

**INCCA Indian Network for Climate Change Assessment**

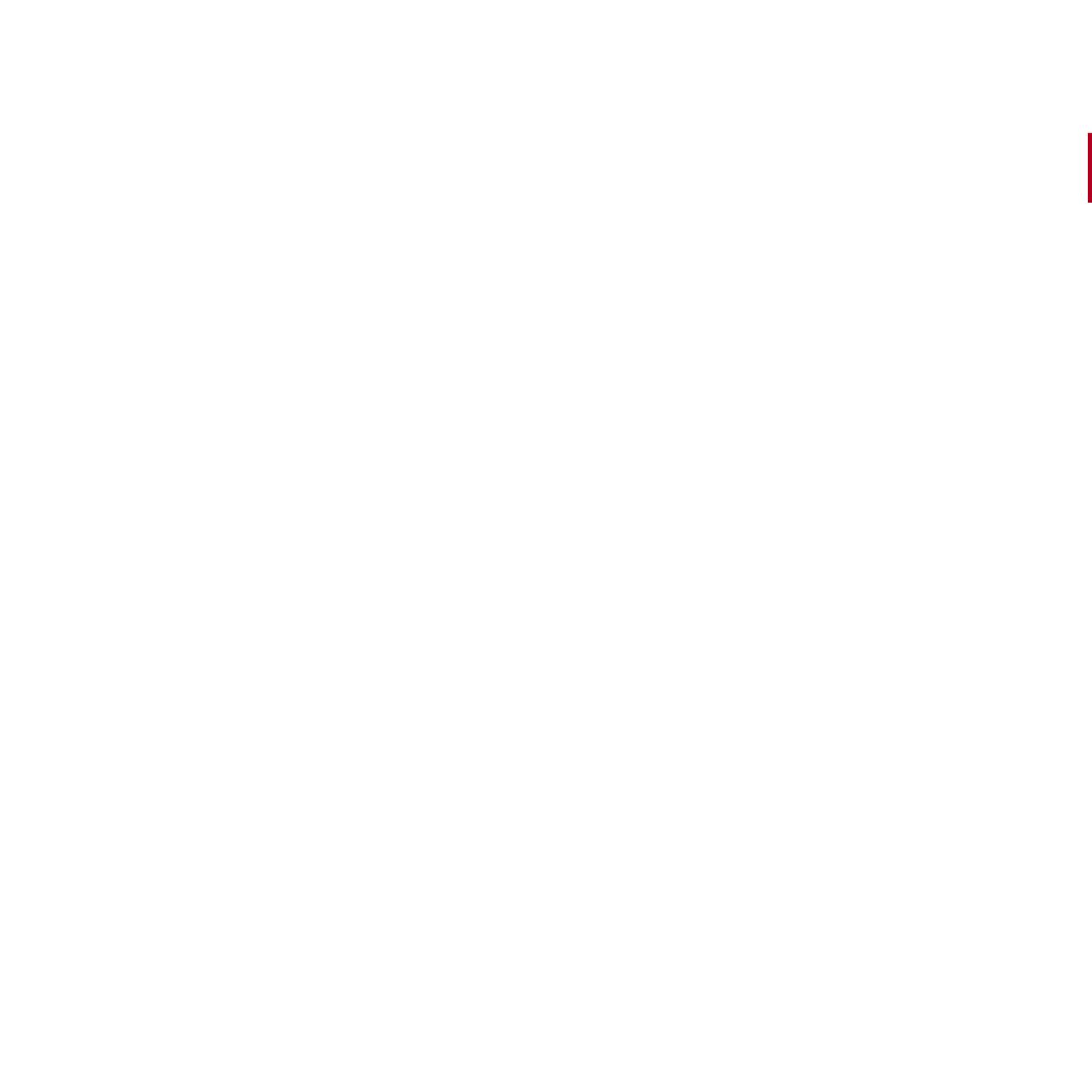
# **India: Greenhouse Gas Emissions 2007**

**Executive Summary**



Ministry of Environment and Forests  
Government of India

May 2010



# **India: Greenhouse Gas Emissions 2007**

## **Executive Summary**





## Foreword



I am pleased to introduce the publication - **India's Greenhouse Gas Emissions 2007**. This Report, being brought out by the Indian Network of Climate Change Assessment (INCCA), provides updated information on India's Greenhouse Gas Emissions for the year 2007. Until today, the only official emissions estimates available were for the year 1994. This was very inadequate. I had been keen that to enable informed decision-making and to ensure transparency, we should publish updated emissions estimates. I am glad that our team of scientists took up this challenge and have prepared this report with estimates for 2007 in record time. More than 80 scientists from 17 institutions across India have contributed to this Assessment. I am particularly pleased that with this publication, **India has become the first "non-Annex I" (i.e. developing) country to publish such updated numbers**. I am also happy to announce that we will publish our emissions inventory in a two-year cycle going forward. We will be the first developing country to do so.

According to the results, India ranks 5<sup>th</sup> in aggregate GHG emissions in the world, behind USA, China, EU and Russia in 2007. **Interestingly, the emissions of USA and China are almost 4 times that of India in 2007. It is also noteworthy that the emissions intensity of India's GDP declined by more than 30% during the period 1994-2007, due to the efforts and policies that we are proactively putting in place.** This is a trend we intend to continue. As you are aware, we have already announced our intent to further reduce the emissions intensity of our GDP by 20-25% between 2005 and 2020 even as we pursue the path of inclusive growth.

INCCA, launched on 14<sup>th</sup> October 2009, is a network comprising 127 research institutions, tasked with undertaking research on the science of climate change and its impacts on the different sectors of the economy across the various regions of India. As I mentioned at the launch, we must make the "3 M's" – Measurement,

Modelling and Monitoring – the essence of our policy making and we must build indigenous capacity for this. This report is a step in this direction. I look forward to INCCA's next major publication – a "4X4" assessment of the impacts of climate change on four sectors – water resources, agriculture, forests and human health – in four critical regions of India – the Himalayan region, North east, Western Ghats and Coastal India, which will be released in November 2010.

