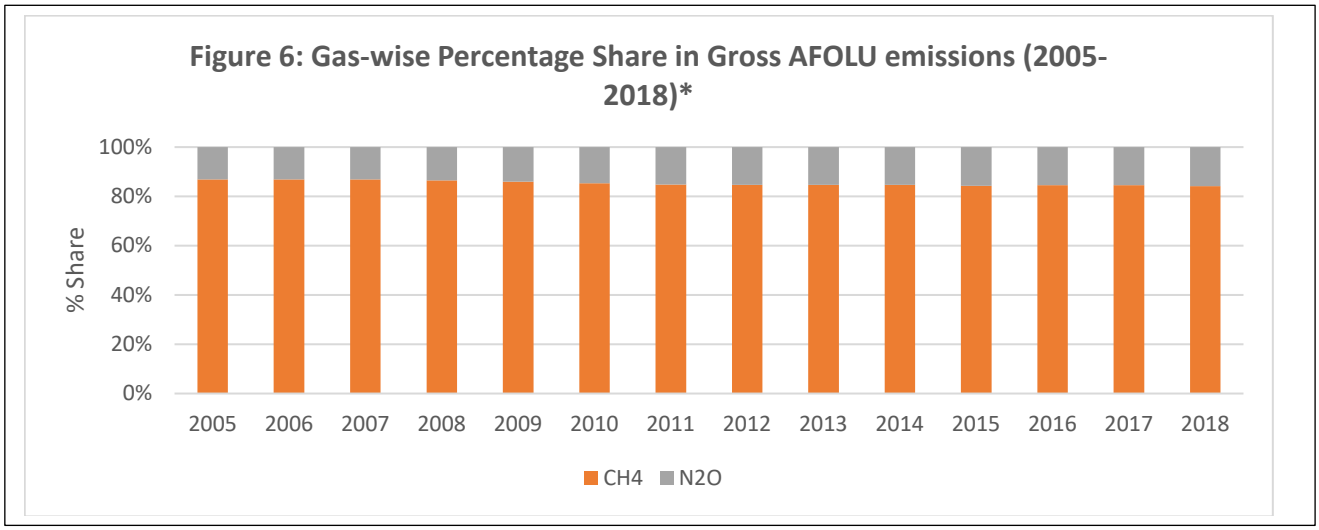
Thus, overall, the most important contribution of GHG emissions in the AFOLU sector can be attributed to the categories of Enteric Fermentation, Rice Cultivation and Agriculture Soils.

2.3 Trends in GHG emissions by type of GHG

The Trend of GHG emissions by the type of GHG is given in Figures 5. It is to be noted that emissions of all GHGs were converted to CO_2e using GWP of AR2. Notably, overall CO_2 gas emissions arising from Land sub-sector were removed throughout the reference period. CH_4 continued to be the highest contributor to AFOLU sector emissions across all the years. Emissions of N_2O were much smaller throughout the reference period (see Figure 6).



The overall share of CH_4 and N_2O in the gross AFOLU[4] emissions is illustrated below.



[4] Gross AFOLU emissions exclude emissions form Land sub-sector

*Share of gases is computed using unit of Mt CO_2e

Distribution of emissions from different key source categories is given in the Table 2.3 below.

