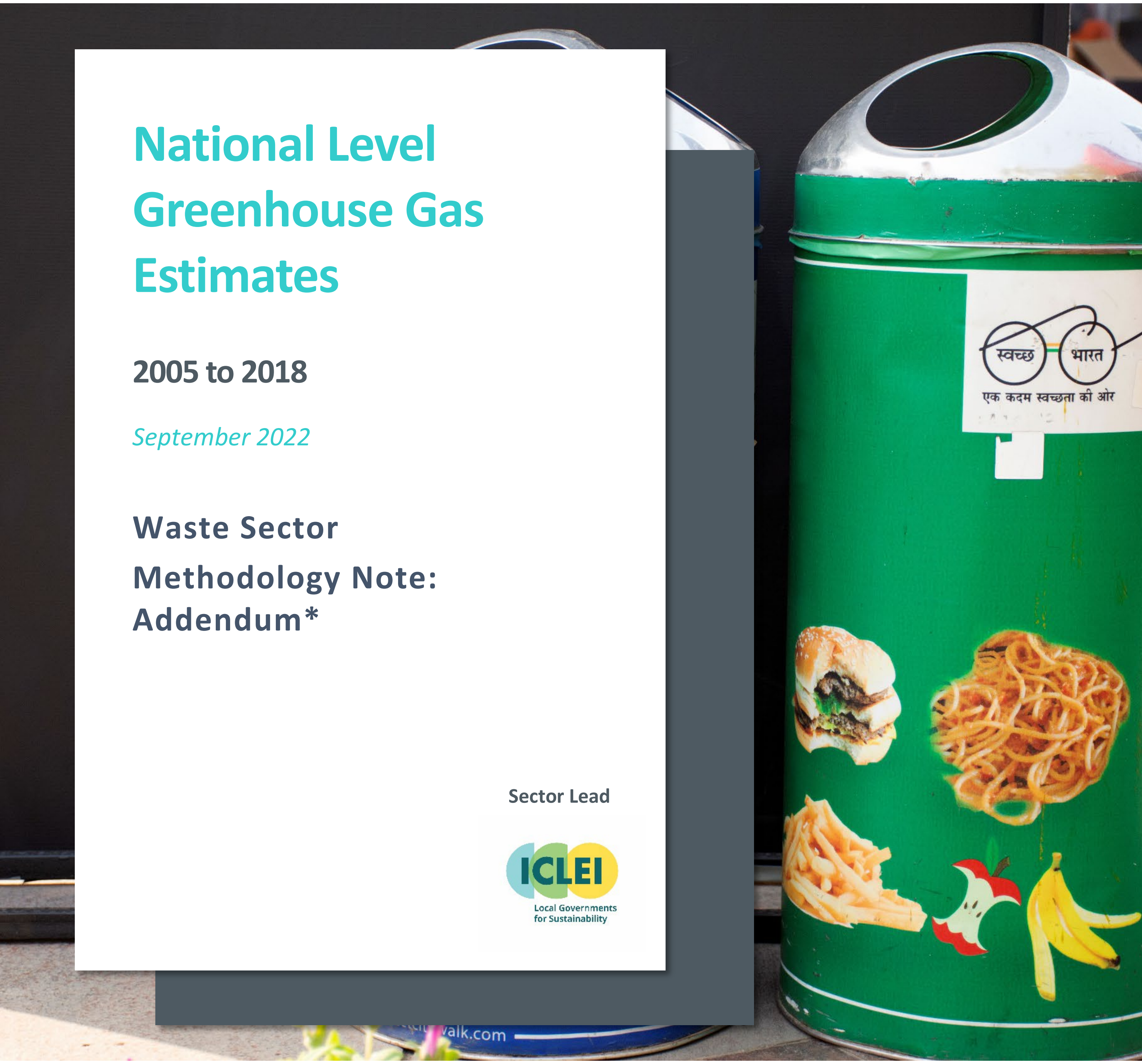
GHG Platform INDIA



National Level Greenhouse Gas Estimates

2005 to 2018

September 2022

Waste Sector Methodology Note: Addendum*

Sector Lead

ICLEI Local Governments for Sustainability

CEEW THE COUNCIL | CIMMYT International Maize and Wheat Improvement Center | CSTEP 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

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Contents

List of Tables

List of Figures

Executive Summary

Key Highlights

- In the Waste sector, domestic wastewater is the major contributing key source category over the reporting period (2005 to 2018) with an average share of 49.3%. It is followed by industrial wastewater (41.5%) and municipal solid waste (9.2%).
- Majority of the emissions during the estimation period of 2005 to 2018 occur from the release of CH_4 gas, followed by N_2O gas. Emissions of CH_4 gas contribute to around 83.8% of the overall GHG emissions with N_2O emissions contributing to the remaining 16.2% of cumulative emissions from 2005 to 2018.
- The states of Uttar Pradesh, Maharashtra, Gujarat, Andhra Pradesh, Tamil Nadu, and West Bengal contribute to 55.5% of the total Waste sector emissions from 2005 to 2018, which can be correlated to higher population size in these large states resulting in higher generation of solid waste and domestic wastewater, and significant organic wastewater generation from industries.

Background Information of GHG emissions in the Waste Sector

India's total GHG emissions for the Waste sector in 2018 are estimated to be 114.50 Million tonnes of CO_2e. The primary source of emissions is wastewater treatment and discharge with estimated emissions of 101.27 Million tonnes of CO_2e. Emissions from domestic wastewater and industrial wastewater amount to 63.76 Million tonnes of CO_2e and 37.51 Million tonnes of CO_2e respectively, while solid waste disposal contributes to emissions of 13.23 Million tonnes of CO_2e.

Waste management activities such as collection, treatment and disposal of solid waste and wastewater lead to GHG emission in the form of CH_4 and N_2O gases. CH_4 is the primary GHG emitted from solid waste disposal, domestic wastewater, and industrial wastewater and accounts for 83.8% of the cumulative Waste sector emissions in 2018 while N_2O emissions make up the remaining 16.2% of emissions from the sector.

Table 1: Snapshot of GHG estimates by gas and source category for Waste sector

IPCC ID	Key Source category	GHG Emissions in 2018		
		Million tCH_4	Million tN_2O	Million tCO_2e
4	**Waste**	**4.5**	**0.064**	**114.50**
4A	Solid Waste Disposal	0.63	0	13.23
4D	Waste water treatment & discharge	3.87	0.064	101.27
4D1	Domestic wastewater treatment & discharge	2.09	0.064	63.76
4D2	Industrial wastewater treatment & discharge	1.79	0	37.51

Summary of GHG sources and sinks

- Domestic wastewater treatment and discharge (4D1) has contributed the most to GHG emissions in the sector over the reporting period, accounting for 55.7% in 2018. Rising volumes of domestic wastewater in urban and rural areas across states, combined with the prevalence of systems/pathways with high GHG emission generation potential, such as septic tanks, inadequately managed aerobic treatment plants, and untreated discharge of domestic wastewater, result in higher emissions for this source category.

- Industrial wastewater treatment and discharge (4D2) contributed the second largest share of waste sector GHG emissions. Pulp and paper, Fertilizers and Meat Sectors are identified as the essential industries having high organic wastewater generation and GHG emission. The three industries combined contributed to 91.4% of the cumulative industrial wastewater emissions in 2018.

- Disposal of solid waste (4A) contributed to 11.6% of the aggregate emissions from the Waste sector in 2018, with emissions across states driven by higher waste generation, changing waste composition, and inadequate levels of waste processing leading to higher quantum of municipal solid waste going to disposal sites.

Summary of GHG trends

GHG emissions from the Waste sector have increased at a compound annual growth rate (CAGR) of 2.02% during the assessment period of 2005-2018.

- Emissions from solid waste disposal have registered the highest CAGR of 4.97% among the 3 sub-sectors.
- GHG emissions from domestic wastewater discharge have grown at CAGR of 2.93% while industrial wastewater emissions have increased at a CAGR of 0.03% from 2005 to 2018.

1. Introduction and Background

1.1 Context

This report has been developed as part of the GHG Platform India to help readers understand the process followed by ICLEI South Asia in calculating state level emission estimates for the waste sector and aggregating these further to estimate the national level emissions for the Waste Sector for the period 2005 to 2018.

1.2 GHG Coverage

The emission estimation scope covers three GHGs currently: Carbon Dioxide (CO_2), Methane (CH_4), and Nitrous Oxide (N_2O). Activities in the Waste sector lead to emission of two GHGs, namely CH_4 and N_2O, both of which are accounted under the estimates reported herein.

The 100-year Global Warming Potential (GWP) values for CO2, CH_4 and N_2O gases respectively, as provided by the Intergovernmental Panel on Climate Change (IPCC) in its Second Assessment Report, 1996 and the latest updated GWP values in IPCC's Sixth Assessment Report, 2022 have been referred while reporting the emission estimates in terms of CO_2 equivalent (CO_2e) (see Table 2).

Table 2: Global warming potential as per IPCC assessment reports

Name of the gas	Formula	Global Warming Potential (GWP)		Global Temperature change Potential (GTP)	
		SAR	AR6	SAR	AR6
Carbon dioxide	CO_2	1	1	1	1
Methane	CH_4	21	27.9	5	5.38
Nitrous oxide	N_2O	310	273	270	233

Source: IPCC Second Assessment Report, 1996 and Sixth Assessment Report, 2022

1.3 Key economic sectors covered

As per IPCC reporting structure, the following source categories and sub-categories under the Waste sector have been considered in the emission estimation. The relevant gases considered under each sub –category is also indicated below.

- 4A Solid Waste Disposal
  - 4A2 Unmanaged Waste Disposal Sites: CH_4
- 4D Wastewater treatment and discharge
  - 4D1 Domestic Wastewater Treatment and Discharge: CH_4 & N_2O
  - 4D2 Industrial Wastewater Treatment and Discharge: CH_4

The source categories and sub-categories considered for the state-level estimates are in line with India's national reporting documents i.e., (i) INCCA report[1] with estimates for the year 2007 (MoEFCC, 2012), (ii) 1st Biennial Update Report[2] to UNFCCC (BUR 1) with estimates for the year 2010 (MoEFCC,

[1] Available at: https://www.iitr.ac.in/wfw/web_ua_water_for_welfare/water/WRDM/MOEF_India_GHG_Emis_2010.pdf
[2] Available at http://unfccc.int/resource/docs/natc/indbur1.pdf

2015), (iii) 2nd Biennial Update Report[3] to UNFCCC (BUR 2) with estimate for the year 2014 and (iv) 3rd Biennial Update Report[4] to UNFCCC (BUR 3) with estimate for the year 2016.

1.4 Boundary of GHG estimates

The geospatial boundary of State-level GHG emission estimates for the Waste sector includes all the 36 states and union territories in India (referred to as 'states' throughout this document), spanning a geographical area of 3.28 million sq. km and housing a population of 1.2 billion as per Census 2011. Within this geographical boundary, emissions of CH_4 and N_2O from the source categories of '4A Solid waste disposal' and '4D Wastewater treatment and discharge' are included in this assessment.

The scope of emission estimation from solid waste disposal is limited to the urban areas within India given that rural areas lack the requisite waste management and disposal systems and thereby GHG emission generation can be insignificant in the absence of controlled/semi-controlled anaerobic conditions, in line with India's three national reporting reference documents.

1.5 Reporting Period

The time period for the state-level GHG emission estimations and subsequently aggregated national level GHG estimates is from 2005 to 2018. Through its Nationally Determined Contribution under the Paris Agreement, 2016, India has targeted reducing the emission intensity of its economy by 33–35% by the year 2030 as compared to that in the base year of 2005 (GoI, 2016). Therefore, this emission estimation exercise for the Waste sector has selected the same base year of 2005.

1.6 Institutional Information

ICLEI South Asia has been a partner of the GHG Platform-India since the platform's inception and has been leading the Platform's work on the Waste sector. Further information on ICLEI South Asia can be found at http://southasia.iclei.org/

The following staff members from ICLEI South Asia's Energy & Climate team, which handles ICLEI's portfolio of energy and climate mitigation projects, have been involved in the preparation of the emission estimates and this methodology note:

- Soumya Chaturvedula, Deputy Director: Provided strategic and expert inputs towards methodological approach for emission estimation and finalization of the methodology note.
- Nikhil Kolsepatil, Senior Manager- Energy & Climate: Led overall preparation and finalization of the emission estimates and the methodology document. Undertook review and inputs to finalize this document including methodological approach, identification of datasets, assumptions to close data gaps, finalization of emission estimates and this document for all sub-sectors.
- Prateek Mishra, Project Engineer – Energy & Climate: Coordinated and undertook tasks towards methodology preparation and finalization, data identification, collection and estimate preparation, review and finalization of data and inventory estimates for all sub-sectors.
- Anandhan Subramaniyam, Senior Manager- Energy & Climate: Provided inputs on data collection, research, validation and estimate preparation for the domestic wastewater sub-sector.

[3] Available at: https://unfccc.int/sites/default/files/resource/INDIA%20SECOND%20BUR%20High%20Res.pdf
[4] Available at: https://unfccc.int/sites/default/files/resource/INDIA_%20BUR-3_20.02.2021_High.pdf

1.7 Data collection process and Storage

To ensure that the estimates from the emission source categories represent the existing condition of waste management across the states in India, it has been sought to use Tier 1 and Tier 2 country-specific and state-level data in the assessment to the extent possible. The emission estimates are based primarily on aggregated secondary data collected by ICLEI South Asia from published documents and reports of relevant government departments, nodal agencies, and research institutions at the state as well as national level, including the Central Pollution Control Board (CPCB) and corresponding State Pollution Control Boards (SPCB), the National Environmental Engineering Research Institute (NEERI), various industry departments and associations, and the Ministry of Urban Development among others. Telephonic interactions were held with experts and representatives from bodies such as Central Paper & Pulp Research Institute among others to seek inputs on data availability.

The data collected was in various forms and units and has been assessed to ensure its applicability within the emission estimation boundaries and subsequently processed for further use. The emission estimation method, reporting period, boundaries, year-wise activity data, emission factors and relevant parameters along with data sources and any assumptions to address gaps, and state-level emission results have been transparently recorded in this reporting document and in excel spread sheets to provide clear understanding and to enable reconstruction of the emission estimations as required. All information collected and compiled for the emission estimates has been archived electronically in separate folders for future use as needed along with copies of relevant references or data sources. The final emission estimates and reporting documents are published and available on the GHG Platform India website (www.ghgplatform-india.org).