Once again, I congratulate our team of scientists who have put this assessment together. I look forward to the results of the other upcoming studies of INCCA.



**Jairam Ramesh**

Minister of State for Environment & Forests  
(Independent Charge)

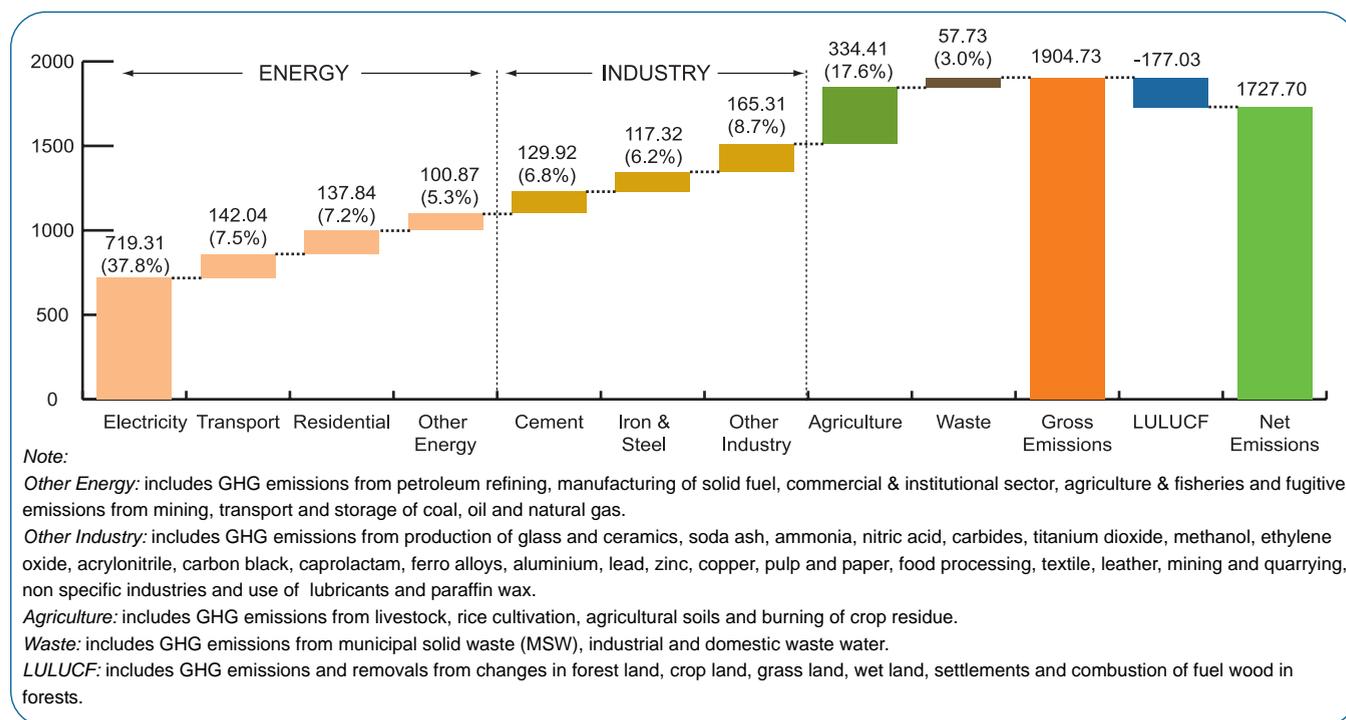
# Executive Summary

This assessment provides information on India's emissions of Greenhouse gases (Carbon Dioxide [CO<sub>2</sub>], Methane [CH<sub>4</sub>] and Nitrous Oxide [N<sub>2</sub>O]) emitted from anthropogenic activities at national level from:

- Energy;
- Industry;
- Agriculture;

- Waste; and
- Land Use Land Use Change & Forestry (LULUCF).

The distribution of GHG emissions by sector are shown in Figure ES1. Detailed emissions estimates are provided in Annexure.



**Figure ES1:** GHG emissions by sector in 2007 (million tons of CO<sub>2</sub> eq). Figures on top indicate the emissions by sectors and in brackets indicate % of emission of the category with respect to the net CO<sub>2</sub> equivalent emissions. See glossary for definition of CO<sub>2</sub> equivalent.

## A. KEY RESULTS

- The net Greenhouse Gas (GHG) emissions from India in 2007, that is emissions with LULUCF, were 1727.71 million tons of CO<sub>2</sub> equivalent (eq) of which
  - CO<sub>2</sub> emissions were 1221.76 million tons;
  - CH<sub>4</sub> emissions were 20.56 million tons; and
  - N<sub>2</sub>O emissions were 0.24 million tons
- GHG emissions from Energy, Industry, Agriculture, and Waste sectors constituted 58%, 22%, 17% and 3% of the net CO<sub>2</sub> eq emissions respectively.
- Energy sector emitted 1100.06 million tons of CO<sub>2</sub> eq, of which 719.31 million tons of CO<sub>2</sub> eq were emitted from electricity generation and 142.04 million tons of CO<sub>2</sub> eq from the transport sector.
- Industry sector emitted 412.55 million tons of CO<sub>2</sub> eq.
- LULUCF sector was a net sink. It sequestered 177.03 million tons of CO<sub>2</sub>.
- India's per capita CO<sub>2</sub> eq emissions including LULUCF were 1.5 tons/capita in 2007.

## B. 1994 AND 2007 GHG EMISSIONS - A COMPARISON

The 1994 assessment is available in India's Initial National Communication to the UNFCCC. Both the 1994 and 2007 assessments have been prepared using the IPCC guidelines for preparation of national greenhouse gas emissions by sources and removal by sinks. The distinctive key features of the two assessments and the improvements in the 2007 assessments are indicated in Box ES1.

The total GHG emissions without LULUCF have grown from 1251.95 million tons in 1994 to 1904.73 million tons in 2007 at a compounded annual growth rate (CAGR) of 3.3% and with LULUCF the CAGR is 2.9%. Between 1994 and 2007, some of the sectors indicate significant growth in GHG emissions such as cement production (6.0%), electricity generation (5.6%) and transport (4.5%). A comparative analysis of GHG emissions by sector is shown in Table ES1.