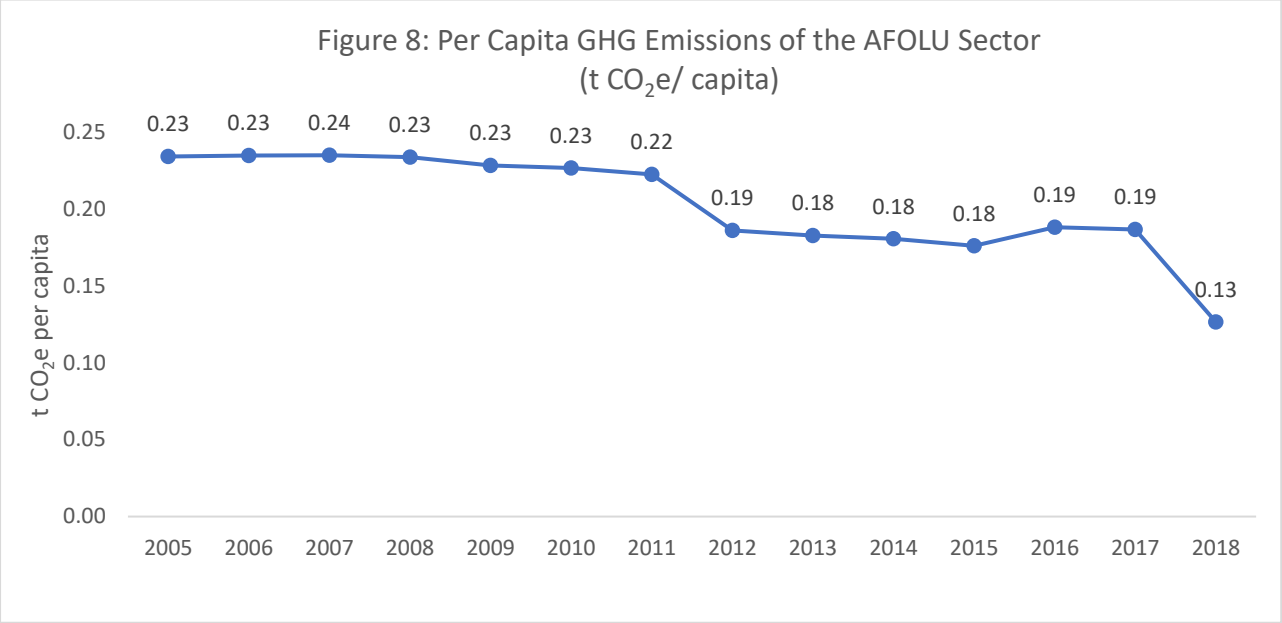
Table 2.3: Gas-wise contribution by sub-sectors within AFOLU sector (2018)				
IPCC ID	**Key source category**	**%CO_2**	**%CH_4**	**%N_2O**
3A	Livestock	-	74.92	1.27
3B	Land	100% (removals)	-	-
3C	Aggregate Sources and Non-CO_2 Emission Sources on Land	-	25.08	98.73

2.4 Key drivers of the emission trends in AFOLU sector

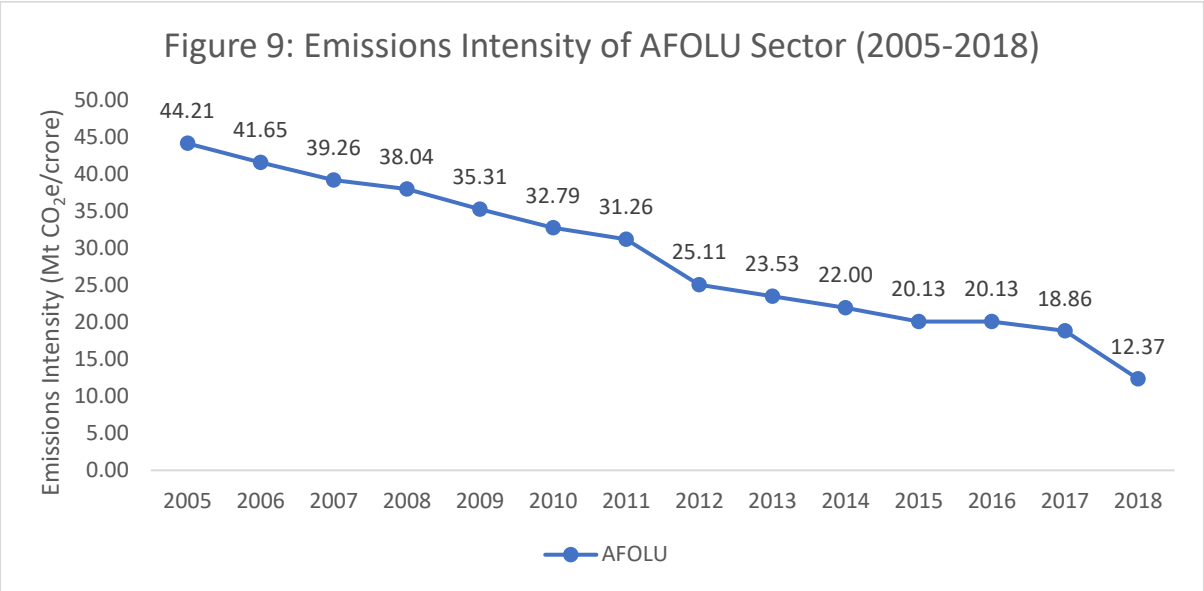
The key drivers of emissions from the AFOLU sector were Enteric Fermentation, Rice Cultivation, Agriculture Soils and Manure Management. Since these drivers were either stagnant or increased nominally, the gross emissions of the AFOLU sector remained stagnant through the reference period. The emissions estimates from each of the key source categories is elaborated in Table 2.4.