Summary of Extrapolations and Assumptions to address data challenges

4A Solid Waste Disposal

- Year-on-year data on municipal solid waste generation, waste composition across the states emission is lacking, with inconsistencies observed in reported data for states available from different sources.

4D1 Domestic Wastewater Treatment and Discharge

- Recent information on some parameters is not available in the public domain at all. This includes state-wise average per capita BOD value, average per capita protein intake and degree of utilization and hence previous year data from national publications have been used for the emission estimates
- As recent census survey has still not be published, state population data has been projected based on average state-wise growth between 2001 and 2011.

4D2 Industrial Wastewater Treatment and Discharge

- Information on industrial production for Tannery for the estimation period is not readily available in the public domain and hence data was extrapolated based CAGR in previous years
- Unavailability of reliable data on industrial production has been encountered in the state-level emission estimates. For certain industry sectors including petroleum, pulp & paper, iron & steel, rubber and sugar, the industrial production data is not available at the state-level. Thus state-wise production was apportioned/extrapolated based on previous year data set.

- Information on coffee production for the North-eastern states is not available and hence extrapolated based on previous year data set.

Further information on the data sources and assumptions considered for the three sub-sectors are provided in Annexures A, B and C.

1.9 Quality Control (QC) and Quality Assurance (QA)

Internal quality control (QC) procedures applied to the emission estimates include generic quality checks in terms of the calculations, processing, consistency, and clear recording and documentation as follows:

- The input activity data for each emission source sub-category has been selected from that available in different datasets by duly factoring in its relative time-series consistency and temporal and spatial applicability.
- The input data in the calculation sheets has been checked internally for transcription errors on a sample basis for all the three sub-sectors.
- The calculation spread sheets have been checked for correct application of formulae, activity and factors and to ensure that calculations are correct. Manual calculations have been carried out for a part of the state emission estimates in all 3 sub-sectors to verify the spread sheet results.
- Appropriate recording, conversions, processing and consistency of measurement units for parameters and emission has been checked across the reporting period.
- The state-wise emission estimates of each year of the reporting period have been compared to check for consistency in trends and detect any major deviations which cannot be correlated with corresponding changes in activity data and/or emission factors.
- A sheet providing an overview of sector, level of aggregation, reporting period, authors, reporting entity, version and usage policy has been included in the source category emission calculation spread sheets that are linked to the main emission reporting spread sheet. The state emission calculation equations, relevant data and parameter values used, intermediate formulae and cells wherein these are linked, and emission results are clearly depicted in the calculation spread sheets for all 3 sub-categories.
- The reporting document has been checked to confirm all relevant references and secondary sources for activity data and emission factors have been included and cited along with web links in line with the platform’s citation policy.

2. Trends and analysis of GHG emissions from Waste Sector

2.1 Overview of the sector

Emission estimates for the waste sector are provided below for the base year (2005) and the reporting year (2018):

Table 3: Aggregated GHG emission estimates for the Waste sector for 2005 and 2018

IPCC ID	Source Category	GHG Emission (Million tonnes of CO_2e) based on Global Warming Potential values from IPCC Second Assessment Report (SAR)[5]			GHG Emission (Million tonnes of CO_2e) based on Global Warming Potential values from IPCC Sixth Assessment Report (AR6)[6]		
		2005	2018	Percent change (2005-2018)	2005	2018	Percent change (2005-2018)
4	**Waste**	**88.23**	**114.50**	**29.77%**	**110.20**	**142.92**	**29.69%**
4A	**Solid Waste Disposal**	**7.05**	**13.23**	**87.66%**	**9.36**	**17.57**	**87.71%**
4A2	Unmanaged Waste Disposal Sites	7.05	13.23	87.66%	9.36	17.57	87.71%
4D	**Wastewater Treatment and Discharge**	**81.18**	**101.27**	**24.75%**	**100.84**	**125.35**	**24.31%**
4D1	Domestic Wastewater Treatment and Discharge	43.82	63.76	45.50%	51.21	75.77	47.96%
4D2	Industrial Wastewater Treatment and Discharge	37.36	37.51	0.40%	49.63	49.57	-0.12%

- The total aggregated GHG emissions from the Waste sector in India in the year 2018 are estimated to be 114.50 Million tonnes of CO_2e, representing an increase of 29.77% (or 26.27 Million tonnes of CO_2e) from 2005.
- GHG emissions from domestic wastewater treatment and discharge emissions grew by 49.01% (or 19.94 Million tonnes of CO_2e) to 63.76 Million tonnes of CO_2e in 2018 from 43.82 Million tonnes of CO_2e in 2005.
- GHG emissions from industrial wastewater treatment and discharge in 2018 is estimated to be 37.51 Million tonnes of CO_2e. Industrial wastewater related emissions increased by only 0.4% (or 0.15 Million tonnes of CO_2e) from 2005 to 2018.
- The contribution of solid waste disposal to GHG emission is estimated to be around 13.23 Million tonnes of CO_2e in the year 2018. Emissions from solid waste disposal have increased by 87.66% (an absolute increase of 6.18 Million tonnes of CO_2e) from the base year 2005.

2.2 Trend in aggregated GHG emissions

Treatment and discharge of domestic wastewater is the largest source of GHG emissions in India's Waste Sector, contributing to 55.7% of the aggregated state-level emissions from the sector in 2018.

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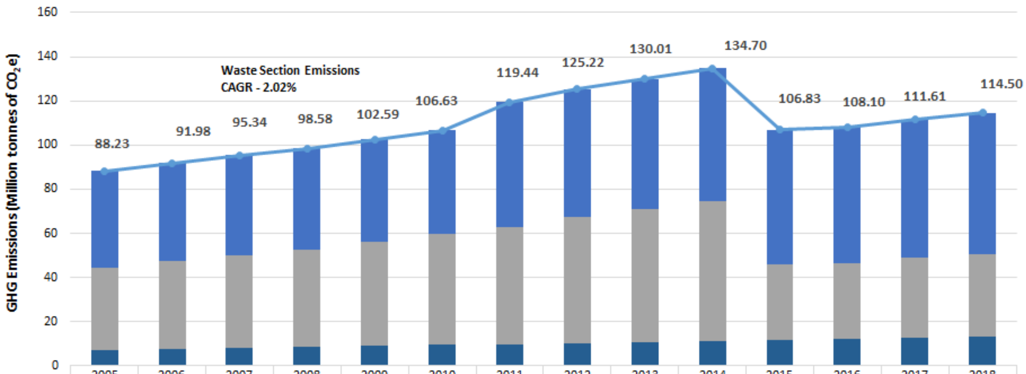
[5] 100-year GWP values specified for the 3 GHGs considered for the Waste Sector are CO_2: 1, CH_4: 21, N_2O: 310 as per the IPCC Second Assessment Report, 1996, Technical Summary, Table 4.
Available at https://www.ipcc.ch/ipccreports/sar/wg_I/ipcc_sar_wg_I_full_report.pdf

[6] 100-year GWP values specified for the 3 GHGs considered for the Waste Sector are CO_2: 1, CH_4: 27.9, N_2O: 273 as per the IPCC Sixth Assessment Report, 2014, Climate Change 2022: AR6 WGI Report, Table 7.SM.7
Available at:
https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter_07_Supplementary_Material.pdf

With a share of 32.8% in 2018, industrial wastewater treatment and discharge was the second largest contributor to the total Waste sector GHG emissions. Solid waste disposal accounted for 11.5% of the country's cumulative Waste sector GHG emissions in 2018.

From 2005 to 2018, GHG emissions from all three source categories portray an increasing trend with total emissions from the Waste sector rising at a CAGR of 2.02%. The trend of the overall aggregate emission is observed to be quite steady with a relatively higher rise between for the year 2010 and 2011 which can be correlated with the corresponding increase in the estimated state-level domestic wastewater emissions.



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Domestic Wastewater	43.82	44.53	45.24	45.76	46.36	47.06	56.79	57.90	58.92	60.02	61.04	61.75	62.76	63.76
Industrial Wastewater	37.36	39.90	42.07	44.30	47.25	50.12	52.74	56.94	60.23	63.42	34.12	34.18	36.14	37.51
Solid Waste Disposal	7.05	7.55	8.03	8.51	8.98	9.45	9.92	10.37	10.85	11.26	11.67	12.17	12.71	13.23
Waste Aggregated	88.23	91.98	95.34	98.58	102.59	106.63	119.44	125.22	130.01	134.70	106.83	108.10	111.61	114.50

All values in the table represented are in million tCO_2e

Figure 1: Trend of GHG Emissions from Waste Sector

The above graph shows a varying trend for the overall GHG emissions from the Waste sector during the assessment period. The aggregated GHG emissions during the assessment period (2005-2018) increased from 88.23 Million tonnes of CO_2e in 2005 to 114.50 Million tonnes of CO_2e in 2018. A linear increasing trend can be observed for the aggregated sectoral emissions until 2014, with a sudden decline in 2015. Between 2016 and 2018 a linear increasing trend is again observed. The decline in overall emissions in 2015 can be attributed to the decrease in emissions from industrial wastewater.

2.3 Trend in GHG emissions by type of GHG

The source categories covered in the assessment for the Waste sector results in emissions of two GHGs, CH_4 and N_2O. CH_4 is the primary GHG emitted from the waste sector and accounts for 83.8% of the total cumulative emissions between 2005 and 2018. The remaining 16.2% of the emissions during the said time period results from the emission of N_2O gas. N_2O emissions occur due to the presence of protein content in domestic wastewater and from its disposal into waterways, lakes or seas domestic wastewater.

The total CH_4 emissions from the Waste sector in the year 2018 amounted to 94.54 Million tonnes of CO_2e while N_2O emissions amounted around 19.96 million tonnes of CO_2e. Between 2005 and 2018, CH_4 emissions from the waste sector increased with a CAGR of 1.9% while N_2O emissions increase with a CAGR of 1.7%. Tonnes of CO_2e. CH_4 and N_2O emissions contributed to 82.3% and 17.7% of the sector's total GHG emissions respectively in 2005, as compared to a share of 82.6% from CH4 emissions and 17.4% from N2O emissions in 2018. However, despite an overall increase between 2005 and 2018, emissions of both CH_4 and N_2O portray a varying trend during the said assessment period, similar to that of the aggregate emissions trend. This can be observed in Figure 2 below.

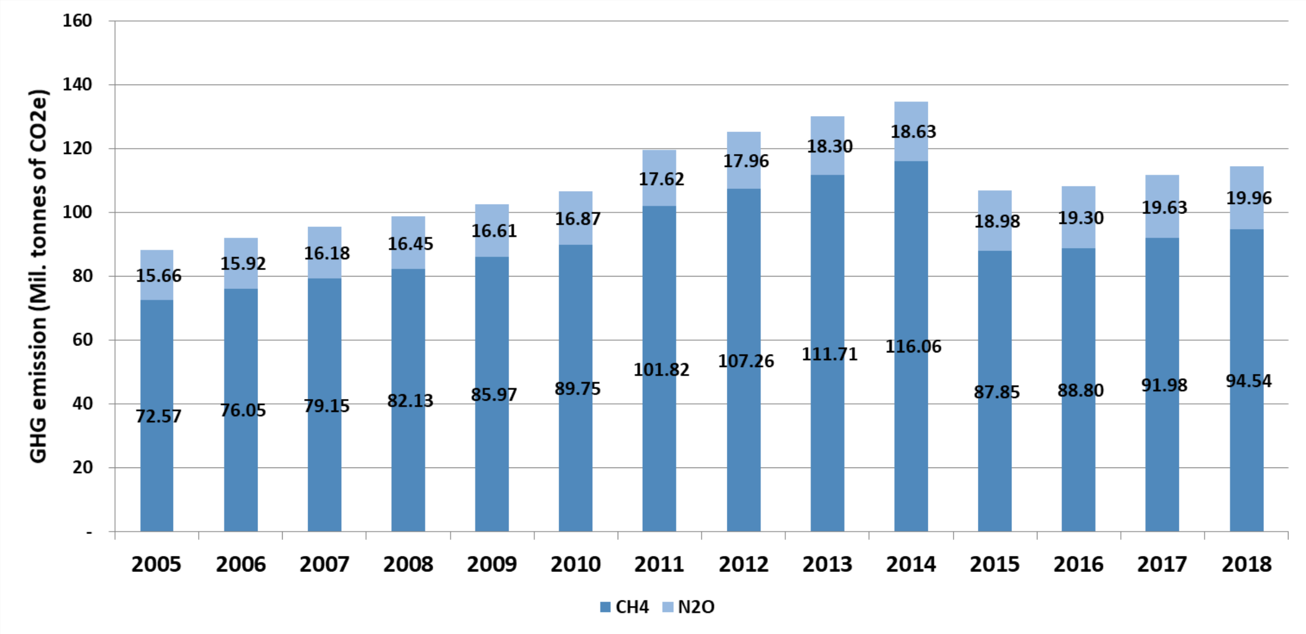


Figure 2: Trend of Gas-wise emission estimates for Waste Sector, 2005-2018

Table 4: Distribution of GHG emission contribution by source category for 2018

IPCC ID	Key source category	Share of CH_4 emission	Share of N_2O emission
4D	**Waste Sector**	**82.6%**	**17.4%**
4A2	Unmanaged waste disposal sites	100%	0%
4D1	Domestic Wastewater Treatment and Discharge	68.7%	31.3%
4D2	Industrial Wastewater Treatment and Discharge	100%	0%

2.4 Trend of GHG emissions from Source Categories

Table 5: Trend of GHG emission estimates by source categories

Source Category	Emissions in Million tonnes of CO_2e				Percent change		
	2005	2010	2015	2018	2005-2010	2010-2015	2005-2018
4. Waste	88.23	106.6	106.8	114.50	20.82%	0.19%	29.77%
4A2. Unmanaged Waste Disposal Sites	7.05	9.45	11.67	13.23	34.04%	23.49%	87.66%
4D1. Domestic Wastewater Treatment and Discharge	43.82	47.05	61.03	63.76	7.37%	29.71%	45.5%
4D2. Industrial Wastewater Treatment and Discharge	37.36	50.11	34.12	37.51	34.16%	-31.91%	0.40%

2.4.1 4A Solid Waste Disposal

GHG Emissions from disposal of municipal solid waste is noticed to have increased significantly between 2005 and 2018. Solid waste disposal contributed to cumulative GHG emission of 13.23 Million tonnes of CO_2e in 2018 as against 7.05 Million tonnes of CO_2e in 2005. The emissions from solid waste disposal grew 87.66% in absolute terms at a CAGR of 4.97% from 2005 to 2018.