### Box ES1: 2007 and 1994 - Key Methodological Features and Improvements

1994 Assessment	2007 Assessment
<ul style="list-style-type: none"> <li>■ Estimates made using only revised 1996 IPCC guidelines.</li> </ul>	<ul style="list-style-type: none"> <li>■ Estimates made using revised IPCC 1996 guidelines (1997), IPCC Good Practice Guidance (2000), the LULUCF Good Practice Guidance (2003).</li> </ul>
<ul style="list-style-type: none"> <li>■ LULUCF included emissions from changes in forest land.</li> </ul>	<ul style="list-style-type: none"> <li>■ Carbon pools in addition to forests have been considered in the LULUCF sector (crop land, grass land, settlements).</li> </ul>
<ul style="list-style-type: none"> <li>■ Emission factors were a mix of default factors taken from IPCC and country specific (CS) emission factors. 26% of the source categories used CS factors.</li> </ul>	<ul style="list-style-type: none"> <li>■ Emission factors were also a mix of default and CS but leading to improved accuracy as more number of CSs have been used in this assessment (35% of the source categories used CS factors).</li> </ul>
<ul style="list-style-type: none"> <li>■ The 1994 assessment splits the emissions from industry in to two parts - fossil fuel and process. The fossil fuel emissions are reported in Energy and process emissions in Industry.</li> </ul>	<ul style="list-style-type: none"> <li>■ The 2007 assessment reports both fossil fuel related and process based emissions from Industry as a part of the Industry sector.</li> </ul>
<ul style="list-style-type: none"> <li>■ In 1994, 7% of the total CO<sub>2</sub> eq emissions were made using Tier III approach.</li> </ul>	<ul style="list-style-type: none"> <li>■ In 2007, 12% of the emissions are made using Tier III approach, implying greater accuracy.</li> </ul>

**Table ES1:** A comparison of GHG emissions by sector between 1994 and 2007 in million tons of CO<sub>2</sub> eq.

	1994	2007	CAGR (%)
Electricity	355.03 (28.4%)	719.30 (37.8%)	5.6
Transport	80.28 (6.4%)	142.04 (7.5%)	4.5
Residential	78.89 (6.3%)	137.84 (7.2%)	4.4
Other Energy	78.93 (6.3%)	100.87 (5.3%)	1.9
Cement	60.87 (4.9%)	129.92 (6.8%)	6.0
Iron & Steel	90.53 (7.2%)	117.32 (6.2%)	2.0
Other Industry	125.41 (10.0%)	165.31 (8.7%)	2.2
Agriculture	344.48 (27.6%)	334.41 (17.6%)	-0.2
Waste	23.23 (1.9%)	57.73 (3.0%)	7.3
Total without LULUCF	1251.95	1904.73	3.3
LULUCF	14.29	-177.03	
Total with LULUCF	1228.54	1727.71	2.9

Note: Figure in brackets indicate percentage emissions from each sector with respect to total GHG emissions without LULUCF in 1994 and 2007 respectively

## C. IMPLEMENTATION ARRANGEMENT

This assessment has been prepared under the aegis of the Indian Network for Climate Change Assessment (INCCA). An initiative being coordinated by the Ministry of Environment and Forests, Government of India. (Box ES2 & Figure ES2).

## D. SECTORAL DESCRIPTION OF THE EMISSIONS

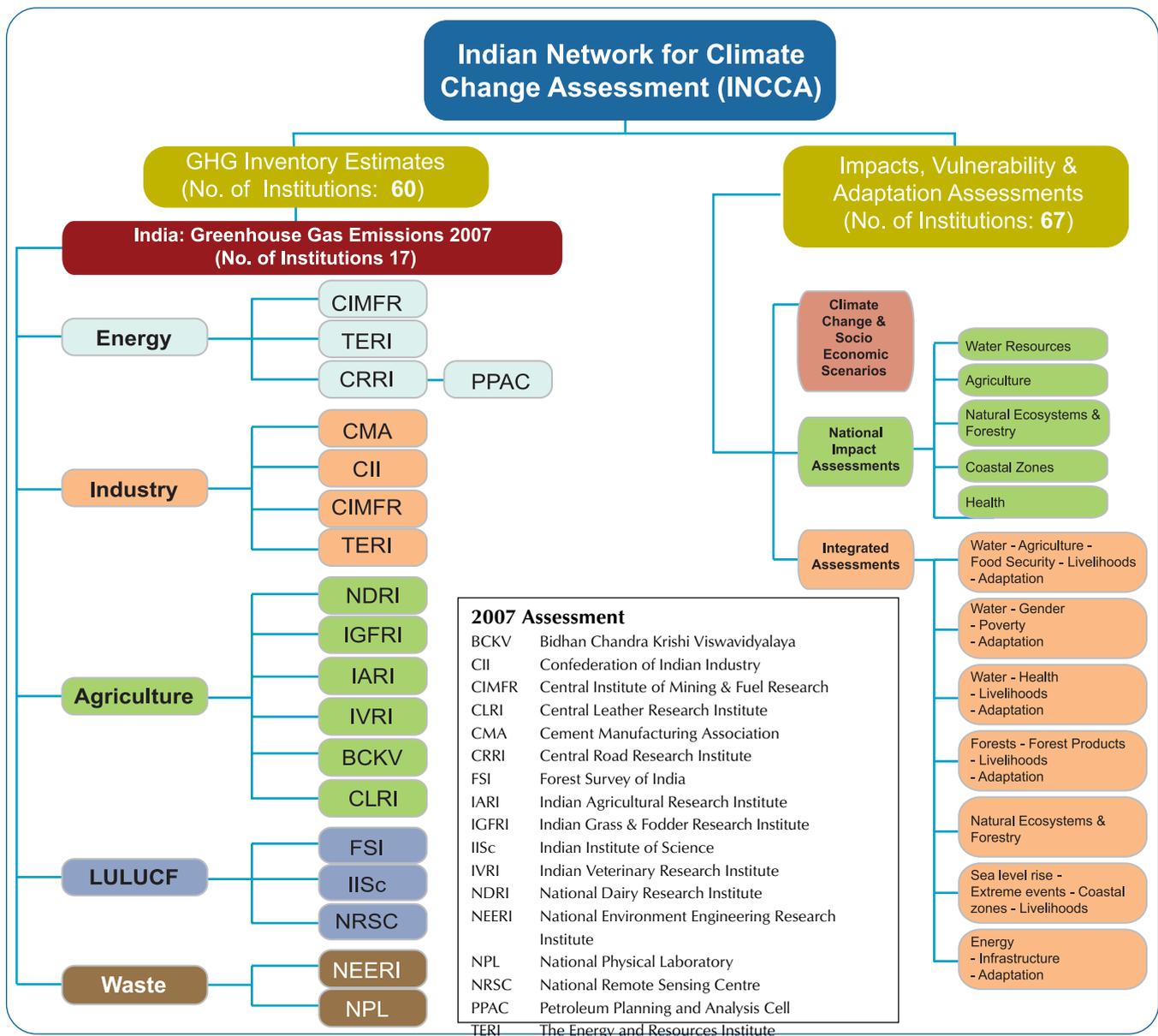
**Energy:** The energy sector emitted 1100.06 million tons of CO<sub>2</sub> eq due to fossil fuel combustion in electricity generation, transport, commercial/Institutional establishments, agriculture/fisheries, and energy intensive industries such as petroleum refining and manufacturing of solid fuels, including biomass use in residential sector. Fugitive emissions from mining and extraction of coal, oil