Table 2.4: Category-wise emissions contribution by sub-sector within gross AFOLU emissions (excluding Land sub-sector) (2018)			
GHG Emissions	**in Mt CO_2e**	**% of gross AFOLU emissions**	**Cumulative emissions (% of Gross AFOLU)**
Enteric Fermentation	201.57	57.34	57.34%
Rice Cultivation	67.70	19.26	76.60%
Agriculture Soils	52.57	14.95	91.55%
Manure Management	20.90	5.95	97.49%
Biomass Burning in Cropland and Forest Land	8.81	2.51	100%
Total (w/o Land)	351.55		

2.5 Per Capita and Emissions Intensity of AFOLU Emissions



The per capita GHG emissions of the AFOLU sector in India decreased at a compounded rate of 4.62% from 0.23 tCO_2e per capita in 2005 to 0.13 tCO_2e per capita in 2018 (see Figure 8). This decline in the per capita emissions from AFOLU can be attributed to the increase in removals from the Land sub-sector, particularly Forest Land category, coupled with an increase in the population of India.



As seen in Figure 9, the emissions intensity (emissions per unit of GDP at constant prices-2011-12 series) of India from AFOLU sector witnessed a downward trend at a compounded rate of 9.33% due to a decline in emissions from this sector coupled with a significant rise in India's GDP (GDP values are sourced from the Ministry of Statistics Planning and Implementation).

2.6 Comparison with National Inventories

Table 2.5: Category-wise details of deviation in AFOLU sector GHG emissions estimates between GHGPI and official inventories published by Government of India (2007 to 2016)

Key Source Category	% Deviation between GHGPI and INCAA (2007)	% Deviation between GHGPI and BUR I (2010)	% Deviation between GHGPI and BUR III (2011)	% Deviation between GHGPI and BUR III (2012)	% Deviation between GHGPI and BUR III (2013)	% Deviation between GHGPI and BUR III (2014)	% Deviation between GHGPI and BUR III (2015)	% Deviation between GHGPI and BUR III (2016)
3A1 Enteric Fermentation	-2.18%	-9.73%	-6.91%	-9.38%	-10.43%	-11.47%	-9.52%	-9.57%
3A2 Manure Management	778.64%	663.06%	-24.74%	-25.53%	-25.53%	-26.14%	-23.62%	-23.51%
3B1 Forest Land	30.43%	-55.79%	23.79%	23.79%	24.17%	29.64%	29.99%	-8.36%
3B2 Cropland	-85.29%	-72.44%	-81.38%	-90.72%	-90.73%	-88.84%	-88.79%	-88.99%
3B3 Grasslands	324.44%	-19.99%	60.47%	-94.50%	-94.51%	-96.61%	-97.22%	-97.26%
3B5 Settlements	2333.18%	-64.65%	128.62%	-95.11%	-95.17%	-86.00%	-85.96%	-87.62%
3B6 Other Land								
3C1a Biomass burning in forest land								
3C1b Biomass burning in cropland	-8.03%	-22.73%	-23.56%	-23.42%	-24.59%	-24.79%	-24.37%	-26.52%
3C4&**3C5** Direct and Indirect emissions from managed soils	-0.28%	-39.43%	-36.93%	-36.54%	-36.48%	-36.83%	-34.79%	-34.61%
3C7 Rice Cultivation	0.40%	-4.04%	-4.51%	-3.22%	-6.26%	-7.30%	-6.83%	-6.21%