Rising trends in GHG emission are primarily due to changes in the total quantum of solid waste, its composition, and the method of disposal and characteristics related to the disposal site. In the short-term for the reporting period from 2005-2018, the rise in solid waste disposal emissions is driven by increasing waste generation rates and growing population, resulting in higher quantum of solid waste going to disposal sites.

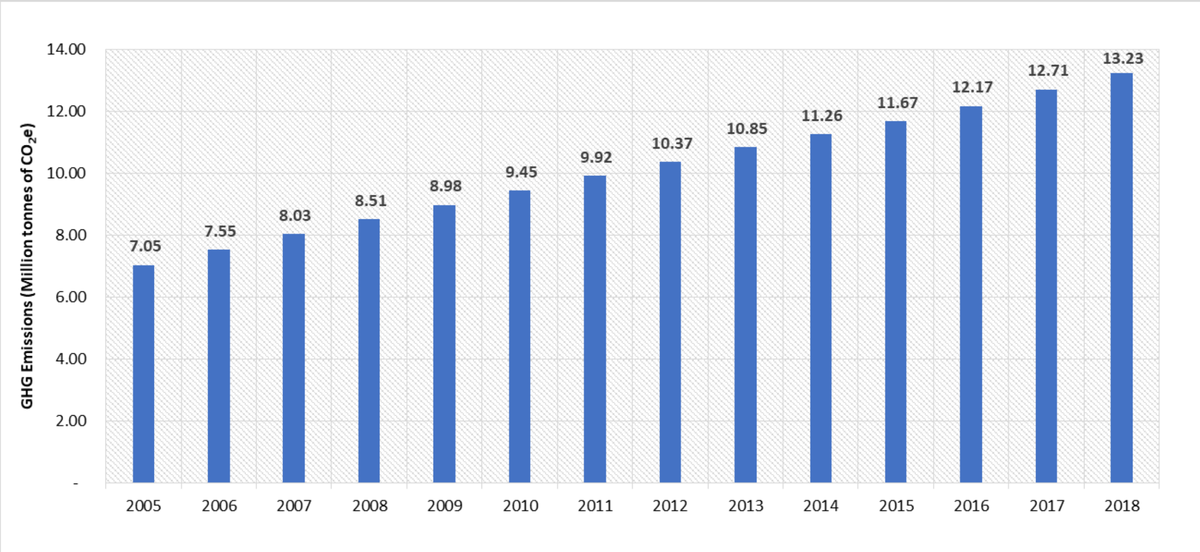
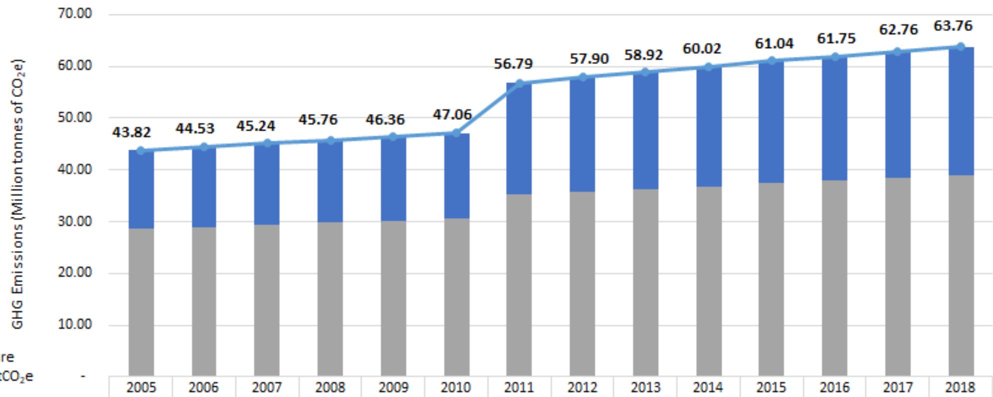


Figure 3: Trend of GHG Emissions from Solid Waste Disposal, 2005-2018

2.4.2 4D1 Domestic Wastewater Treatment and Discharge

In 2018, domestic wastewater treatment and discharge contributed to total GHG emissions of 63.76 million tCO_2e, up from 43.82 million tCO_2e in 2005. Between 2005 and 2018, emissions from this source category increased by 45.5% in absolute terms, at a CAGR of 2.93%. The trend of GHG emissions from domestic wastewater discharge and treatment is shown in the Figure 4 below.

Emissions from rural domestic wastewater in 2018 is estimated to contribute around 61% of the state aggregate domestic wastewater emissions, while the urban domestic wastewater is contributes the remaining 39%. The rural population, however, accounted for 72.19% and 68.85% of aggregated state population of India in the year 2001 and 2011 respectively. This corresponds to a significantly higher per capita emissions from urban areas. The per capita GHG emissions from domestic wastewater for the urban population in 2018 is estimated to be 53.46 kg CO_2e/person while for rural population it is estimated to be 43.05 kg CO_2e/person. As a result, per capita GHG emissions from urban household wastewater are approximately 24.18% greater in 2018 than per capita GHG emissions from rural domestic wastewater.

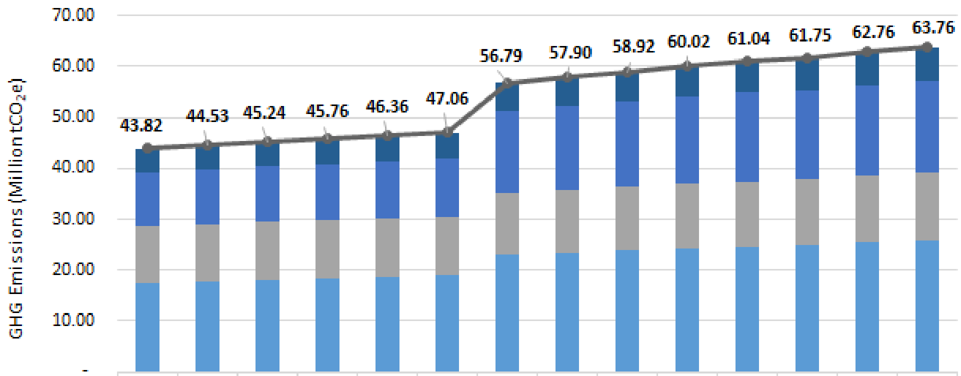


All values in the table are represented in Million tCO_2e

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Urban	15.25	15.55	15.85	15.96	16.17	16.46	21.55	22.11	22.56	23.18	23.64	23.80	24.24	24.68
Rural	28.57	28.98	29.39	29.80	30.19	30.60	35.23	35.79	36.36	36.84	37.40	37.96	38.52	39.08
Domestic Wastewater Aggregated	43.82	44.53	45.24	45.76	46.36	47.06	56.79	57.90	58.92	60.02	61.04	61.75	62.76	63.76

Figure 4: Trend of GHG Emissions from Domestic Wastewater Treatment and Discharge, 2005-2018

CH_4 emissions from urban domestic wastewater are estimated to be substantially larger than N_2O emissions, accounting for 72.96% of total GHG emissions. N_2O emissions account the remaining 27.04%. During 2005 to 2018, the CH4 emissions from urban domestic wastewater increased from 10.68 Million tonnes of CO_2e to 18.01 Million tonnes of CO_2e at a CAGR of 4.10% while the N_2O emissions increased to 6.67 Million tonnes of CO_2e in 2018 from 4.57 Million tonnes of CO_2e at a CAGR of 2.95%.



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
N2O Emissions (Urban) (tCO2e)	4.57	4.70	4.83	4.96	5.01	5.14	5.45	5.63	5.81	5.99	6.17	6.34	6.51	6.67
CH4 emission (Urban) (tCO2e)	10.68	10.85	11.01	11.00	11.16	11.32	16.11	16.48	16.76	17.19	17.47	17.46	17.73	18.01
N2O Emissions (Rural) (tCO2e)	11.09	11.22	11.35	11.49	11.60	11.73	12.17	12.33	12.49	12.64	12.81	12.96	13.12	13.28
CH4 emission (Rural) (tCO2e)	17.49	17.76	18.04	18.31	18.59	18.86	23.06	23.46	23.87	24.19	24.59	24.99	25.40	25.80
Total	43.82	44.53	45.24	45.76	46.36	47.06	56.79	57.90	58.92	60.02	61.04	61.75	62.76	63.76

All values in the tbale are prepresented in million tCO_2e

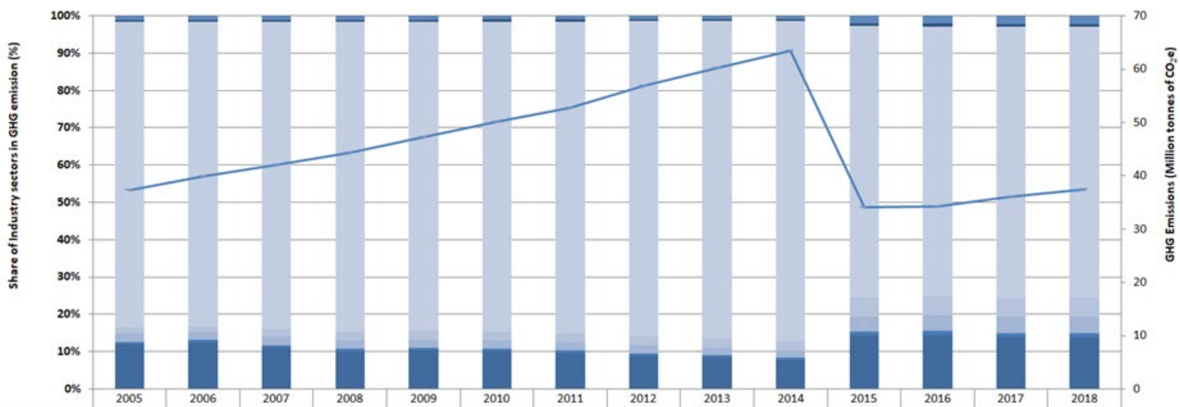
Figure 5: Gas wise aggregated GHG emission from Urban and Rural Domestic wastewater treatment and discharge, 2005-2018

In rural areas, CH_4 emissions from rural domestic wastewater increased at a CAGR of 3.04% to 25.80 Million tonnes of CO_2e in 2018 from in 17.49 Million tonnes of CO_2e in 2005. The increased emissions are most likely attributable to an increase in the volume of wastewater handled in rural regions, as reported by Census 2011, particularly in terms of the total percentage of rural households linked to septic tanks across states. N_2O emissions from rural domestic wastewater show a steady increasing growing with a CAGR of 1.4% to 13.28 Million tonnes of CO_2e from 11.09 Million tonnes of CO_2e over the reporting period.

2.4.3 4D2 Industrial Wastewater Treatment and Discharge

GHG emission estimates for industrial wastewater include 11 industrial sectors - Fertilizers, Meat, Sugar, Coffee, Pulp and Paper, Petroleum, Rubber, Dairy, Tannery, Iron and Steel, and Fish processing. Production activity in all 11 of these sectors results in generation of wastewater with significant organic load with potential to release CH_4 emissions, which is dependent on the type of wastewater treatment.

The cumulative GHG emission from industrial wastewater treatment and discharge has marginally increased from 37.36 Million tonnes CO_2e in 2005 to 37.51 Million tonnes CO_2e in 2018, at a CAGR of 0.003%. The trend of industrial wastewater missions can be seen in the figure 6 below.



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Fish processing	1.1%	1.1%	1.1%	1.1%	1.1%	1.0%	1.0%	1.0%	1.0%	1.0%	2.0%	2.1%	2.2%	2.3%
Tannery	0.6%	0.6%	0.6%	0.5%	0.5%	0.5%	0.5%	0.4%	0.4%	0.5%	0.7%	0.8%	0.7%	0.7%
Rubber	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Pulp & Paper	81.9%	81.6%	82.3%	83.1%	82.9%	83.2%	83.6%	84.5%	85.0%	85.7%	72.8%	72.1%	72.7%	72.6%
Meat	1.5%	1.4%	2.1%	2.3%	2.3%	2.3%	2.5%	2.5%	2.5%	2.5%	5.1%	5.3%	5.2%	5.2%
Dairy	2.3%	2.2%	2.2%	2.2%	2.2%	2.1%	2.1%	2.0%	2.0%	2.0%	4.0%	4.2%	4.2%	4.3%
Petroleum	0.3%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	0.4%	0.3%	0.3%	0.6%	0.7%	0.7%	0.7%
Coffee	0.4%	0.4%	0.4%	0.4%	0.4%	0.3%	0.3%	0.3%	0.3%	0.3%	0.6%	0.5%	0.5%	0.5%
Sugar	0.1%	0.1%	0.1%	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Fertilizers	11.8%	12.3%	11.0%	10.0%	10.2%	10.1%	9.6%	8.8%	8.4%	7.6%	14.1%	14.3%	13.8%	13.6%
Iron & Steel	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total CO2e emissions (Mil. tonnes)	37.36	39.90	42.07	44.30	47.25	50.12	52.74	56.94	60.23	63.42	34.12	34.18	36.14	37.51

Figure 6: Trend of GHG Emissions from industrial Wastewater Treatment and Discharge, 2005-2018

Figure 6 shows a varying trend in industrial wastewater emissions during the assessment period (2005 to2018). This varying trend can be attributed to changes in treatment technology/systems, wastewater characteristics and production technology leading to reduced wastewater generation. Pulp & Paper industry is the most critical industry type and is responsible for 72.6% of the total industrial wastewater emissions in 2018. It is followed by Fertilizers industry that contributes to around 13.6% of the total emissions.

2.5 State-wise analysis of emissions

About 55% of the cumulative waste sector GHG emissions in 2018 are contributed by six states of Uttar Pradesh, Maharashtra, Gujarat, Andhra Pradesh, Tamil Nadu, and West Bengal. The high percentage of emissions from these states is largely due to their big populations which result in higher volumes of domestic wastewater and solid waste production, and higher GHG emissions. These states also have greater levels of industrial activity and wastewater production which results in higher industrial wastewater emissions. State-wise GHG emissions between 2005 and 2018 are presented in Table 6 below.