### Box ES2: Indian Network for Climate Change Assessment (INCCA)

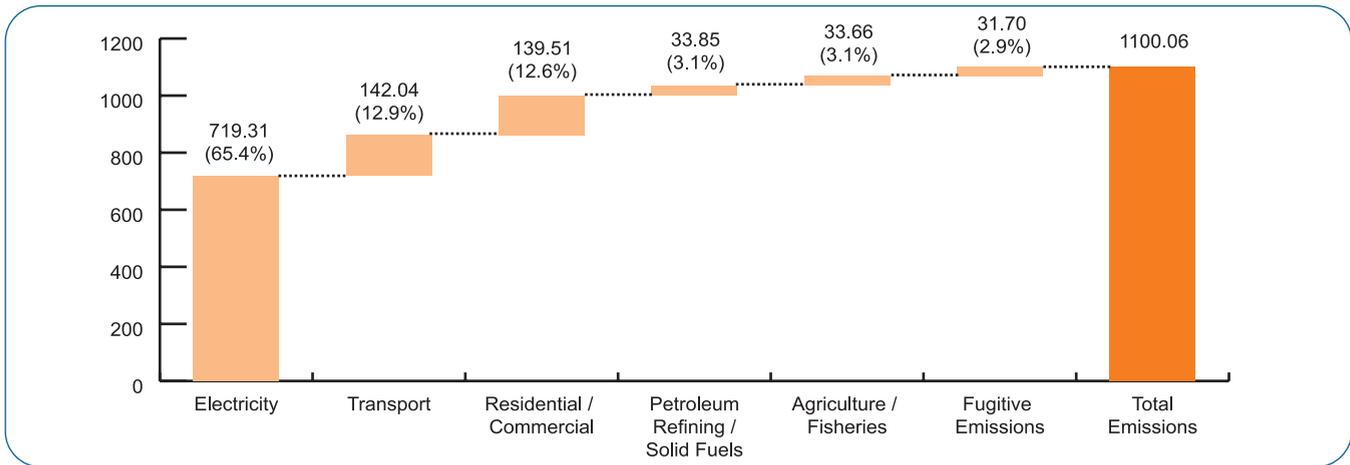
Launched on October 14, 2009, the network comprises of 127 institutions and 228 scientists across India

#### Role

- Assess the drivers and implications of climate change through scientific research
- Prepare climate change assessments once every two years (GHG estimations and impacts of climate change, associated vulnerabilities and adaptation)
- Develop decision support systems
- Build capacity towards management of climate change related risks and opportunities



**Figure ES2:** INCCA and Network for preparing the Greenhouse Gas Emissions 2007. For the complete list of institutions participating in INCCA, see Annure 4 of the main document.



**Figure ES3:** GHG emissions from Energy Sector (million tons of CO<sub>2</sub> eq).

and natural gas are also accounted for in the energy sector. The distribution of the emissions across the source categories in energy sector is shown in Figure ES3.

**Electricity Generation:** The total greenhouse gas emissions from electricity generation in 2007 was 719.31 million tons CO<sub>2</sub> eq. This includes both grid and captive power. The CO<sub>2</sub> eq emissions from electricity generation were 65.4% of the total CO<sub>2</sub> eq emitted from the energy sector. Coal constituted about 90% of the total fuel mix used.

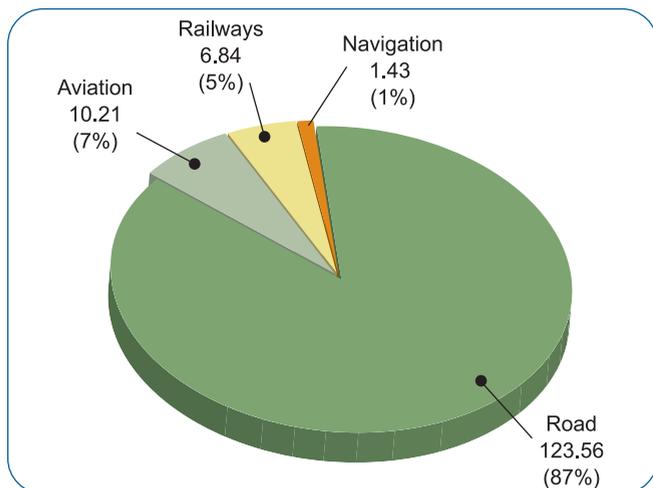
**Petroleum Refining and Solid Fuel Manufacturing:** These energy intensive industries emitted 33.85 million tons of CO<sub>2</sub> eq in 2007. The solid fuels include manufacturing of coke & briquettes.