The above table summarizes the deviation of emissions from AFOLU source categories as estimated during GHGPI Phase-IV exercise with respect to emissions as reported by the Government of India in the various national inventories. High deviations in Manure Management in 2007 and 2010 are observed between the national inventories and the GHGPI estimated. We cannot clearly explain these differences since the information regarding the methodologies and assumptions used in calculating the national inventories is not available in the public domain. Moreover, livestock category wise emissions are not provided for manure management in the national inventories. Instead, emissions are reported for the entire livestock category. However, with respect to the recent GoI inventories, the deviation of GHGPI estimates has significantly reduced for manure management. There is a noticeably high deviation in the Land sub-sector, particularly in the Settlements sub-sector. Deviation in emissions in this sub-sector can be attributed to the differences between underlying data used as well as aggregation and disaggregation of categories in the sub-sector. Other categories show relatively smaller deviations which can be attributed to changes in or access to more detailed activity source data and/or change in tier of estimation.

3. Methodology

3.1 Approach and emission factors used

The details of the methodological approach, as defined by IPCC, as well as the type of emission factors used, for estimation of GHG emissions under each sub-sector and category are summarized in Table 3.1 below

Table 3.1: Source category-wise details on tier approach and type of emission factor used

IPCCID	GHG source & sinkcategories	CO_2		CH_4		N_2O	
		Method Applied	Emission Factor	Method Applied	Emission Factor	Method Applied	Emission Factor
3A1	**Enteric Fermentation**					NA	NA
3A1a	Cattle	Not Applicable (NA)		T2	CS		
3A1ai	Dairy cows (Indigenous and Cross Bred)			T2	CS		
3A1aii	Other cattle or Non-dairycows (Indigenous and Cross Bred)			T2	CS		
3A1b	Buffalo (dairy and non-dairy)			T2	CS		
3A1c	Sheep			T2	CS		
3A1d	Goats			T2	CS		
3A1e	Camels			T1	D		
3A1f	Horses and ponies			T1	D		
3A1g	Donkeys			T1	D		
3A1h	Pigs			T1	D		
3A2a	**Manure Management**	NA					
3A2ai	Cattle			T2	CS	T1	D
3A2aii	Dairy cows (Indigenous and Cross Bred)			T2	CS		
3A2b	Other cattle or Non-dairy cows (Indigenous and Cross Bred)			T2	CS		
3A2c	Buffalo (dairy and non-dairy)			T2	CS		
3A2d	Sheep			T2	CS		
3A2e	Goats			T2	CS		
3A2f	Camels			T1	D		
3A2g	Horses and ponies			T1	D		
3A2h	Donkeys			T1	D		
3A2a	Pigs			T1	D		
3B	**Land**						
3B1	**Forest Land**	T2	CS	NA		NA	
3B2	**Cropland**	T2	CS				
3B2a	Cropland Remaining Cropland						
3B2bi	Forestland converted to Cropland						
3B2bii	Grassland converted to Cropland						
3B2biii	Wetland converted to Cropland						
3B2biv	Settlements converted to Cropland						