Table 6: GHG estimates by State for Waste sector, 2005-2018

Name of the state	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Andaman & Nicobar	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05
Andhra Pradesh	7.65	7.98	8.26	8.57	9.07	9.36	10.45	11.28	11.74	9.18	6.28	6.54	6.81	6.94
Arunachal Pradesh	0.06	0.06	0.07	0.07	0.06	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09
Assam	1.66	1.71	1.77	1.81	1.87	1.89	2.05	2.22	2.36	2.55	2.03	2.02	2.07	2.11
Bihar	3.08	3.14	3.22	3.29	3.30	3.37	3.90	4.10	4.22	4.33	4.44	4.55	4.66	4.78
Chandigarh	0.09	0.10	0.10	0.05	0.05	0.05	0.25	0.26	0.26	0.26	0.27	0.16	0.16	0.17
Chhattisgarh	0.97	1.00	1.04	1.07	1.10	1.12	1.33	1.40	1.44	1.48	1.43	1.47	1.51	1.54
Dadra & Nagar Haveli	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04
Daman & Diu	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04
Delhi	1.25	1.30	1.35	1.37	1.39	1.44	1.65	1.71	1.77	1.80	1.86	1.93	1.99	2.04
Goa	0.25	0.26	0.26	0.26	0.28	0.27	0.28	0.26	0.28	0.30	0.30	0.30	0.30	0.30
Gujarat	9.20	9.72	10.05	10.38	11.00	11.67	12.39	13.47	14.23	14.77	9.55	9.48	9.86	10.11
Haryana	1.51	1.58	1.67	1.73	1.79	1.90	2.43	2.49	2.52	2.57	2.30	2.32	2.41	2.48
Himachal Pradesh	0.53	0.56	0.58	0.61	0.64	0.68	0.82	0.84	0.85	0.88	0.58	0.59	0.62	0.64
Jammu & Kashmir	0.58	0.61	0.63	0.65	0.68	0.70	0.83	0.85	0.88	0.90	0.86	0.89	0.92	0.94
Jharkhand	0.97	1.00	1.04	1.07	1.08	1.11	1.24	1.28	1.31	1.35	1.38	1.42	1.46	1.49
Karnataka	4.11	4.30	4.46	4.62	4.85	5.01	5.66	5.90	6.00	6.07	4.94	5.07	5.24	5.37
Kerala	3.00	3.10	3.15	3.25	3.36	3.50	3.61	3.71	3.80	3.88	3.51	3.61	3.73	3.84
Lakshadweep	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Madhya Pradesh	3.41	3.51	3.60	3.67	3.79	3.90	4.46	4.59	4.71	5.42	4.93	4.89	4.97	5.09
Maharashtra	8.95	9.33	9.71	10.04	10.51	11.02	11.92	12.31	12.52	13.17	10.78	11.01	11.41	11.77
Manipur	0.11	0.11	0.11	0.11	0.11	0.11	0.14	0.14	0.14	0.15	0.15	0.15	0.15	0.16
Meghalaya	0.12	0.12	0.13	0.13	0.13	0.13	0.16	0.16	0.17	0.17	0.18	0.20	0.20	0.19
Mizoram	0.06	0.06	0.06	0.06	0.06	0.06	0.08	0.09	0.09	0.09	0.09	0.10	0.10	0.10
Nagaland	0.11	0.11	0.10	0.11	0.11	0.11	0.15	0.15	0.15	0.15	0.14	0.14	0.14	0.14
Odisha	2.61	2.78	2.91	2.98	3.15	3.35	3.64	3.65	3.73	3.85	3.20	3.14	3.17	3.23
Puducherry	0.09	0.09	0.10	0.10	0.11	0.11	0.13	0.13	0.13	0.14	0.14	0.15	0.15	0.16
Punjab	4.10	4.31	4.52	4.77	4.99	5.29	6.29	6.46	6.86	7.00	4.64	4.64	4.87	5.00

Name of the state	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Rajasthan	3.32	3.38	3.47	3.53	3.61	3.68	4.22	4.31	4.44	4.62	4.55	4.64	4.73	4.83
Sikkim	0.04	0.04	0.03	0.03	0.03	0.04	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06
Tamil Nadu	7.57	7.85	8.10	8.37	8.83	9.32	9.86	10.47	11.34	11.9	8.59	8.66	8.99	9.30
Telangana	-	-	-	-	-	-	-	-	-	2.75	2.66	2.63	2.71	2.80
Tripura	0.15	0.15	0.15	0.16	0.17	0.18	0.19	0.20	0.20	0.21	0.21	0.22	0.22	0.23
Uttar Pradesh	13.76	14.40	15.03	15.65	16.05	16.72	18.85	19.85	20.91	21.50	16.99	17.15	17.62	18.05
Uttrakhand	3.03	3.28	3.48	3.69	3.90	4.27	4.75	4.95	4.84	5.03	2.79	2.80	2.96	3.05
West Bengal	5.81	5.97	6.14	6.30	6.44	6.13	7.46	7.76	7.86	7.98	6.79	6.97	7.20	7.36
Total GHG emissions	**88.23**	**91.98**	**95.34**	**98.58**	**102.59**	**106.63**	**119.44**	**125.22**	**130.01**	**134.70**	**106.83**	**108.10**	**111.61**	**114.50**

The maximum GHG emissions in 2018 are from the state of Uttar Pradesh which contributes around 15.8% of the cumulative Waste Sector emissions. It is followed by Maharashtra which contributes 10.3% of the cumulative emissions. Contribution of top six states in the total cumulative Waste emissions can be seen in figure 7.

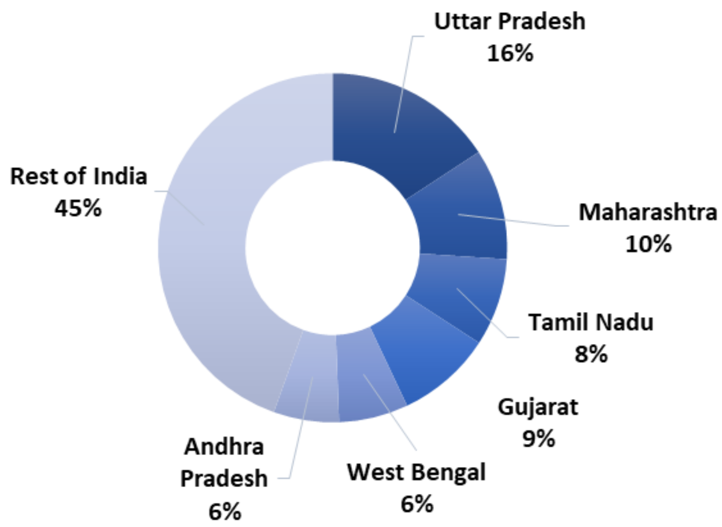
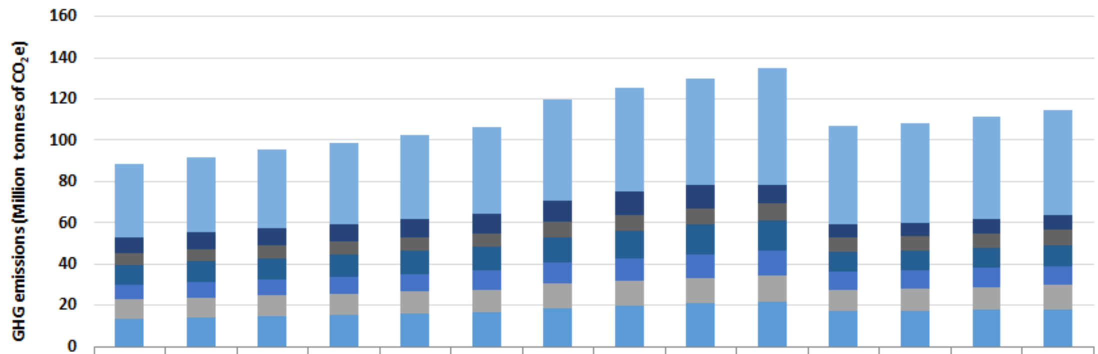


Figure 7: State Share in Cumulative Waste Sector GHG Emissions, 2018



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Rest of India	35.28	36.72	38.06	39.26	40.68	42.41	48.51	50.07	51.42	56.20	47.85	48.29	49.73	50.98
Andhra Pradesh	7.65	7.98	8.26	8.57	9.07	9.36	10.45	11.28	11.74	9.18	6.28	6.54	6.81	6.94
West Bengal	5.81	5.97	6.14	6.30	6.44	6.13	7.46	7.76	7.86	7.98	6.79	6.97	7.20	7.36
Gujarat	9.20	9.72	10.05	10.38	11.00	11.67	12.39	13.47	14.23	14.77	9.55	9.48	9.86	10.11
Tamil Nadu	7.57	7.85	8.10	8.37	8.83	9.32	9.86	10.47	11.34	11.90	8.59	8.66	8.99	9.30
Maharashtra	8.95	9.33	9.71	10.04	10.51	11.02	11.92	12.31	12.52	13.17	10.78	11.01	11.41	11.77
Uttar Pradesh	13.76	14.40	15.03	15.65	16.05	16.72	18.85	19.85	20.91	21.50	16.99	17.15	17.62	18.05

Figure 8: State-wise trend of Cumulative GHG Emissions from Waste Sector, 2005-2018

2.6 Key drivers of the emission trends in Waste sector

GHG emissions from the Waste sector portray a varying trend with a significant year on year increase until 2014. However, a notable decline is observed in 2015. Since 2016, a steady growth is observed. This varying trend results from the growth in industrial wastewater related emissions, which in turn stems from higher level of industrial activity (i.e. Industrial production) across states until 2014. The sudden decline in the source category emissions from 2015 onwards is due to changes in the treatment technology/systems, and wastewater generation per tonne of production and wastewater characteristics.

Growth of domestic wastewater emissions is driven by increased volumes of wastewater to be treated in both urban and rural regions due to population growth. Dependency of population on discharge/treatment systems with high GHG emission generation potential such as septic tanks, inadequately managed aerobic treatment plants, and untreated discharge of domestic wastewater is leading to higher emissions. GHG emission from solid waste disposal is observed to be rising due to growing population, increase in per capita waste generation, changing waste composition, and inadequate levels of waste processing over the emission estimation period.

3. Methodology

3.1 Sector-wise Methodology Updates

Table 7: Updates/ refinements to category wise methodologies

IPCC ID	GHG source & sink categories	Update to methodology if any
4A	Solid Waste Disposal	No updates to methodology. Solid Waste Generation data for Goa for the year 2015 has been updated
4D1	Domestic Wastewater Treatment and Discharge	No updates to methodology. Rural population estimates for the states have been updated. Minor discrepancies were identified in the calculation of Urban domestic wastewater emissions from 2005 to 2015 and thereby the emission estimation have been revised, with marginal changes in estimates.
4D2	Industrial Wastewater Treatment and Discharge	No updates to methodology. Organic concentration (i.e. characteristic of wastewater) (COD), Methane Correction Factors (MCF) of the effluent treatment systems and Wastewater generated per tonne of product for various industries have been updated as per the values used in the India's Third Biennial Update Report to the United Nations Framework Convention on Climate Change (BUR III)[4].

3.2 Approach and emission factors used

Table 8: Source category wise summary of tier approach and type of emission factor used

IPCC ID	GHG source & sink Categories	CO_2		CH_4		N_2O	
		Method Applied	Emission Factor	Method Applied	Emission Factor	Method Applied	Emission Factor
4A	Solid Waste Disposal	**NA**	**NA**	**T1, T2**	**D, CS**	**NA**	**NA**
4D1	Domestic Wastewater Treatment and Discharge	**NA**	**NA**	**T1**	**D**	**T1**	**D**
4D2	Industrial Wastewater Treatment and Discharge	**NA**	**NA**	**T1**	**D**	**NA**	**NA**

Notes: NA – not applicable

3.3 Recalculation

Recalculation of emissions has been carried out in all three sub-sectors to capture refinement in data based on updated information available.

3.3.1 4A Solid Waste Disposal

The methodological approach for the present estimation (version 4.0) has remained consistent as in the previous estimates. For solid waste disposal recalculation has been carried out for the year 2015.

The recalculation results from updation in the activity data on quantity of solid waste going to disposal site for the state of Goa in 2015. A comparison of the updated activity data across sector is presented in Table 9 and Table 10 below.

Table 9: Change in Activity Data for Goa state

Year	Total Waste sent to Solid Waste Disposal sites - Goa (TPD)		Percent difference w.r.t. Phase 3
	Phase 4	Phase 3	
2015	160.67	160.17	0.312%

Table 10: Recalculation of GHG emission estimates for Solid Waste Disposal

Year	GHG Emissions estimates from Solid Waste Disposal (tonnes of CO_2e)		Difference in GHG Emissions (tonnes of CO_2e)	Percent difference w.r.t. Phase 3
	Phase 4	Phase 3		
2015	11,669,559	11,669,533	26	0.0002%

3.3.2 4D1 Domestic Wastewater Treatment and Discharge

The methodological approach for the present estimation (version 4.0) has remained consistent as in the previous estimates. A recalculation for Domestic Wastewater Treatment and Discharge for both rural and urban agglomeration has been undertaken and reported in this note.

Emission estimates from domestic wastewater are directly proportional to following activity data parameters:

- Human Population
- Annual per capita protein consumption (Protein) (kg/capita/day)
- Extent of different discharge systems

In the current emission estimation process, the rural population figures were updated from 2005 to 2015 based on available information (see Table 11). Thereby, previous emission estimates for rural domestic wastewater (phase 3) have been recalculated and updated as noted in Table 12 below.

In addition, discrepancies/errors were identified in the calculation of urban wastewater emissions from phase 3. These errors have been rectified in the current phase 4 estimation, resulting in minor changes in urban waste emissions from 2005 to 2015 as compared to phase 3, as noted in Table 12 below.