**Transport:** The transport sector emissions are reported from road transport, aviation, railways and navigation. In 2007, the transport sector emitted 142.04 million tons of CO<sub>2</sub> eq. Road transport, being the dominant mode of transport in

the country, emitted 87% of the total CO<sub>2</sub> equivalent emissions from the transport sector. The aviation sector in comparison only emitted 7% of the total CO<sub>2</sub> eq emissions. The rest were emitted by railways (5%) and navigation (1%) sectors. The bunker emissions from aviation and navigation have also been estimated but are not counted in the national totals. (Figure ES4).

**Residential & Commercial:** The residential sector in India is one of the largest consumers of fuel outside the energy industries. Biomass constitutes the largest portion of the total fuel mix use in this sector. Commercial and institutional sector uses oil & natural gas over and above the conventional electricity for its power needs. The total CO<sub>2</sub> eq emission from residential & commercial/institution sector was 139.51 million tons of CO<sub>2</sub> eq in 2007.

**Agriculture & Fisheries:** The agriculture/ fisheries activities together emitted 33.66 million tons of CO<sub>2</sub> eq due to energy use in the sector other than grid electricity.

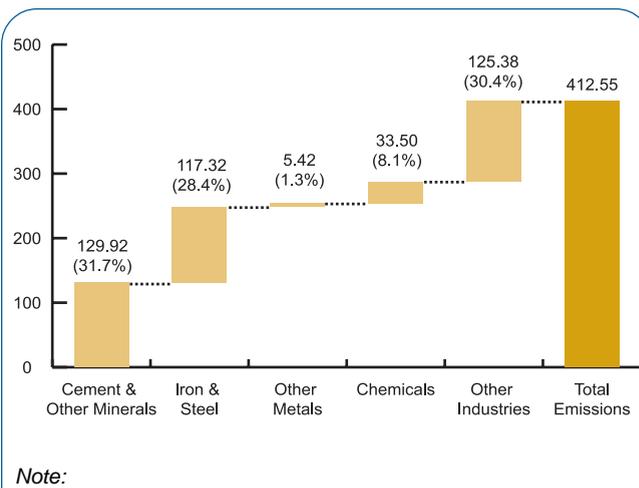


**Figure ES4:** GHG emissions from Transport Sector by mode of transport in 2007 (million tons of CO<sub>2</sub> eq).

**Fugitive Emissions:** CH<sub>4</sub> escapes into the atmosphere due to mining of coal, and due to venting, flaring, transport and storage of oil and natural gas. The total CO<sub>2</sub> eq emissions from this source category in 2007 was 31.70 million tons CO<sub>2</sub> eq.

**Industry:** Industrial activities together emitted 412.55 million tons of CO<sub>2</sub> eq of GHG in 2007. Industry sector emissions have been estimated from manufacturing of minerals, metals, chemicals, other specific industries, and from non-energy product use. The emissions covered in the industry sector include fossil fuel combustion related emissions as well as the process based emissions. (Figure ES5).

**Cement and Other Minerals:** The cement industry emitted 129.92 million tons of CO<sub>2</sub>, which is 32% of the total CO<sub>2</sub> eq emissions from the Industry sector. The emissions cover the entire technology mix for manufacturing of cement in the country covering large, medium and white cement



**Note:**

**Other Metals:** includes GHG emissions from production of ferroalloys, aluminium, lead, zinc and copper.

**Chemicals:** includes GHG emissions from production of ammonia, nitric acid, adipic acid, caprolactam, carbide, titanium dioxide, petrochemicals and black carbon, methanol, ethylene, ethylene oxide, acrylonitrile, ethylene dichloride and vinyl chloride monomer and other chemicals (see glossary for details).

**Other Industries:** includes GHG emissions from pulp and paper, food processing, textile and leather, mining and quarrying and non specific industries. It also includes emissions from non-energy product use.

**Figure ES5:** GHG emissions from Industry Sector (million tons of CO<sub>2</sub> eq).

plants. The other minerals like glass and ceramic production and soda ash use together emit 1.01 million tons of CO<sub>2</sub> eq.

**Iron and Steel and Other Metals:** The iron and steel industry emitted 117.32 million tons of CO<sub>2</sub> eq. The estimate covers integrated and mini steel plants. The production of other metals, namely, aluminum, ferroalloys, lead, zinc and copper production lead to an emission of 5.42 million tons of CO<sub>2</sub> eq.

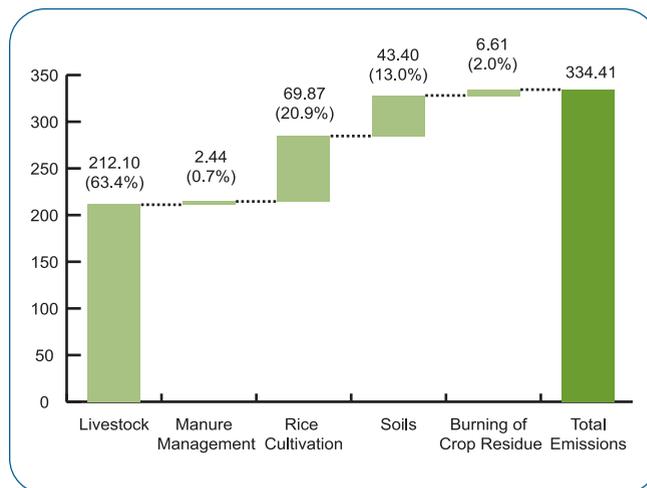
**Chemicals:** The chemical industries together emitted 8.1% of the total GHG emissions from the industry sector (33.50 million tons). See Fig. ES5 & Glossary for details of sub-categories included.

**Other Industries:** Other industries comprising of pulp/paper, leather, textiles, food processing, mining and quarrying, and non specific industries comprising of rubber, plastic, watches, clocks, transport equipment, furniture etc., together emitted 124.53 million tons. The rest of the emissions in the Industry sector came from the non-energy product uses and this sector emitted 0.85 million tons of CO<sub>2</sub> eq, and was mainly from use of oil products and coal-derived oils primarily intended for purposes other than combustion.