3B2bv	Other Land converted to Cropland						
3B3	**Grassland**	T2	CS				
3B3a	Grassland Remaining Grassland						
3B3bi	Cropland converted to Grassland						
3B3ii	Forestland converted to Grassland						
3B3iii	Wetland converted to Grassland						
3B3iv	Settlements converted to Grassland						
3b3bv	Other Land converted to Grassland						
3B5	**Settlements**	T2	CS				
3B5a	Settlements Remaining Settlements						
3B5bi	Forestland converted to Settlements						
3B5bii	Cropland converted to Settlements						
3B5biii	Wetland converted to Settlements						
3B5biv	Grassland converted to Settlements						
3B5v	Other Land converted to Settlements						
3B6	**Other land**	T2	CS				
3B6a	Other Land Remaining Other Land						
3B6bi	Forestland converted to Other Land						
3B6bii	Cropland converted to Other Land						
3B6biii	Grassland converted to Other Land						
3B6biv	Settlements converted to Other Land						
3B6bv	Wetland converted to Other Land						
3C	**Aggregate Sources**						
3C1a	Biomass burning in Forestland	NA		T2	CS		
3C1b	Biomass Burning in Cropland	NA		T1	CS	T2	CS
3C4	Direct N2O emissions from Managed Soils	NA				T1	CS
3C5	Indirect N2O emissions from Managed Soils	NA				T2	CS
3C7	Rice Cultivation	NA		T3	CS	T2	CS

3.2 Sector-wise Methodology Updates

IPCC Category	Activity Data Source	Emission Factor	Update to methodology, if any
3A1 Enteric Fermentation 3A2 Manure Management	Livestock Census of India for 2003, 2007, 2012 and 2019	NATCOM-II: Indigenous cattle, crossbred cattle and buffalo IPCC 2006: remaining categories Literature Review: Mahadeswara, S. and Shashirekha, V., (2003)	No updates to methodology.
3B1 Forest Land	State of Forest Reports published by Forest Survey of India 2005 to 2021	State of Forest Reports 2017, 2019 and 2021 FSI	It is assumed that the carbon stock density reported for a particular year, applies to the forest land for all the previous years until the year when Carbon Stock Density (CSD) has been revised. The state-level CSD (reported for the year 2015) obtained from SFR 2017 is applied to the range 2005 to 2015, since the previous reported value for state-level CSD is for the year 2004. The next reported CSD is in SFR 2019 (reporting for the year 2017). This carbon stock density is applied to the years 2016 and 2017. Similarly, the CSD reported in SFR 2021 is applied to the years 2018 and 2019. Therefore, the time-periods selected to assess change in carbon stock for the states is based on the reported carbon stock densities by FSI.

			Further, in consultation with sectoral experts, the national sink due to forests was estimated, which was then reconciled with the state values based on previous years' estimates. The rest of the methodology to estimate emissions/removals from Forest Land remains the same as the previous phase.
3B2 Cropland	EnviStats (2018, 2020) of Ministry of Statistics and Programme Implementation (MoSPI)	Biomass: BUR III SOC (Cropland, Grassland, Other lands): Sreenivas et al., 2016 SOC (Settlements): Sarkar et al., 2022 SOC (Wetlands): Chapter 2, IPCC 2006 Guidelines Stock Change Factors: Respective land-use category chapters, IPCC 2006 Guidelines	The methodology remains the same. Activity data obtained from EnviStats reports published by MoSPI (2018 and 2020). In addition to considering Cropland remaining Cropland, all Land converted to Cropland were considered, these include Forest Land converted to Cropland, Grassland converted to Cropland, Settlements converted to Cropland, Other lands converted to Cropland and Wetlands converted to Croplands. All country specific reference soil organic carbon values (SOC_{ref}) were obtained from Sreenivas et al (2016) except SOC_{ref} for settlements which was obtained from Sarkar et al. (2022). The default SOC_{ref} value for wetlands was obtained from Table 2.3, Chapter 2, Volume 4 IPCC 2006 Guidelines. The default stock change factors (F_{lu}, F_{mg}, and F_i) were obtained from Chapter 2 and the respective land category chapters in Volume 4, IPCC 2006 Guidelines
3B3 Grassland			The methodology remains the same. Activity data obtained from EnviStats reports published by MoSPI (2018 and 2020). In addition to considering Grasslands remaining Grasslands, all