Table 11: Comparison of Urban and Rural Population Estimates for Domestic Wastewater Treatment and Discharge

Domestic waste water	Population (Millions)	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Rural	Phase 4	778.96	788.04	797.13	806.21	815.29	824.38	833.46	843.95	854.85	865.12	876.01
	Phase 3	754.08	756.95	759.82	762.68	765.55	768.41	833.46	781.74	785.98	789.99	800.44
	Percent difference	3.30%	4.11%	4.91%	5.71%	6.50%	7.28%	0.00%	7.96%	8.76%	9.51%	9.44%

Domestic waste water	Population (Millions)	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	wrt Phase 3											

Table 12: Comparison of GHG emission estimates in phase 4 and phase 3 for Domestic Wastewater Treatment and Discharge with recalculation

Domestic waste water	GHG Estimates (Million tonnes of CO_2e)	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Rural	Phase 4	28.57	28.98	29.39	29.80	30.19	30.60	35.23	35.79	36.36	36.84	37.40
	Phase 3	28.25	28.58	28.91	29.24	29.56	29.89	34.40	34.96	35.44	35.83	36.39
	Percent difference wrt Phase 3	1.13%	1.40%	1.66%	1.91%	2.10%	2.33%	2.39%	2.35%	2.56%	2.76%	2.74%
Urban	Phase 4	15.25	15.55	15.85	15.96	16.17	16.46	21.55	22.11	22.56	23.18	23.64
	Phase 3	15.25	15.55	15.85	16.10	16.32	16.63	21.67	22.12	22.58	23.19	23.61
	Percent difference wrt Phase 3	-0.01%	0.005 %	0.02%	-0.87%	-0.90%	-1.04%	-0.54%	-0.05%	-0.07%	-0.04%	0.11%

3.3.3 4D2 Industrial Wastewater Treatment and Discharge

The methodological approach for the present estimation (version 4.0) has remained consistent as in the previous estimates. A recalculation of GHG emissions for Industrial Wastewater Treatment and Discharge has been undertaken and reported.

Emission estimates from industrial wastewater are directly proportional to following activity data parameters:

- Wastewater generation per tonne of product (m^3/tonne) (specific to each industry type)
- COD values for the wastewater (kg COD/m^3) (specific to each industry type)
- Methane Correction Factor (MCF) (based on broad treatment technology used by sector)

Based on information published in India's recent BUR 3 document, updated values of either one, two or all three of the said activity parameters have been used in the current emission estimates (version 4.0) for the industry sectors of Sugar, Coffee, Petroleum, Dairy, Meat, Pulp & Paper, Fish Processing, and Tannery. A comparison of the updated activity data across these sectors is presented in Table 12 below.

Table 13: Changes in Activity Data for Industry sectors

Industry Sector	Wastewater generation (m3/tonne of product) (2005-2018)			COD (kg COD/m3) (2005-2018)			MCF (2005-2018)			Source of updated activity data
	Phase 4	Phase 3	Difference w.r.t Phase 3	Phase 4	Phase 3	Difference w.r.t Phase 3	Phase 4	Phase 3	Difference w.r.t Phase 3	
Fertilizers	8	67	737.5 %	3	3	0.0%	0.2	0.3	50%	- Wastewater generation and MCF values from India's BUR 3 document - No change in COD value
Sugar	0.4	0.4	0.0%	2.5	5	-50.0%	0.8	0.8	0.0%	- COD values from India's BUR 3 document - No change in wastewater generation and MCF value
Coffee	15	15	0.0%	9	9	0.0%	0.80	0.8	0.0%	- Wastewater generation value from India's BUR 2 Report 2014 - No change in COD value
Petroleum	0.6	0.6	0.0%	1	1	0.0%	0.3	0.0	-	- MCF value from India's BUR 3 document - No change in COD and wastewater generation value
Dairy	6	6	0.0%	2.24	3	-25.3%	0.8	0.5	-37.5%	- COD and MCF values from India's BUR 3 document - No change in wastewater generation value
Meat	11.7	11.7	0.0%	5	5	0.0%	0.8	0.8	0.0%	- No change in values

Industry Sector	Wastewater generation (m3/tonne of product) (2005-2018)			COD (kg COD/m3) (2005-2018)			MCF (2005-2018)			Source of updated activity data
	Phase 4	Phase 3	Difference w.r.t Phase 3	Phase 4	Phase 3	Difference w.r.t Phase 3	Phase 4	Phase 3	Difference w.r.t Phase 3	
Pulp & Paper	57 (only for 2015)	127.5	-55.29 %	5.9	2	195%	0.8	0.8	0.0%	- Wastewater generation and COD value from India's BUR 3 document
Tannery	32	35	-8.57%	3.1	4.5	-31.1%	0.2	0.8	300%	Wastewater generation, COD and MCF values from India's BUR 3 document
Fish Processing	13	13	0.0%	2.5	2.5	0.0%	0.3	0.0	-	MCF value from India's BUR 3 document

Table 14: Recalculation of CH_4 emission estimates for Industrial Wastewater Treatment and Discharge

Year	CH_4 estimates from Industrial wastewater treatment and discharge (Million tonnes of CO_2e)		Percent difference w.r.t. Phase 3
	Phase 4	Phase 3	
2005	37.35	13.39	178.9%
2006	39.89	14.22	180.5%
2007	42.06	15.30	174.9%
2008	44.30	16.26	172.4%
2009	47.24	17.25	173.8%
2010	50.11	18.30	173.8%
2011	52.73	19.38	172.1%
2012	56.93	20.95	171.7%
2013	60.23	22.17	171.6%
2014	63.42	23.50	169.8%
2015	34.12	24.22	40.8%

Table 15: Comparison of GHG emission estimates in phase 4 and phase 3 for Industry Sectors with recalculation

Industry Sector	CH_4 Estimates (Million tonnes of CO2e)	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Fertilizers	Phase 4	4.42	4.91	4.62	4.42	4.84	5.05	5.04	5.02	5.05	4.85	4.81
	Phase 3	0.35	0.39	0.37	0.35	0.39	0.40	0.40	0.40	0.40	0.39	0.38
	Percent difference wrt Phase 3	1156%	1156%	1156%	1156%	1156%	1156%	1156%	1156%	1156%	1156%	1156%
Sugar	Phase 4	0.02	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03
	Phase 3	0.04	0.07	0.07	0.04	0.04	0.06	0.07	0.06	0.06	0.07	0.07
	Percent difference wrt Phase 3	-50%	-50%	-50%	-50%	-50%	-50%	-50%	-50%	-50%	-50%	-50%
Petroleum	Phase 4	0.12	0.13	0.14	0.15	0.17	0.18	0.19	0.20	0.21	0.21	0.22
	Phase 3	-	-	-	-	-	-	-	-	-	-	-
	Percent difference wrt Phase 3	-	-	-	-	-	-	-	-	-	-	-
Dairy	Phase 4	0.85	0.89	0.94	0.98	1.02	1.06	1.11	1.16	1.20	1.27	1.35
	Phase 3	1.81	1.91	2.01	2.10	2.18	2.28	2.39	2.48	2.58	2.72	2.90
	Percent difference wrt Phase 3	-53%	-53%	-53%	-53%	-53%	-53%	-53%	-53%	-53%	-53%	-53%
Pulp & Paper	Phase 4	30.59	32.54	34.62	36.83	39.18	41.68	44.07	48.09	51.17	54.33	24.84
	Phase 3	10.37	11.03	11.73	12.48	13.28	14.13	14.94	16.30	17.35	18.42	18.84
	Percent difference wrt Phase 3	195%	195%	195%	195%	195%	195%	195%	195%	195%	195%	32%
Tannery	Phase 4	0.22	0.23	0.23	0.24	0.24	0.25	0.25	0.25	0.27	0.29	0.25
	Phase 3	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10

Industry Sector	CH_4 Estimates (Million tonnes of CO2e)	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	Percent difference wrt Phase 3	176%	176%	176%	176%	176%	176%	176%	176%	176%	176%	152%
Fish Processing	Phase 4	0.41	0.43	0.45	0.47	0.50	0.52	0.54	0.57	0.61	0.64	0.68
	Phase 3	-	-	-	-	-	-	-	-	-	-	-
	Percent difference wrt Phase 3	-	-	-	-	-	-	-	-	-	-	-

4. Comparison with National Inventories

The aggregated emission estimates for the Waste sector under this assessment has been compared with the national level GHG estimates reported by the Government of India for the four reference points of 2007, 2010, 2014 and 2016.

Table 16: Source category wise deviation in GHG estimates between GHGPI and official inventories published by Government of India for Waste sector

Key source category	GHG emission estimates (Million tonnes of CO_2e)											
	2007			2010			2014			2016		
	INCCA	GHGPI	Difference	BUR 1	GHGPI	Difference	BUR 2	GHGPI	Difference	BUR 3	GHGPI	Difference
Solid Waste Disposal	12.69	8.03	-36.7%	13.96	9.45	-32.3%	15.07	11.26	-25.3%	15.83	13.23	-16.4%
Domestic Wastewater	22.98	45.23	96.8%	29.38	47.05	60.1%	36.68	60.01	63.6%	38.84	63.76	64.2%
Industrial Wastewater	22.1	42.06	90.3%	21.7	50.11	130.9%	26.49	63.42	139.4%	20.56	37.50	82.4%
Waste (Total)	**57.77**	**95.32**	**65.0%**	**65.04**	**106.61**	**63.9%**	**78.24**	**134.69**	**72.1%**	**75.23**	**114.49**	**52.2%**

Key Highlights

- The aggregated emission estimates for the Waste sector under this assessment have been compared with the national level GHG estimates reported by the Government of India for the three reference points of 2007, 2010, 2014 and 2016. GHGPI estimates for the Waste sector are seen to be higher than official estimates across the four years of 2007, 2010, 2014 and 2016, with domestic wastewater and industrial wastewater emissions estimated to be much higher than the Government of India estimates. The total Waste sector estimates have a deviation of 52.2% in 2016 as compared to official estimates reported in India's recent BUR 3 report.

- The aggregate GHGPI estimates for solid waste disposal show under-estimation, with a difference of -16.4% in 2016 as compared to official estimates reported in India's BUR 3. The reason for this deviation could be the variation in waste quantum generated and going to landfill, DOC value and urban population figure assumed in the estimation.

- The aggregate GHGPI estimates for domestic wastewater are higher than corresponding official inventory estimates from BUR 3, with a deviation of 64.2% in 2016. Variation in the proportion of treated and untreated wastewater as well as the consideration of rural domestic wastewater related emissions in the estimation, could be the cause of this difference. Another likely cause of deviation in emissions is the inclusion of rural domestic wastewater emissions in the GHGPI estimates. However the BUR 3 report does not provide clarity on whether CH_4 emissions from rural domestic wastewater are included in official estimates for 2016. Given the limited information in this regard in National Communication documents it is difficult to fully comprehend the underlying reasons for deviation in the GHGPI estimates and official inventory estimates for domestic wastewater.

- The aggregate GHGPI estimates for industrial wastewater show an over-estimation, with a difference of 82.4% in 2016 as compared to official estimates reported in India's BUR 3. The cause for this divergence could be the variation in activity data (production) for different industries and treatment technology assumed in the estimation.

Annexures

Annexure A: Data sources and Assumptions for Solid Waste Disposal

Activity Data/Emission Factor Parameter	Methodological Approach	Source
Solid Waste Disposal		
Activity Data		
Urban Population	• As reported for the years 1951, 1961, 1971, 1981, 1991, 2001 and 2011. • Year-wise population estimated on the basis of decadal population growth trends	Census of India
Mass of Waste deposited (W)	Mass of MSW generated has been estimated using data on urban population and the per capita waste generation. Average proportion of waste going to disposal site has been applied to calculate mass of waste that is deposited in dumpsites. a) Per capita waste generation: • Historical national-level data on urban per capita waste generation has been used to estimate the annual rate of change as indicated in the adjacent Table. The respective annual rates for different time periods as indicated have been applied to estimate per capita waste generation values for the states, using reported data in 2005 as a basis. • Information for Telangana is for the year 2014 based on the data reported by CPCB for year 2014-15 b) Proportion of waste to disposal site: • Reliable information at the state level on quantity or proportion of waste going to landfill is not available for the time period 1954-2010. Therefore, it is assumed that 70% of the generated waste goes to landfill during this period, in consonance with the assumption for National level estimates. • In the National level estimates 70% of the generated waste is assumed to go to landfill across the reporting period of 2005-2018. • In order to maintain consistency with National level estimates, in the case of states wherein the estimated proportion of	a) **Per capita waste generation**: • Waste Generation and Composition for 2004-05, Central Pollution Control Board (CPCB)[7], **Telangana:** Consolidated Annual Review Report on Implementation of municipal Solid Wastes Management and Handling) rules 2000, CPCB, 2014-15[8] b) **Annual growth rate for the per capita waste generation across different time periods** • TERI (1998): Looking Back to Think Ahead: Green India 2047' c) **Proportion of waste to disposal site:** • Consolidated Annual Review Report on Implementation of municipal Solid Wastes Management and Handling) rules 2000, CPCB, 2011-12[9] • Consolidated Annual Review Report on Implementation of municipal Solid Wastes Management and Handling) rules 2000, CPCB, 2013-14[10] • Consolidated Annual Review Report on Implementation of municipal Solid Wastes Management and Handling) rules 2000, CPCB, 2014-15[8] • Consolidated Annual Review Report on Implementation of municipal Solid Wastes Management and Handling) rules 2016, CPCB, 2015-16[11] • Consolidated Annual Review Report on Implementation of municipal Solid Wastes Management and Handling) rules 2016, CPCB,

[7] Available at: https://cpcb.nic.in/uploads/MSW/Waste_generation_Composition.pdf
[8] Available at: https://cpcb.nic.in/uploads/MSW/MSW_AnnualReport_2014-15.pdf
[9] Available at: https://cpcb.nic.in/uploads/MSW/MSW_AnnualReport_2011-12.pdf
[10] Available at: https://cpcb.nic.in/uploads/MSW/MSW_AnnualReport_2013-14.pdf
[11] Available at: https://cpcb.nic.in/uploads/MSW/MSW_AnnualReport_2015-16.pdf

Activity Data/Emission Factor Parameter	Methodological Approach	Source
	waste going to landfill is obtained as higher than 70%, a value of 70% is considered. • In the case of states wherein the estimated proportion of waste going to landfill obtained is lower than 70% , this estimated value has been retained for the years 2011-2018 for which reported data is available.	2016-17[12] • Consolidated Annual Review Report on Implementation of municipal Solid Wastes Management and Handling) rules 2016, CPCB, 2017-18[13] • Consolidated Annual Review Report on Implementation of municipal Solid Wastes Management and Handling) rules 2016, CPCB, 2018-19[14]
Emission Factors		
Degradable Organic Carbon (DOC)	• DOC values for the organic portion of the waste have been calculated using the IPCC default values for DOC content for the degradable fractions in waste (i.e. paper, rags, and compostable matter) and reported waste composition data across time periods. • The waste composition reported across the years of 1971, 1995 and 2005 is assumed to be applicable for time periods of 1954-1994, 1995-2004, and 2005-2018 respectively. Default DOC content values as per 2006 IPCC Guidelines: **Component** / **Default DOC Content values (Wet waste)[15]** Paper: 40% Rags: 24% Compostable Matter: 15%	**Default DOC content:** • 2006 IPCC Guidelines for National GHG Inventories, Vol. 5, Chapter 2: Waste Generation, Composition and Management Data, Table 2.5[16]. Waste composition from 1971 to 2005: • Integrated Modeling of Solid Waste in India (March,1999) CREED Working Paper Series no 26 and CPCB, 1999 • CPCB and NEERI (2005), Table 2, pg. 3[17] • CPHEEO Manual on Municipal Solid Waste Management-2016, Table 1.6[18]