**Agriculture:** The agriculture sector emitted 334.41 million tons of CO<sub>2</sub> eq in 2007. Estimates of GHG emissions from the agriculture sector arise from enteric fermentation in livestock, manure management, rice paddy cultivation, agricultural soils and on field burning of crop residue. (Figure ES6)

**Livestock:** Enteric fermentation in livestock released 212.10 million tons of CO<sub>2</sub> eq (10.1 million tons of CH<sub>4</sub>). This constituted 63.4% of the total GHG emissions (CO<sub>2</sub> eq) from agriculture sector in India. The estimates cover all livestock, namely, cattle, buffalo, sheep, goats, poultry, donkeys, camels, horses and others. Manure management emitted 2.44 million tons of CO<sub>2</sub> eq.

**Rice Cultivation:** Rice cultivation emitted 69.87 million tons of CO<sub>2</sub> eq or 3.27 million tons of CH<sub>4</sub>. The emissions cover all forms of water management practiced in the country for rice cultivation, namely, irrigated, rainfed, deep water and upland rice. The upland rice are zero emitters and irrigated continuously flooded fields and deep water rice emit maximum methane per unit area.

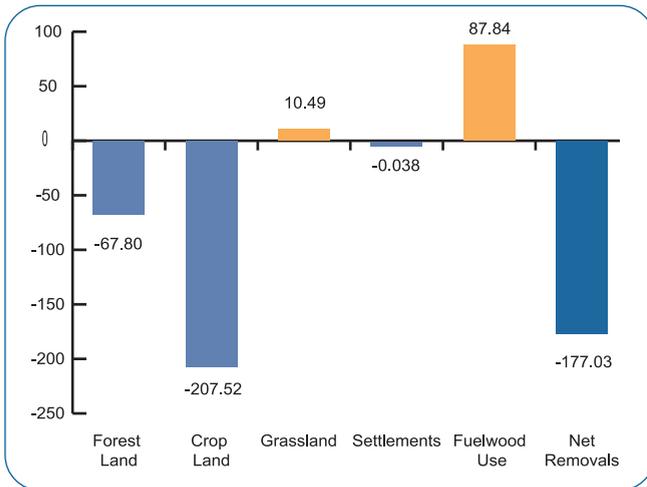


**Figure ES6:** GHG emissions from Agriculture Sector (million tons of CO<sub>2</sub> eq).

**Agricultural Soils and Field Burning of Crop Residue:** Agricultural soils are a source of N<sub>2</sub>O, mainly due to application of nitrogenous fertilizers in the soils. Burning of crop residue leads to the emission of a number of gases and pollutants. Amongst them, CO<sub>2</sub> is considered to be C neutral, and therefore not included in the estimations. Only CH<sub>4</sub> and N<sub>2</sub>O are considered for this report. The total CO<sub>2</sub> eq emitted from these two sources were 50.00 million tons.

**Land Use Land Use Change and Forestry:** The estimates from LULUCF sector include emission by sources and or removal by sinks from changes in forest land, crop land, grassland, and settlements. Wet lands have not been considered due to paucity of data. The LULUCF sector in 2007 was a net sink. It sequestered 177.03 million tons of CO<sub>2</sub> in 2007. (Figure ES7)

**Forest Land:** This includes estimates of emissions and removal from above and below ground biomass in very



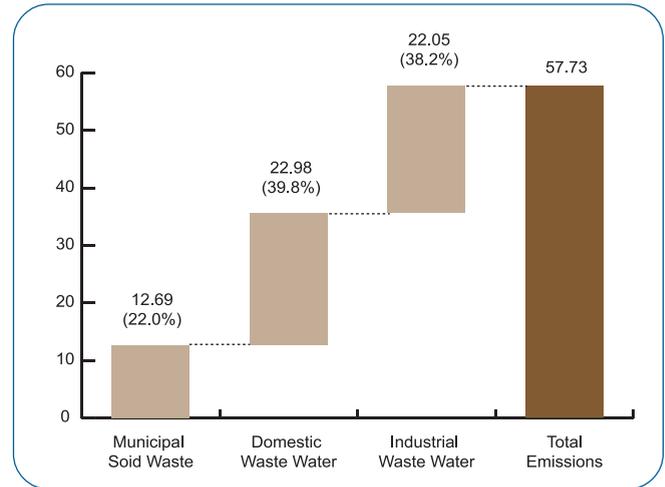
**Figure ES7:** GHG emissions and removals from LULUCF sector (million tons of CO<sub>2</sub> eq).

dense, moderately dense, open forests, and scrub lands. Estimates indicate that forest land sequestered 67.8 million tons of CO<sub>2</sub> in 2007. However, fuel wood extracted non-sustainably from forests lead to an emission of 67.80 million tons of CO<sub>2</sub> in 2007.

**Crop Lands:** The emission estimates have been made from net sown area as well as fallow land. The crop land sequestered 207.52 million tons of CO<sub>2</sub> in 2007.

**Grassland:** Changes in Grassland resulted in the emission of 10.49 million tons of CO<sub>2</sub> due to decrease in grass land area by 3.4 million ha between the two periods.

**Settlements:** Land converted to settlements though increased by 0.01 million ha during the period, however, the conversions did not lead to an emission but a net removal of 0.04 million tons.



**Figure ES8:** GHG emissions from waste (million tons of CO<sub>2</sub> eq).

**Waste:** The waste sector emissions were 57.3 million tons of CO<sub>2</sub> eq from municipal solid waste management, domestic waste water and industrial waste water management. (Figure ES8)

**Municipal Solid Waste (MSW):** Systematic disposal of solid waste is carried out only in the cities in India resulting in CH<sub>4</sub> emissions due to aerobic conditions generated due to accumulation of waste over the years. It is estimated that the MSW generation and disposal resulted in the emissions of 12.69 million tons of CO<sub>2</sub> eq in 2007.

