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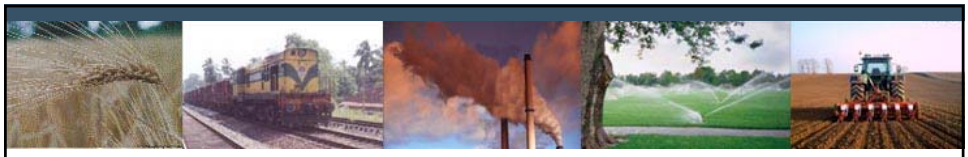
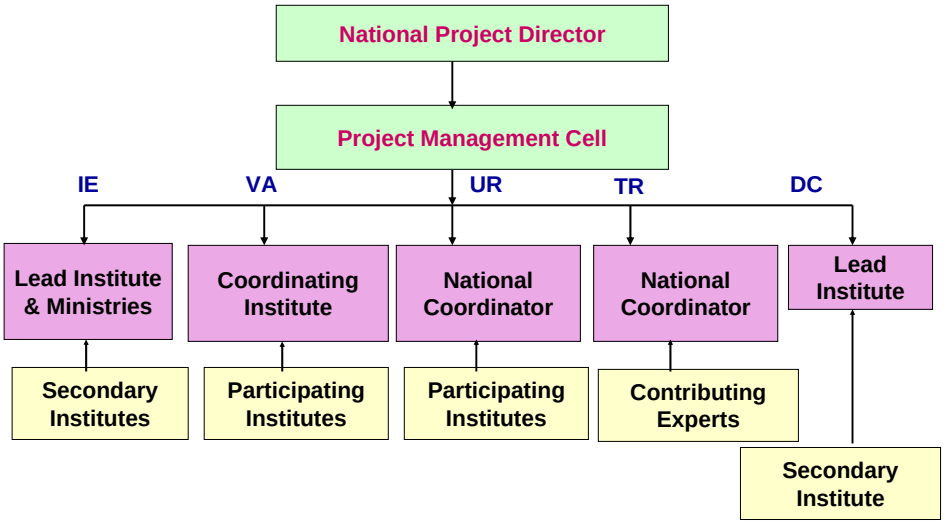


Methodologies for preparation of Inventories for India

Amit Garg

Presentation for the
Workshop on GHG Inventories in Asia Region
Nov 13-14 2003, Phuket, Thailand

Institutional Framework



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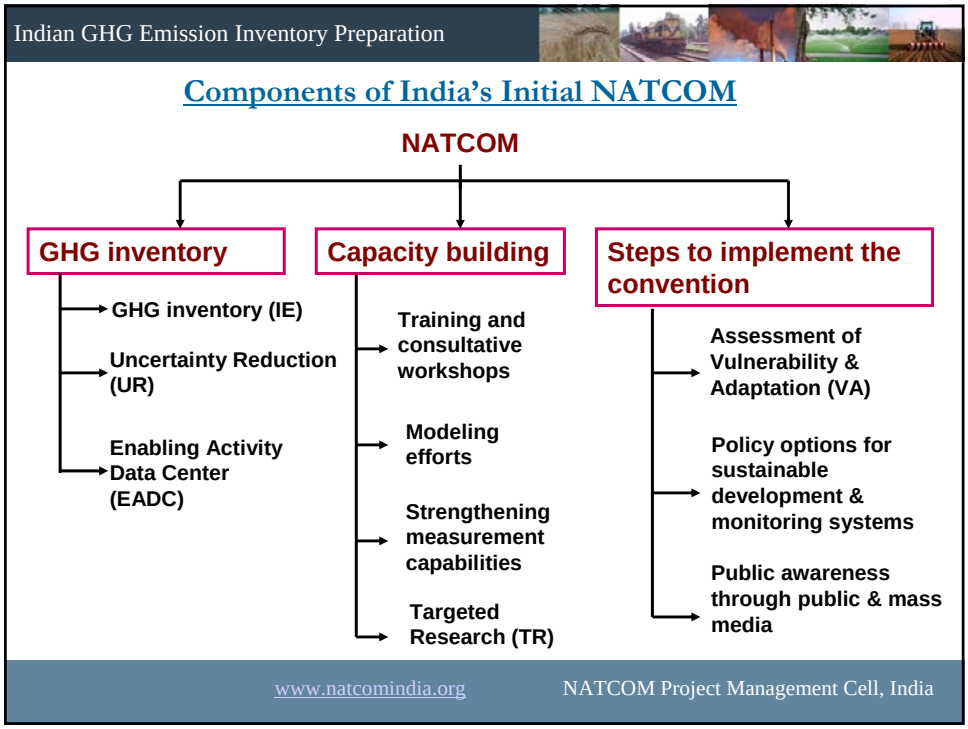