[12] Available at: https://cpcb.nic.in/uploads/MSW/MSW_AnnualReport_2016-17.pdf
[13] Available at: https://cpcb.nic.in/uploads/MSW/MSW_AnnualReport_2017-18.pdf
[14] Available at: https://cpcb.nic.in/uploads/MSW/MSW_AnnualReport_2018-19.pdf
[15] As per 2006 IPCC Guidelines for National GHG Inventories, Vol. 5, Chapter 2: Waste Generation, Composition and Management Data, Table 2.5.
Available at http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_2_Ch2_Waste_Data.pdf
[16] Available at http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_2_Ch2_Waste_Data.pdf
[17] Available at https://www.cpcb.nic.in./uploads/MSW/Waste_generation_Composition.pdf?&page_id=waste-generation-composition
[18] Available at: http://cpheeo.gov.in/upload/uploadfiles/files/Part2.pdf

Activity Data/Emission Factor Parameter	Methodological Approach	Source
Fraction of Degradable Organic Carbon which decomposes (DOC_f)	0.5	IPCC 2006 Guidelines, Vol. 5. Chapter 3: Solid Waste disposal, Equation 3.7[19]
Methane Correction Factor (MCF)	MCF value taken as 0.4 as applicable for unmanaged shallow solid waste disposal sites with depths of less than 5 meters	IPCC 2006 Guidelines, Vol. 5. Chapter 3: Solid Waste disposal, Table 3.1[19]
Fraction of CH_4 in generated landfill gas (F)	0.5	IPCC 2006 Guidelines, Vol. 5. Chapter 3: Solid Waste disposal, Page 3.15[19]
Oxidation factor (OX)	0	IPCC 2006 Guidelines, Vol. 5. Chapter 3: Solid Waste disposal, Table 3.2[19]
Methane Recovery (R)	0	IPCC 2006 Guidelines, Vol. 5. Chapter 3: Solid Waste disposal, Section 3.2.3[19]
Reaction constant (k)	0.84	IPCC 2006 Guidelines, Vol. 5. Chapter 3: Solid Waste disposal, Table 3.3[19]

Annexure B: Data sources and Assumptions for Domestic Wastewater Treatment and Discharge

Activity Data/Emission Factor Parameter	Methodological Approach	Source
Domestic Wastewater Treatment and Discharge		
Activity data		
State population (P)	• Estimated based on the population figures and decadal population growth rates as per Census of India 2001 and 2011	Census of India, Ministry of home affairs, Government of India[20] **Telangana:** 'Statistical Year Book 2017', Directorate of Economics and Statistics, Hyderabad[21] **Andhra Pradesh**[22]

[19] Available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf
[20] Available at: https://niti.gov.in/planningcommission.gov.in/docs/data/datatable/data_2312/DatabookDec2014%20300.pdf
[21] Available at: https://www.telangana.gov.in/PDFDocuments/Statistical-Year-Book-2017.pdf
[22] Available at: https://www.ap.gov.in/wp-content/uploads/2016/01/2-AP-Demography.pdf

Activity Data/Emission Factor Parameter	Methodological Approach	Source
Domestic Wastewater Treatment and Discharge		
Per capita BOD in inventory year, g/person/day	• Per capita BOD value is assumed to be constant for the reporting period, due to lack of published year on year data. • Per Capita BOD values for selected states is available in the reference document. The national level per capita BOD values are used for the States where State-specific BOD values are missing.	National Environmental Engineering Research Institute (NEERI). 2010: Inventorisation of Methane Emissions from Domestic & Key Industries Wastewater – Indian Network for Climate Change Assessment
Degree of utilisation of treatment/discharge pathway or system, j, for each income group fraction i (Ti,j)	• The Treatment/Discharge pathways or systems are broadly classified by the 2006 IPCC Guidelines into Septic tank, Sewer, Latrine, Others and None.[23] • The degree of utilization of treatment/discharge pathway or system is based on the Latrine facility dataset, Census of India. • For 2001, data on number of households connected to Water closet, Pit Latrine, No latrine, pit latrine data is reported by the Census 2001 and available. The classification is however not as detailed as Census 2011 and therefore data for sub-categories such as Septic tank and Piped sewer system in "Water closet", and Public latrine in "No latrine" is not available in Census 2001 data. Data from the year 2011 is used to find the degree of utilization of Septic tank, Sewer and Public latrine of the year 2001. • The degree of utilization of treatment system is estimated for the year 2001 and 2011 is used from 2005 to 2010 and 2011 to 2018 respectively. **Piped sewer:** The STP capacity that is operational in the GHG emission estimation period (2005 to 2018) is identified from CPCB and STP performance evaluation reports. Based on the technology the aerobic and anaerobic categorization of STP is done. The STPs that are installed and not operational are considered to be 'collected and not treated'. These values (aerobic STP percent, anaerobic STP percent & collected	2006 IPCC Guidelines, Vol. 5, Chapter 6: Wastewater Treatment and Discharge, table 6.5 Census of India – Availability and type of Latrine facility: 2001 – 2011 (For Urban and Rural data) **Sewage Treatment Plant data** **1999:** CPHEEO (2005): Status of Water Supply, Sanitation and Solid Waste Management in Urban Areas. Estimated based on reported information referred from Appendix 2: Table B-2 and Table B-3.[24] **2008-09:** CPCB (2008): Evaluation of Operation and Maintenance of Sewage Treatment Plants in India-2007. Information referred from Table 2.1, Table 2.2 and Chapter 3[25]. CPCB (2009): Status of Water Supply, Wastewater Generation and Treatment in Class-I Cities & Class-II Towns Of India. Information referred from Table 3.4, Table 3.5, Table 3.6, Table 3.11, Table 3.12, Table 3.18, Table 3.19[26]

[23] Available at table 6.5 of 2006 IPCC Guidelines, Vol. 5, Chapter 6: Wastewater Treatment and Discharge
[24] Available at: http://cpheeo.nic.in/status_watersupply.pdf
https://www.indiawaterportal.org/sites/indiawaterportal.org/files/Status_Study_Water_Supply_Sanitation_Solid_Waste_Management_CPHEEO_2005.pdf
[25] Available at: http://www.cpcb.nic.in/upload/NewItems/NewItem_99_NewItem_99_5.pdf
[26] Available at: http://cpcb.nic.in/upload/NewItems/NewItem_153_Foreword.pdf

Activity Data/Emission Factor Parameter	Methodological Approach	Source
Domestic Wastewater Treatment and Discharge		
	and not treated) are estimated for the years 2005 to 2018. The corresponding percentage is multiplied with 'Piped sewer' to estimate the emissions from individual discharge pathways. **Rural:** In line with the above procedure the degree of utilization/discharge pathways for the rural areas for 2001 and 2011 are also referred/estimated from 'availability of different types of latrine facilities - 2001 and 2011 **Piped sewer:** Wastewater treatment facilities are largely absent in rural areas, the rural wastewater that is collected through the sewer network largely does not undergo any treatment downstream of the sewer network. Therefore, the portion of rural domestic wastewater that is collected and conveyed through the sewer network is assumed to not undergo any treatment and decomposes under aerobic conditions, thereby not leading to CH_4 emission.	CPCB (2010): Annual report 2009-10. Information referred from Table 6.2, Table 6.3, Chapter XiV[27] CPCB (2013): Performance Evaluation of STPs under NCRD. Information referred from Table 2, Table 3, Table 4, Table 5, Table 8, Table 14, Annexure – IV[28]. **<u>2014-15:</u>** CPCB (2015): Inventorization of STPs. Information referred from Table 3 and Chapter 4[29]. CPCB: Monitoring of STPs in Karnataka 2014-15. Information referred on STPs throughout the document.[30] **<u>2020:</u>** National Inventory of Sewage Treatment Plants, March 2021, CPCB[31]
Fraction of population in income group i (Ui)	The values of fraction of population in the income group (i.e. fraction of urban and rural population) have been sourced from Census of India data for 2001 and 2011. • The data have been used for the years 2005 to 2010, due to lack of year – wise information. . • The data have been used for subsequent years, 2011 to 2018, due to lack of year-wise information.	Census of India, Ministry of home affairs, Government of India[20]

[27] Available at: http://cpcb.nic.in/upload/AnnualReports/AnnualReport_40_Annual_Report_09-10.pdf
[28] Available at: http://cpcb.nic.in/upload/NewItems/NewItem_195_STP_REPORT.pdf
[29] Available at: http://www.cpcb.nic.in/upload/NewItems/NewItem_210_Inventorization_of_Sewage-Treatment_Plant.pdf
[30] Available at: http://cpcb.nic.in/zonaloffice/banglore/STP_report_karnataka.pdf
[31] Available at: https://cpcb.nic.in/openpdffile.php?id=UmVwb3J0RmlsZXMvMTIyOF8xNjE1MTk2MzIyX21lZGlhcGhvdG85NTY0LnBkZg==

<table>
<tr><th>Activity Data/Emission Factor Parameter</th><th>Methodological Approach</th><th>Source</th></tr>
<tr><td colspan="3">Domestic Wastewater Treatment and Discharge</td></tr>
<tr><td>Organic Component removed as Sludge, kg BOD/year (BOD)</td><td>0</td><td>2006 IPCC Guidelines, Vol. 5, Chapter 6: Wastewater Treatment and Discharge, Equation 6.1[32].</td></tr>
<tr><td>Correction factor for additional industrial BOD discharged into sewers (I)</td><td>Based on the 2006 IPCC Guidelines, the default values of “I”, for collected and uncollected wastewater, have been used, for both urban and rural assessment.
<table><tr><th>“I” for Collected Wastewater</th><th>I” for Uncollected Wastewater</th></tr><tr><td>1.25</td><td>1</td></tr></table></td><td>2006 IPCC Guidelines, Vol. 5, Chapter 6 - Wastewater treatment and discharge, Equation 6.3[32]</td></tr>
<tr><td>Amount of CH_4 recovered in inventory year (R)</td><td>0</td><td>2006 IPCC Guidelines, Vol. 5, Chapter 6: Wastewater Treatment and Discharge, equation 6.1[32]</td></tr>
<tr><td>Annual per capita protein consumption, kg/person/year</td><td>The values for per capita protein consumption, for both urban and rural population, have been sourced from NSSO reports on nutritional intake in India 2004-05, 2009-10 and 2011-12.
As the updated year-wise values of per capita protein consumption are not available for urban and rural population, therefore, the available values based on NSSO surveys in 2004-05, 2009-10 and 2011-12 have been used across the reporting period for 2005 to 2008, 2009 to 2010, and 2011 to 2018 respectively.</td><td>2005-08: Nutritional Intake in India 2004-05, Table 3R for Rural protein intake and Table 3U for Urban protein intake[33].

2009-2010: Nutritional Intake in India, 2009-10. The NSSO survey was conducted over two rounds (or schedules). Values used are average values based on findings across the two schedules in the NSSO survey 2009-10 as indicated in Table 3A-R & Table 3C-R for Rural and Table 3A-U & Table 3C-U for Urban[34].

2011-18: Nutritional Intake in India 2011-12. The NSSO survey was conducted over two rounds (or schedules). Values used are average values based on findings across the two schedules in the NSSO survey 2011-12 as indicated in Table 3A & Table 3B[35].</td></tr>
<tr><td colspan="3">Emission factors</td></tr>
<tr><td>Maximum CH_4 producing capacity, kg CH4/kg BOD (Bo)</td><td>0.6</td><td>2006 IPCC Guidelines, Vol. 5, Chapter 6 - Wastewater treatment and discharge, Table 6.2[32].</td></tr>
</table>

[32] Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf
[33] Available at: https://www.mospi.gov.in/documents/213904/301563//513_final1602138884492.pdf/401f305e-f6c0-5a1d-e72e-9f3c2d6da8e1
[34] Available at: https://www.mospi.gov.in/documents/213904/301563//nss_rep_5401602585283910.pdf/0d39e18a-5a76-79a7-10af-cb6f4b3b339a
[35] Available at: https://www.mospi.gov.in/documents/213904/301563//nss_report_560_19dec141602578465383.pdf/67bb29fa-2126-90c5-32ef-79a1ab810712

<table>
<tr><th>Activity Data/Emission Factor Parameter</th><th>Methodological Approach</th><th>Source</th></tr>
<tr><td colspan="3">Domestic Wastewater Treatment and Discharge</td></tr>
<tr><td>Methane correction factor (MCF_j)</td><td>The following assumptions have been made:
• The portion of urban wastewater that is collected in sewers but is untreated can be handled through 'stagnant sewers' or be discharged into water bodies such as 'sea, lake or river'. The quantity of this untreated wastewater that is discharged into water bodies is unknown and therefore the entire portion of collected and untreated urban wastewater is accounted under 'stagnant sewer'.
• Wastewater generated in rural areas is not handled or treated in any way and decomposes under aerobic conditions[36]. Thus, the proportion of rural wastewater that is collected and conveyed through sewer systems is also assumed to not undergo any treatment downstream and decomposes under aerobic conditions, thereby not leading to CH_4 emissions. Thus, the 'flowing sewer' system has MCF value as '0'.
• Rural wastewater that is uncollected and untreated can be either discharged into 'sea, lake or river' or 'to ground'. However, as the quantity of wastewater that is discharged 'to ground' is unknown, therefore the entire portion of uncollected and untreated rural wastewater is accounted under 'sea, lake or river discharge'.