**Waste Water:** The waste water generation emissions are the sum total of emissions from domestic waste water and waste water disposal in industries. Waste water management in both these categories together emitted 45.03 million tons of CO<sub>2</sub>

## E. FUTURE DIRECTIONS

The robustness of the GHG inventory making process is dependent on the Tier of methodology used. Higher the Tier, more representative is the emission estimated of the actual emissions. Of the total 1727.71 million tons of CO<sub>2</sub> equivalent emissions from India in 2007, 21% of the emissions have been estimated using Tier I methodology, 67% by Tier II and 12% by Tier III.

**Riding the Tier Ladder:** For improving the inventory estimations of key categories using Tier II and Tier I methodologies, there is a need to move up the Tier ladder. Strategies needed include improvement in assimilation of activity data representing national circumstances, bridging data gaps, and eliminating uncertainties by developing country specific GHG emission factors.

**Capacity Building and National Greenhouse Gas Inventory Management System:** Capacity building is essential at institutional and individual levels. Capacity at the institutional level addresses the needs of inventory preparation at national, sectoral and point source level that requires systematic collection and archiving of data on a continuous basis. Establishment of a National Inventory Management System is therefore necessary. It is also important to involve additional institutions with varied research experience, to widen the pool of researchers and enable the integration of latest practices.

Greenhouse gas emissions by sources and removal by sinks from India in 2007 (thousand tons)

	CO <sub>2</sub> emissions	CO <sub>2</sub> removals	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub> equivalent
<b>GRAND TOTAL</b>	<b>1497029.20</b>	<b>275358.00</b>	<b>20564.20</b>	<b>239.31</b>	<b>1727706.10</b>
<b>ENERGY</b>	<b>992836.30</b>		<b>4266.05</b>	<b>56.88</b>	<b>1100056.89</b>
Electricity generation	715829.80		8.14	10.66	719305.34
Other energy industries	33787.50		1.72	0.07	33845.32
Transport	138858.00		23.47	8.67	142038.57
<i>Road transport</i>	<i>121211.00</i>		<i>23.00</i>	<i>6.00</i>	<i>123554.00</i>
<i>Railways</i>	<i>6109.00</i>		<i>0.34</i>	<i>2.35</i>	<i>6844.64</i>
<i>Aviation</i>	<i>10122.00</i>		<i>0.10</i>	<i>0.28</i>	<i>10210.90</i>
<i>Navigation</i>	<i>1416.00</i>		<i>0.13</i>	<i>0.04</i>	<i>1431.13</i>
Residential	69427.00		2721.94	36.29	137838.49
Commercial / Institutional	1657.00		0.18	0.04	1673.18
Agriculture/ Fisheries	33277.00		1.20	1.15	33658.70
Fugitive emissions			1509.40		31697.30
<b>INDUSTRY</b>	<b>405862.90</b>		<b>14.77</b>	<b>20.56</b>	<b>412546.53</b>
<b>Minerals</b>	<b>130783.95</b>		<b>0.32</b>	<b>0.46</b>	<b>130933.27</b>
Cement production	129920.00				129920.00
Glass & ceramic production	277.82		0.32	0.46	427.14
Other uses of soda ash	586.12				586.12
<b>Chemicals</b>	<b>27888.86</b>		<b>11.14</b>	<b>17.33</b>	<b>33496.42</b>
Ammonia production	10056.43				10056.43
Nitric acid production				16.05	4975.50
Carbide production	119.58				119.58
Titanium dioxide production	88.04				88.04
Methanol production	266.18		0.91		285.37
Ethylene production	7072.52		9.43		7270.64
EDC & VCM production	198.91				198.91
Ethylene Oxide production	93.64		0.19		97.71
Acrylonitrile production	37.84		0.01		37.98
Carbon Black production	1155.52		0.03		1156.07
caprolactam				1.08	336.22
Other chemical	8800.21		0.56	0.20	8873.97
<b>Metals</b>	<b>122371.43</b>		<b>0.95</b>	<b>1.11</b>	<b>122736.91</b>
Iron & Steel production	116958.37		0.85	1.09	117315.63
Ferroalloys production	2460.70		0.08		2462.29

(contd...)

	CO <sub>2</sub> emissions	CO <sub>2</sub> removals	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub> equivalent
Aluminium production	2728.87		0.01	0.00	2729.91
Lead production	84.13		0.00	0.01	86.38
Zinc production	76.11		0.00	0.01	77.99
Copper	63.25		0.01	0.00	64.70
<b>Other Industries</b>	<b>123969.17</b>		<b>2.37</b>	<b>1.65</b>	124530.44
Pulp and paper	5222.50		0.05	0.08	5248.35
Food processing	27625.53		1.12	0.22	27717.25
Textile and leather	1861.11		0.03	0.02	1867.94
Mining and quarrying	1460.26		0.06	0.01	1464.62
Nonspecific industries	87799.77		1.11	1.32	88232.28
<b>Non energy product use</b>	<b>849.49</b>				849.49
Lubricant	776.75				776.75
Paraffin wax	72.75				72.75
<b>AGRICULTURE</b>			<b>13767.80</b>	<b>146.07</b>	<b>334405.50</b>
Enteric fermentation			10099.80		212095.80
Livestock Manure management			115.00	0.07	2436.70
Rice cultivation			3327.00		69867.00
Soils				140.00	43400.00
Burning of crop residue			226.00	6.00	6606.00
<b>LULUCF</b>	<b>98330.00</b>	<b>275358.00</b>			<b>-177028.00</b>
Forestland		67800.00			-67800.00
Cropland		207520.00			-207520.00
Grassland	10490.00				10490.00
Settlement		38.00			-38.00
Wetland	NE				NE
Other land	NO				NO
Fuel wood use in forests	87840.00				87840.00
<b>Waste</b>			<b>2515.58</b>	<b>15.80</b>	<b>57725.18</b>
Municipal Solid waste			604.51		12694.71
Domestic waste water			861.07	15.80	22980.47
Industrial waste water			1050.00		22050.00
<b>Bunkers*</b>	<b>3454</b>		<b>0.03</b>	<b>0.10</b>	<b>3484.45</b>
Aviation Bunkers	3326		0.02	0.09	3355.31
Marine bunkers	128		0.01	0.003	129.14

Note: LULUCF: Land Use Land Use Change & Forestry

\*Not included in the national totals.