			Land converted to Grassland were considered (all Land includes Forest Land, Cropland, Settlements, Other lands and Wetlands). All country specific reference soil organic carbon values (SOC_{ref}) were obtained from Sreenivas et al (2016) except SOC_{ref} for settlements which was obtained from Sarkar et al. (2022). The default SOC_{ref} value for wetlands was obtained from Table 2.3, Chapter 2, Volume 4 IPCC 2006 Guidelines. The default stock change factors (F_{lu}, F_{mg}, and F_i) were obtained from Chapter 2 and the respective land category chapters in Volume 4, IPCC 2006 Guidelines
3B5 Settlements			The methodology remains the same. Activity data obtained from EnviStats reports published by MoSPI (2018 and 2020). In addition to considering Settlements remaining Settlements, all Land converted to Settlements were considered (all Land includes Forest Land, Cropland, Grasslands, Other Lands and Wetlands). All country specific reference soil organic carbon values (SOC_{ref}) were obtained from Sreenivas et al (2016) except SOC_{ref} for settlements which was obtained from Sarkar et al. (2022). The default SOC_{ref} value for wetlands was obtained from Table 2.3, Chapter 2, Volume 4 IPCC 2006 Guidelines. The default stock change factors (F_{lu}, F_{mg}, and F_i) were obtained from Chapter 2 and the respective land category chapters in Volume 4, IPCC 2006 Guidelines

3B6 Other Lands			The methodology remains the same. Activity data obtained from EnviStats reports published by MoSPI (2018 and 2020). In addition to considering Other Land remaining Other Land, all Land converted to Other Land, were considered (all Land includes Forest Land, Cropland, Settlements, Grasslands and Wetlands). All country specific reference soil organic carbon values (SOC_{ref}) were obtained from Sreenivas et al (2016) except SOC_{ref} for settlements which was obtained from Sarkar et al. (2022). The default SOC_{ref} value for wetlands was obtained from Table 2.3, Chapter 2, Volume 4 IPCC 2006 Guidelines. The default stock change factors (F_{lu}, F_{mg}, and F_i) were obtained from Chapter 2 and the respective land category chapters in Volume 4, IPCC 2006 Guidelines
3C1a Biomass Burning in Forest Land	State of Forest Reports published by Forest Survey of India 2005 to 2021	BUR III, Reddy et al. 2017	No change in methodology in calculations for 2005 to 2014. For Biomass burning in forests, 2015 onwards, the average biomass burnt (in t/ha) as reported in BUR III is used to estimate Forest area burnt at all-India level. Further, the state wise burnt area was then apportioned in respect to state wise burnt area as given in *Reddy et al 2017*.
3C1b Biomass Burning in Cropland	Directorate of Economics and Statistics, Ministry of Agriculture (Latest APY state data and previous APY state data	NATCOM-II (Andreae and Merlet 2001) IPCC 2006, Jain et al. 2014	No change in methodology w.r.t. phase III
3C4 Direct N_2O emissions from Managed Soils	Indian Fertilizer Scenario, Department of Fertilizers, Ministry of Chemicals and Fertilizers Government of India	NATCOM-II, Bhatia et al., 2004	No change in methodology w.r.t. phase III

3C5 Indirect N_2O emissions from Managed Soils	Statistical Year Book, Ministry of Statistics and Programme Implementation	NATCOM-II, Bhatia et al. 2013	No change in methodology w.r.t. phase III
3C7 Rice Cultivation	Directorate of Economics and Statistics, Department of Agriculture and Farmer's Welfare, Government of India	NATCOM-II, Gupta et al., 2009, and Pathak et al., 2010	No change in methodology. Data source was updated, the new data source is from the Directorate of Economics and Statistics, Ministry of Agriculture. The portal gives year wise, state wise APY statistics.