<table>
<tr><th>Treatment/ discharge pathway or system (j)</th><th>MCF_j</th></tr>
<tr><td>Anaerobic reactor</td><td>0.80</td></tr>
<tr><td>"Centralized, aerobic treatment plant, I not well managed, overloaded)"</td><td>0.30</td></tr>
<tr><td>"Centralized, aerobic treatment plant well managed"</td><td>0.00</td></tr>
<tr><td>Stagnant Sewer</td><td>0.50</td></tr>
<tr><td>Sea Lake or river discharge</td><td>0.10</td></tr>
<tr><td>Flowing Sewer (open/closed)</td><td>0.00</td></tr>
<tr><td>Septic system</td><td>0.50</td></tr>
<tr><td>Latrine - Dry climate, ground water table lower</td><td>0.50</td></tr>
</table></td><td>2006 IPCC Guidelines, Vol. 5, Chapter 6: Wastewater treatment and discharge, Table 6.3[32].</td></tr>
</table>

[36] India's Second National Communication. Available at: https://unfccc.int/resource/docs/natc/indnc2.pdf

Activity Data/Emission Factor Parameter	Methodological Approach		Source
Domestic Wastewater Treatment and Discharge			
	than latrine, communal (many users)		
	Latrine (Dry climate, ground water table lower than latrine, small family (3-5 members))	0.10	
Fraction of Nitrogen in Protein (F_{NPR})	0.16		2006 IPCC Guidelines, Vol. 5, Chapter 6: Wastewater Treatment and Discharge, equation 6.8 and table 6.11[32].
Factor for Non-consumed protein added to the wastewater ($F_{NON-CON}$)	1.4		2006 IPCC Guidelines, Vol. 5, Chapter 6: Wastewater Treatment and Discharge, table 6.11[32].
Factor for Industrial and commercial co-discharged protein into the sewer system ($F_{IND-COM}$)	1.25		2006 IPCC Guidelines, Vol. 5, Chapter 6: Wastewater Treatment and Discharge, table 6.11[32].
Nitrogen removed with sludge (N_{SLUDGE})	0		2006 IPCC Guidelines, Vol. 5, Chapter 6: Wastewater Treatment and Discharge, equation 6.8[32].

Annexure C: Data sources and Assumptions for Industrial Wastewater Treatment and Discharge

Activity Data/Emission Factor Parameter	Methodological Approach	Source
Industrial Wastewater Treatment and Discharge		
Activity Data		
Industrial Production (Pi)	Production datasets available on financial year basis have been converted to calendar year datasets for a given calendar year by considering 3/4th of the value from the previous financial year (corresponding to 9 months from April to December out of 12 months in a year) and 1/4th from the next financial year (corresponding to 3 months	**Iron and Steel:** **Pig Iron -** • Indian Bureau of Mines- The Indian Minerals Yearbook 2019 (Part- II: Metals & Alloys – Iron & Steel and Scrap), Table 8[37] • Indian Bureau of Mines- The Indian Minerals Yearbook 2018 (Part- II:

[37] Available at: https://ibm.gov.in/?c=pages&m=index&id=1473

Activity Data/Emission Factor Parameter	Methodological Approach	Source
	from January to March out of 12 months in a year). **<u>Fertilizers</u>** • Nitrogen fertilizer production for the period 2015-16 to 2018-19 is not available and has been estimated based on annual average growth trend over 5 year period from 2009-10 to 2014-15. **<u>Sugar</u>** • State-wise data on Sugar Production for years 2012-13 and 2016-17 to 2018-19 is not available. National-level Sugar production data available for 2012-13 and 2016-17 to 2018-19 has been apportioned to each of the states based on corresponding proportions over a 5 year period from 2010-11 to 2015-16 for 2012-13 , except former Andhra Pradesh since the state was divided into two states post 2012-13. • For Andhra Pradesh, corresponding proportion to the national-level production for 2010-11 and 2011-12 has been used to estimate figures for 2012-13. **<u>Coffee</u>** • In the Andhra Pradesh & Orissa cluster, Andhra Pradesh and Orissa share has been assumed to be of 95% and 5% approximately in the Coffee Production as per the official inputs of the coffee board. • In the North Eastern Region, the states of Assam and Meghalaya have an approximate share of 20% each and the rest of the five states have a share of approximately 12% each in the North	Metals & Alloys – Iron & Steel and Scrap), Table 8[38] • Indian Bureau of Mines- The Indian Minerals Yearbook 2017 (Part- II: Metals & Alloys – Iron & Steel and Scrap), Table 8[39] • Indian Bureau of Mines- The Indian Minerals Yearbook 2016 (Part- II: Metals & Alloys – Iron & Steel and Scrap), Table 8[40] • Indian Bureau of Mines- The Indian Minerals Yearbook 2015 (Part- II: Metals & Alloys – Iron & Steel and Scrap), Table 8[41] • Indian Bureau of Mines- The Indian Minerals Yearbook 2014 (Vol-II: Reviews on Metals and Alloys, Part- II : Metals & Alloys – Iron & Steel and Scrap), Table 8[42] • Indian Bureau of Mines- The Indian Minerals Yearbook 2013 (Vol-II: Reviews on Metals and Alloys, Part- II : Metals & Alloys – Iron & Steel and Scrap), Table 8[43] • JSW Steel website, JSW Steel - An Overview[44] • Indian Bureau of Mines- The Indian Minerals Yearbook 2016 (Part- II: Metals & Alloys – Iron & Steel and Scrap), Table 8 and Table for SAIL – Hot Metal, Page 9-14[45] • Ministry of Steel, Government of India- Annual Report 2018-19, Annexure VII[46] • Ministry of Steel, Government of India- Annual Report 2017-18, Annexure VII[46] • Ministry of Steel, Government of India- Annual Report 2014-15, Annexure VII[46] • Ministry of Steel, Government of India- Annual Report 2012-13, Annexure VII[46] • Ministry of Steel, Government of India- Annual Report 2008-09, Annexure VII[46]

[38] Available at: https://ibm.gov.in/?c=pages&m=index&id=1363
[39] Available at: https://ibm.gov.in/?c=pages&m=index&id=1009
[40] Available at: https://ibm.gov.in/index.php?c=pages&m=index&id=883
[41] Available at: https://ibm.gov.in/?c=pages&m=index&id=1379
[42] Available at: http://ibm.nic.in/index.php?c=pages&m=index&id=481
[43] Available at: https://ibm.gov.in/index.php?c=pages&m=index&id=398
[44] Available at: https://www.jsw.in/jsw-steel-2017/mda.html
[45] Available at: https://ibm.gov.in/writereaddata/files/05222018175300Ironandsteelandscrap2016.pdf
[46] Available at: https://steel.gov.in/annual-reports

Activity Data/Emission Factor Parameter	Methodological Approach	Source
	Eastern region's total Coffee Production as per the official inputs of the coffee board. **Petroleum** • As the data on production of petroleum products is not available, hence, national-level data on production of petroleum products has been apportioned, based on corresponding proportions of 'Total volume of Crude Oil processed' by refineries located in the state. **Dairy** • State-wise data on Milk processed by dairies is not available. National-level data available on production of Milk has been apportioned to each of the states based on corresponding proportions of 'Installed capacity' of Dairies located in different states. **Pulp & Paper** • State-wise Paper production for the time period from 2004-05 to 2009-10 is not available. The total National-level production has been estimated for these years by applying an average annual growth rate of 6% to the available data from 2010-11 to 2013-14 as per communication from Central Pulp & Paper Research Institute (CPPRI). • The Paper production for each state for this period from 2004-05 to 2009-10 and 2016-17 to 2018-19 has subsequently been estimated based on the corresponding average percentage share of each state as per reported data from 2010-11 to 2013-14 and 2011-12 and 2015-16 respectively. Data reported for paper production by CPPRI for 2014-15 and 2015-16 has been updated subsequently.	**Sponge Iron -** • Indian Minerals Yearbook 2019, Part- II : Metals & Alloys, IRON & STEEL AND SCRAP, Indian Bureau of Mines, Table 9[47] • Indian Minerals Yearbook 2018, Part- II : Metals & Alloys, IRON & STEEL AND SCRAP, Indian Bureau of Mines, Table 9[48] • Indian Minerals Yearbook 2017, Part- II : Metals & Alloys, IRON & STEEL AND SCRAP, Indian Bureau of Mines, Table 9[49] • Indian Minerals Yearbook 2016, Part- II : Metals & Alloys, IRON & STEEL AND SCRAP, Indian Bureau of Mines, Table 9[50] • Indian Minerals Yearbook 2015, Part- II : Metals & Alloys, IRON & STEEL AND SCRAP, Indian Bureau of Mines, Table 9[51] • Indian Minerals Yearbook 2014, Part- II : Metals & Alloys, IRON & STEEL AND SCRAP, Indian Bureau of Mines, Table 9[52] • Ministry of Steel, Government of India-Annual Report 2018-19, Annexure III[46] • Indian Bureau of Mines- The Indian Minerals Yearbook 2016 (Vol-II: Reviews on Metals and Alloys, Part- II : Metals & Alloys – Iron & Steel and Scrap), Table 2[40] • Indian Bureau of Mines- The Indian Minerals Yearbook 2012 (Vol-II: Reviews on Metals and Alloys, Part- II : Metals & Alloys – Iron & Steel and Scrap), Table 2[53] • Ministry of Steel, Government of India-Annual Report 2008-09, Annexure VII[46] **Sponge Iron -**

[47] Available at: https://ibm.gov.in/?c=pages&m=index&id=1473
[48] Available at: https://ibm.gov.in/?c=pages&m=index&id=1363
[49] Available at: https://ibm.gov.in/?c=pages&m=index&id=1009
[50] Available at: https://ibm.gov.in/index.php?c=pages&m=index&id=883
[51] Available at: https://ibm.gov.in/?c=pages&m=index&id=1379
[52] Available at: http://ibm.nic.in/index.php?c=pages&m=index&id=481
[53] Available at: https://ibm.gov.in/index.php?c=pages&m=index&id=176

Activity Data/Emission Factor Parameter	Methodological Approach	Source
	Rubber • State-wise data on Natural and Synthetic Rubber processed by states is not available. National-level data on cumulative production of Natural and Synthetic Rubber has been apportioned to each of the states based on the available data on no. of licensed rubber manufacturers across the emission reporting period. **Tannery** • Tannery Production data is not available for the period 2016 to 2018. The production figure has been projected based on the annual average growth rate of tannery production between 2005 and 2015. • State-wise data on leather processed by states not available. National-level data available on cumulative production of Bovine, Sheep, lamb, Goat and kid skins and hides has been apportioned to each of the states based on the available data for year 2005-06 on corresponding 'Gross Value Added' by Tannery sector. Data on number of tannery factories is available however data on corresponding 'production or installed capacities' is not known for these tanneries. Hence, 'Gross Value Added' is gauged to be a more appropriate metric to represent the manufacturing activity in tannery sector for each state and has been used as a basis for apportionment. Data on 'Gross Value Added' is available only for 2005-06 and has been used across the reporting period for apportionment of national production data.	• Production of Steel Press Information Bureau, Government of India[54] • Report of the Working Group on Steel Industry for 12th FYP (2012-2017), Ministry of Steel 2011, Table 3.7[55] • Indian Bureau of Mines- The Indian Minerals Yearbook 2016 (Vol-II: Reviews on Metals and Alloys, Part- II : Metals & Alloys – Iron & Steel and Scrap), Table 2[40] • Indian Bureau of Mines- The Indian Minerals Yearbook 2012 (Vol-II: Reviews on Metals and Alloys, Part- II : Metals & Alloys – Iron & Steel and Scrap), Table 2[53] • Ministry of Steel, Government of India- Annual Report 2008-09, Annexure VII[46] **Fertilizers:** • Department of Fertilizers, Ministry of Chemicals and Fertilizers, Government of India, Annual Report 2014-15, Annexure IV[56] • Department of Fertilizers, Ministry of Chemicals and Fertilizers, Government of India, Annual Report 2012-13, Annexure IV[57] • Department of Fertilizers, Ministry of Chemicals and Fertilizers, Government of India, Annual Report 2010-11, Annexure IV[58] • Department of Fertilizers, Ministry of Chemicals and Fertilizers, Government of India, Annual Report 2008-09, Annexure IV[59] • Department of Fertilizers, Ministry of Chemicals and Fertilizers, Government of India, Annual Report 2006-07, Annexure IV[60] • Department of Fertilizers, Ministry of Chemicals and Fertilizers, Government

[54] Available at: https://pib.gov.in/PressReleasePage.aspx?PRID=1576418
[55] Available at: http://planningcommission.gov.in/aboutus/committee/wrkgrp12/wg_steel2212.pdf
[56] Available at http://www.fert.nic.in/sites/default/files/fertilizer%20web.pdf
[57] Available at http://fert.nic.in/sites/default/files/Annual_Report2012-13.pdf
[58] Available at http://fert.nic.in/sites/default/files/Annual_Report_English_2011_0.pdf
[59] Available at http://fert.nic.in/sites/default/files/Annual-Report-2008-2009-english.pdf
[60] Available at http://fert.nic.in/sites/default/files/Annual-Report-2006-2007-english.pdf

Activity Data/Emission Factor Parameter	Methodological Approach	Source
		of India, Annual Report 2004-05, Annexure IV[61] **<u>Sugar:</u>** • National Food Security Mission, Ready Reckoner, Crop Unit-IV, Statistics on Cotton, Jute & Sugar, Page 69[62] • Annexure XXIX, Status Paper on Sugarcane, Directorate of Sugarcane Development, Ministry of Agriculture[63] • Directorate of Sugar, Department of Food and Public Distribution, Ministry of Consumer Affairs, Food and Public Distribution, GoI[64] **<u>Coffee:</u>** • **2008-09 to 2018-19:** Database on Coffee - Part I, Coffee Board, Ministry of Commerce and Industry, Government of India[65][66][67][68][69][70] • **2004-05 to 2007-08:** Dy. Director (Market Research), Coffee Board **<u>Petroleum:</u>** • Petroleum Planning & Analysis Cell (PPAC), Ministry of Petroleum & Natural Gas – Production of Petroleum Products[71][72] **<u>Dairy:</u>** • Basic Animal Husbandry Statistics - 2019, Department of Animal