NE: Not estimated; NO: Not occurring

## GLOSSARY OF KEY TERMS

**Agriculture:** This includes emissions from enteric fermentation, manure management, rice cultivation, managed soils and burning of crop residue.

**CAGR:** The compound annual growth rate is calculated by taking the  $n^{\text{th}}$  root of the total percentage growth rate, where  $n$  is the number of years in the period being considered.

**Chemicals:** In this document chemicals include production of ammonia, nitric acid, adipic acid, caprolactam, carbide, titanium dioxide, petrochemicals and black carbon, methanol, ethylene, ethylene oxide, acrylonitrile, ethylene dichloride and vinyl chloride, monomer and other chemicals (dyes and pigments, inorganic acids except nitric acid, acyclic hydrocarbons, basic organic chemicals, inorganic compounds, alkalies and other inorganic bases except ammonia, synthetic aromatic products, luminophores, etc).

**CO<sub>2</sub> Equivalent:** It is the sum total of all Greenhouse Gases in terms of their global warming potential. In this document the CO<sub>2</sub> equivalent includes the sum of Carbon dioxide, Methane multiplied by its GWP (21) and Nitrous oxide multiplied by its GWP (310).

**Country Specific Data:** Data for either activities or emissions that are based on research carried out on-site either in a country or in a representative country.

**Emission Factor:** A coefficient that quantifies the emissions or removals of a gas per unit activity. Emission factor are often based on a sample of measurement data, averaged to develop a representative rate of emission for a given activity level under a given set of operating conditions.

**Emissions:** The release of greenhouse gases and / or their precursors into the atmosphere over a specified area and a period of time.

**Energy:** This category included all GHG emissions arising from combustion of fossil fuel and fugitive release of GHG's .

Emissions from the non-energy use are not included here and are reported under the industry sector. This category includes emissions due to fuel combustion from energy industries (electricity generation, petroleum refining, manufacturing of solid fuel), transport, commercial / institutional, residential, agriculture / forestry / fisheries, and fugitive emissions from coal mining and handling and from oil and natural gas.

**Enteric Fermentation:** A process of digestion in herbivores (plant - eating animals) which produces methane as a by-product.

**Estimation:** The process of calculating emissions and / or removal

**Flaring:** Deliberate of burning of natural gas and waste gas / vapour streams, without energy recovery.

**Fossil Fuel Combustion:** Is the intentional oxidation of fossil fuel that provides heat or mechanical work to process.

**Fugitive Emission:** Emission that are not emitted through an intentional release through stack or vent. This can include leaks from plants, pipelines and during mining.

**Global Warming Potential (GWP):** GWPs are calculated as a ratio of radiative forcing of 1 kilogram greenhouse gas emitted to the atmosphere to that from 1 kilogram CO<sub>2</sub> over a period of time (e.g.. 100 years).

**Good Practice:** Is a set of procedures intended to ensure that GHG inventories are accurate, that neither over nor underestimated and that uncertainties are reduced as far as possible. It covers choice estimation methods, quality assurance and quality control, quantification of uncertainties and processes for data archiving and reporting.

**INCCA:** Indian Network for Climate Change Assessment - an initiative being coordinated by the Ministry of Environment and Forests, Government of India.

**Industry:** This includes emissions from industrial processes and

emissions due to fossil fuel combustion in manufacturing industries. The emissions are estimated from mineral industry (cement, lime, glass, ceramics, soda ash use), chemical industries (ammonia, nitric acid, adipic acid, caprolactam, carbide, titanium dioxide, petrochemicals and black carbon, methanol, ethylene, etc.), metal industry (iron and steel, ferroalloys, aluminium, magnesium, lead, sink, etc.), other industry and non-energy products from fuels and solvent use (paraffin wax and lubricants).

**Land Cover:** The type of vegetation, rock, water, etc. covering the earth surface.

**Land Use:** The type of activity being carried out by unit of land

**Land Use Land Use Change and Forestry (LULUCF):** Includes emissions and removal from changes in areas of forest land, crop land, grass land, wet land, settlements and other lands.

**Million Tons:** equal to 10<sup>6</sup> tons.

**Non Energy Products:** Primary or secondary fossil fuels which act as diluent. Examples, lubricants, paraffin wax, bitumen, etc.

**Non Energy Use:** Use of fossil fuels as feedstock, reductant or non-energy products.

**Non-specific industries:** Includes rubber, plastic, medical precision equipments, watches, clocks, other transport, furniture, re-cycling etc.

**Other Energy:** Includes GHG emissions from petroleum refining, manufacturing of solid fuel, commercial & institutional sector, agriculture & fisheries and fugitive emissions from mining, transport and storage of coal, oil and natural gas.

**Other Industry:** Includes GHG emissions from production of food processing, textile, leather, mining and quarrying, non specific industries and use of lubricants and paraffin wax.

**Other Minerals:** In this document other minerals refer to glass and ceramics production and soda ash use.

**Per Capita Emissions:** GHG emissions in CO<sub>2</sub> eq per person.

**Removals:** Removal of greenhouse gases and or their precursors from the atmosphere by a sink

**Sequestration:** The process of storing carbon in a carbon pool.

**Sink:** Any process, activity or mechanism which removes greenhouse gases from the atmosphere.

**Source:** Any process or activity which releases a greenhouse gas.

**Tier I:** Its approach employs activity data that are relatively coarse, such as nationally or globally available estimates of deforestation rates; agriculture production statistics and global land cover maps.

**Tier II:** It uses the same methodological approach as Tier 1 but it applies emission factors and activity data which are defined by the country

**Tier III:** Applies higher order methods are used including models and inventory measurement systems tailored to address national circumstances, repeated over time, and driven by disaggregated levels.

**Uncertainty:** Lack of knowledge of the true value of a variable.

**Waste:** Includes methane emissions from anaerobic microbial decomposition of organic matter in solid waste disposal sites and methane produced from anaerobic decomposition of organic matter by bacteria in sewage facilities in industries and in domestic waste water.





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