[61] Available at http://fert.nic.in/sites/default/files/Annual-Report-2004-2005-english.pdf
[62] Available at: https://nfsm.gov.in/ReadyReckoner/CU4/CUIV_Statistics.pdf
[63] Available at: http://www.nfsm.gov.in/Publicity/2014-15/Books/Status%20Paper%20of%20Sugarcane_Final_New.pdf
[64] Available at: https://dfpd.gov.in/writereaddata/Portal/Magazine/Seasonwiseproductionofsugarfrom201718andonwards.pdf
[65] Available at: https://www.indiacoffee.org/Database/DATABASE_Sep2020_web.pdf
[66] Available at: https://www.indiacoffee.org/Database/Data_base_July19.pdf
[67] Available at: https://www.indiacoffee.org/Database/DATABASE_Nov17_web.pdf
[68] Available at: https://www.indiacoffee.org/Database/DATABASE_July16_I.pdf
[69] Available at: https://www.indiacoffee.org/Database/DATABASE_Feb16_I.pdf
[70] Available at: http://www.indiacoffee.org/database-coffee.html
[71] Available at: http://www.ppac.org.in/WriteReadData/userfiles/file/PT_production_source_H.xls http://www.ppac.org.in/WriteReadData/userfiles/file/PT_production_source_H.xls
[72] Available at: http://www.ppac.org.in/WriteReadData/userfiles/file/PT_crude_H.xls

Activity Data/Emission Factor Parameter	Methodological Approach	Source
		Husbandry, Dairying & Fisheries, Government of India[73] • Basic Animal Husbandry & Fisheries Statistics- 2017, Table 1, Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture, Government of India[74] **Meat:** • Basic Animal Husbandry Statistics- 2019, Table 29, Department of Animal Husbandry, Dairying & Fisheries, GoI[75] • Basic Animal Husbandry Statistics- 2014, Table 19, Department of Animal Husbandry, Dairying & Fisheries, GoI[76] • Basic Animal Husbandry Statistics- 2012, Table 22, Department of Animal Husbandry, Dairying & Fisheries, GoI[77] • Basic Animal Husbandry Statistics- 2006, Table 49, Department of Animal Husbandry, Dairying & Fisheries, GoI[78] • State-wise Meat Production, Handbook of Statistics on Indian States, Reserve Bank of India[79] **Pulp & Paper:** • Sectorial Performance Report on the Pulp & Paper Industry. Statistical Update 2016-17, Central Pulp & Paper Research Institute (print version) • Annual Report 2019-20, Department for Promotion of Industry and Internal Trade, Ministry of Commerce and Industry, GoI[80]. • Annual Report 2018-19, Department for Promotion of Industry and Internal

[73] Available at: https://dahd.nic.in/sites/default/filess/BAHS%20%28Basic%20Animal%20Husbandry%20Statistics-2019%29_1.pdf
[74] Available at : https://dahd.nic.in/sites/default/filess/Basic%20Animal%20Husbandry%20and%20Fisheries%20Statistics%202017.pdf
[75] Available at: https://dahd.nic.in/sites/default/filess/BAHS%20%28Basic%20Animal%20Husbandry%20Statistics-2019%29_1.pdf
[76] Available at: https://dof.gov.in/sites/default/files/2019-12/Final%20BAHS%202014%2011.03.2015%20%202.pdf
[77] Available at: https://dahd.nic.in/sites/default/filess/wool.pdf
[78] Available at: https://agritech.tnau.ac.in/ta/animal_husbandry/animal_statistics.pdf
[79] Available at: https://www.rbi.org.in/Scripts/PublicationsView.aspx?id=20742
[80] Available at: https://dpiit.gov.in/sites/default/files/annualReport_English2019-20.pdf

Activity Data/Emission Factor Parameter	Methodological Approach	Source
		Trade, Ministry of Commerce and Industry, GoI[81]. • Annual Report 2017-18, Department for Promotion of Industry and Internal Trade, Ministry of Commerce and Industry, GoI[82]. **<u>Rubber:</u>** • Statistics & Planning Department, Rubber Board- Rubber Statistical Monthly News -June 2006, Page 2 – Production and Consumption of NR & SR • Statistics & Planning Department, Rubber Board- Rubber Statistical Monthly News -May 2008, Page 2 – Production and Consumption of NR & SR[83] • Statistics & Planning Department, Rubber Board- Rubber Statistical Monthly News –June 2010, Page 2 – Production and Consumption of NR & SR[84] • Statistics & Planning Department, Rubber Board- Rubber Statistical Monthly News –July 2011, Page 2 – Production and Consumption of NR & SR[85] • Statistics & Planning Department, Rubber Board- Rubber Statistical Monthly News –May 2013, Page 2 – Production and Consumption of NR & SR[86] • Statistics & Planning Department, Rubber Board- Rubber Statistical Monthly News –September 2014, Page 2 – Production and Consumption of NR & SR[87] • Statistics & Planning Department, Rubber Board- Rubber Statistical

[81] Available at: https://dpiit.gov.in/sites/default/files/annualReport_2018-19_E_0.pdf
[82] Available at: https://dpiit.gov.in/sites/default/files/annualReport_English_08March2018.pdf
[83] Available at: https://web.archive.org/web/20140921184255/http://www.rubberboard.org.in/RSN/RubberStatisticalMay2008.pdf
[84] Available at: https://web.archive.org/web/20140922072822/http://www.rubberboard.org.in/RSN/RSN_June2010.pdf
[85] Available at: https://web.archive.org/web/20140922081911/http://www.rubberboard.org.in/RSN/RSN_July2011.pdf
[86] Available at: https://web.archive.org/web/20150611070250/http://www.rubberboard.org.in/RSN/RS_News_May2013(annual).pdf
[87] Available at: https://web.archive.org/web/20150612061420/http://www.rubberboard.org.in/PDF/rsnewssep2014.pdf

Activity Data/Emission Factor Parameter	Methodological Approach	Source
		Monthly News –May 2015, Page 2 – Production and Consumption of NR & SR • Statistics & Planning Department, Rubber Board- Rubber Statistical Monthly News –June 2017, Page 2 – Production and Consumption of NR & SR[88] • Statistics & Planning Department, Rubber Board- Rubber Statistical Monthly News –June 2019, Page 2 – Production and Consumption of NR & SR[89] **Tannery** • Food and Agriculture Organization (FAO)- World Statistical Compendium for raw hides and skins, leather and leather footwear 1999-2015, Table 5, Table 7, Table:9[90] • Handbook of Industrial Policy and Statistics 2008-09, Table 14.2-Table 14.36, Department of Industrial Policy and Promotion, Ministry of Commerce & Industry[91] **Fish Processing** • Handbook on Fisheries Statistics 2014, Table A-2: Fish Production by State/ Union Territories 2000-01 to 2013-14[92] • Handbook on Fisheries Statistics 2018, Section A - 3: State / Union Territory wise Fish Production 2011-12 to 2017-18[93] • Handbook on Fisheries Statistics 2020, Table 1.2. State/UT wise Inland and Marine Fish production in India for the period 2015-16 to 2019-20[94]
Wastewater generated,	• Constant values of wastewater generated per tonne of product have been used for all the years (2005-2018) for all the industry sectors due to lack of year-on-year	**Fertilizers, Sugar, Coffee, Petroleum, Dairy, Pulp and Paper, Tannery and Fish Processing:**

[88] Available at: http://www.rubberboard.org.in/rbfilereader?fileid=189
[89] Available at: http://rubberboard.org.in/rbfilereader?fileid=360
[90] Available at: http://www.fao.org/3/a-i5599e.pdf
[91] Available at: https://eaindustry.nic.in/industrial_handbook_200809.pdf
[92] Available at: https://dahd.nic.in/sites/default/filess/Section%20A%20%20%202_0_0.pdf
[93] Available at: https://dof.gov.in/sites/default/files/2020-08/HandbookonFS2018.pdf
[9494] Available at: https://dof.gov.in/sites/default/files/2021-02/Final_Book.pdf

<table>
<tr><th>Activity Data/Emission Factor Parameter</th><th>Methodological Approach</th><th>Source</th></tr>
<tr><td>m3 /t product (Wi)</td><td>information besides Pulp & Paper and Tannery industry, where the values have been updated post 2015 as per the India's BUR 3. Industry wise wastewater generated per tonne of product values used are provided below -.
<table>
<tr><th>Industry</th><th>Wastewater generation
(m^3/tonne of product)</th></tr>
<tr><td>Iron & Steel</td><td>60</td></tr>
<tr><td>Fertilizer</td><td>8</td></tr>
<tr><td>Sugar</td><td>0.4</td></tr>
<tr><td>Coffee</td><td>15</td></tr>
<tr><td>Petroleum</td><td>0.6</td></tr>
<tr><td>Dairy</td><td>6</td></tr>
<tr><td>Meat</td><td>11.7</td></tr>
<tr><td>Pulp & Paper</td><td>127.5 (2005-2014)
57 (205-2018)</td></tr>
<tr><td>Rubber</td><td>26.3</td></tr>
<tr><td>Tannery</td><td>35 (2005-2014)
32 (2015-2018)</td></tr>
<tr><td>Fish Processing</td><td>13</td></tr>
</table></td><td>India's 3rd Biennial Update Report to UNFCCC (BUR 3), Table 2.31[4].

<u>Iron and Steel, Meat and Rubber:</u>

India's Second National Communication to the UNFCCC, 2012, Box 2.7[95].

Pulp & Paper <u>(2005-14)</u>:
• Technical EIA Guidance Manual for Pulp & Paper Industry prepared by IL&FS Ecosmart Limited for MoEF, 2010. Refer Table 3-10, page 67[96]
• Technical Compendium on Energy Saving opportunities – Pulp & Paper sector published by Confederation of Indian Industry, 2013. Refer Table 3 for production share[97].

<u>Tannery (2005-14)</u>

India's 2nd Biennial Update Report to UNFCCC (BUR 2), Table 2.17[3]</td></tr>
<tr><td>Chemical oxygen demand (CODi)</td><td>• Constant values of Chemical Oxygen Demand (CODi) have been used for all the years (2005-2018) for all the industry sectors due to lack of year-on-year information
<table>
<tr><th>Industry</th><th>COD
(kg COD/m^3)</th></tr>
</table></td><td><u>Fertilizers, Sugar, Coffee, Petroleum, Dairy, Pulp and Paper, Tannery and Fish Processing</u>:

India's 3rd Biennial Update Report to UNFCCC (BUR 3), Table 2.31[4].

<u>Iron and Steel and Rubber:</u> NEERI (2010): Status of Methane Emissions from</td></tr>
</table>

[95] Available at https://unfccc.int/sites/default/files/resource/indnc2.pdf
[96] Available at: http://environmentclearance.nic.in/writereaddata/form-1a/homelinks/TGM_Pulp%20and%20Paper_010910_NK.pdf
[97] Available at http://shaktifoundation.in/wp-content/uploads/2014/02/pulp_paper.pdf

<table>
<tr><th>Activity Data/Emission Factor Parameter</th><th>Methodological Approach</th><th>Source</th></tr>
<tr><td></td><td><table>
<tr><td>Iron & Steel</td><td>0.55</td></tr>
<tr><td>Fertilizer</td><td>3.00</td></tr>
<tr><td>Sugar</td><td>2.50</td></tr>
<tr><td>Coffee</td><td>9.00</td></tr>
<tr><td>Petroleum</td><td>1.00</td></tr>
<tr><td>Dairy</td><td>2.24</td></tr>
<tr><td>Meat</td><td>5.00</td></tr>
<tr><td>Pulp & Paper</td><td>5.90</td></tr>
<tr><td>Rubber</td><td>6.12</td></tr>
<tr><td>Tannery</td><td>3.10</td></tr>
<tr><td>Fish Processing</td><td>2.50</td></tr>
</table></td><td>Wastewater and Role of Clean Development Mechanisms in India. Published in the TERI Information Digest on Energy and Environment, [S.l.], p. 155-166, June. 2010. ISSN 0972-6721[98]

<u>Meat</u>: India's 2nd Biennial Update Report to UNFCCC (BUR 2), Table 2.17[3]</td></tr>
<tr><td>Organic component removed as sludge (Si)</td><td>0.35</td><td>2006 IPCC Guidelines, Vol. 5, Chapter 6: Wastewater Treatment and Discharge, Equation Number 6.4[99].</td></tr>
<tr><td>Amount of CH_4 recovered (Ri)</td><td>0</td><td>2006 IPCC Guidelines, Vol. 5, Chapter 6: Wastewater Treatment and Discharge, Equation Number 6.4[99].</td></tr>
<tr><td colspan="3">Emission Factors</td></tr>
<tr><td>Methane correction factor (MCFj)</td><td>• Constant values of Methane correction factor (MCFj) have been used for all the years (2005-2018) for all the industry sectors due to lack of year-on-year information
<table>
<tr><th>Industry</th><th>MCF</th></tr>
<tr><td>Iron &Steel</td><td>0.0</td></tr>
<tr><td>Fertilizer</td><td>0.3</td></tr>
<tr><td>Sugar</td><td>0.8</td></tr>
<tr><td>Coffee</td><td>0.8</td></tr>
</table></td><td><u>Fertilizer, Sugar, Coffee, Petroleum, Dairy, Pulp and Paper, Tannery and Fish Processing</u>:

India's 3rd Biennial Update Report to UNFCCC (BUR 3), Table 2.31[4].

<u>Iron and Steel:</u> Sirajuddin, Ahmed, Umesh Chandra, R. K. Rathi, (2010) "Waste water treatment technologies Commonly practiced in Major Steel Industries of India" In 16th Annual International Sustainable Development Research Conference 2010, 30 May – 1</td></tr>
</table>

[98] Available at: http://www.i-scholar.in/index.php/tidee/article/view/89982

[99] Available at http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf

Activity Data/Emission Factor Parameter	Methodological Approach	Source
	<table><tr><td>Petroleum</td><td>0.3</td></tr><tr><td>Dairy</td><td>0.5</td></tr><tr><td>Meat</td><td>0.8</td></tr><tr><td>Pulp & Paper</td><td>0.8</td></tr><tr><td>Rubber</td><td>0.0</td></tr><tr><td>Tannery</td><td>0.3</td></tr><tr><td>Fish Processing</td><td>0.30</td></tr></table>	June, 2010 The University of Hong Kong, Hong Kong. **Meat:** 2006 IPCC guidelines for National Greenhouse Gas Inventories, Vol. 5, Chapter 6: Wastewater Treatment and Discharge[99]. **Rubber:** Central Pollution Control Board (CPCB), Pollution Control Implementation Division – III report on 'Pollution Control in Natural Rubber Processing Industry'[100].
Maximum CH_4 producing capacity(Bo)	0.25	2006 IPCC Guidelines, Vol. 5, Chapter 6: Wastewater Treatment and Discharge, Equation Number 6.5[99]

[100] Available at: http://cpcb.nic.in/divisionsofheadoffice/pci3/pciiidivrubber.pdf