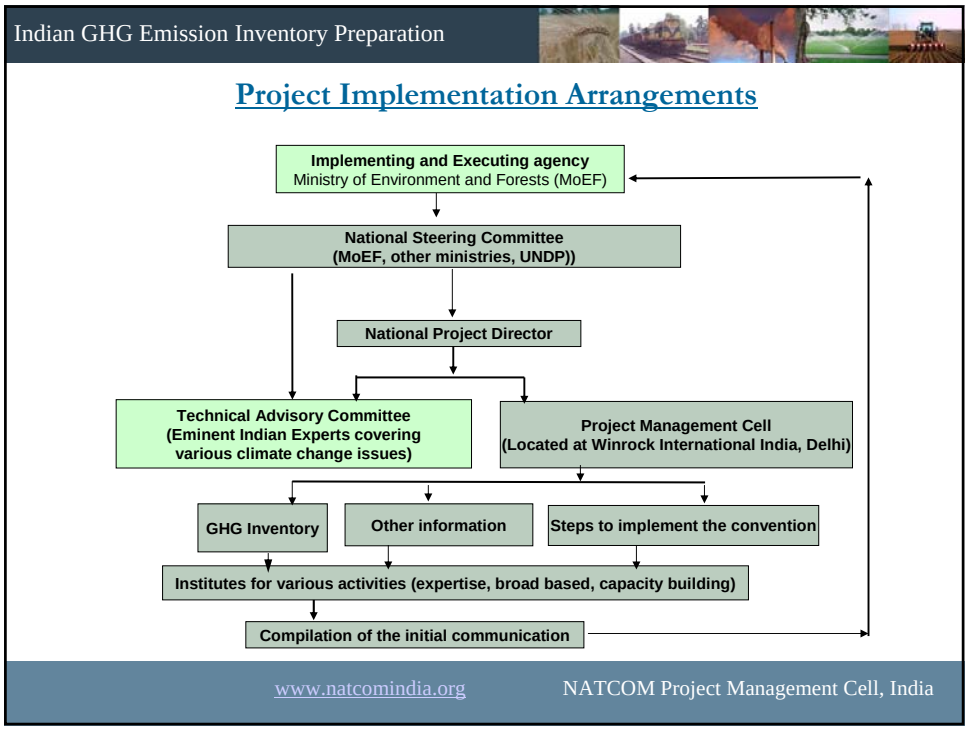

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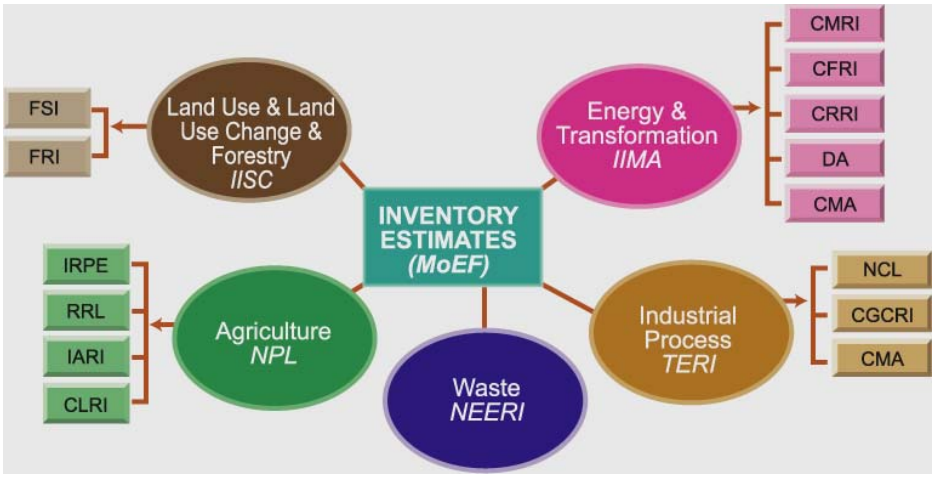
Approach to NATCOM Preparation

- Broad based participatory approach for
  - Development of comprehensive inventory of GHGs for 1994
  - Improve its reliability vis-a-vis reducing uncertainties of GHG emission coefficients in key source categories (IPCC guidelines and methodologies)
  - Vulnerability assessment and adaptation of various sectors to climate change
- Identification of key steps to implement the Convention
- Capacity Building and networking of Institutions through meetings, workshops (training, awareness and thematic) and publications

IE: Institutional Arrangement



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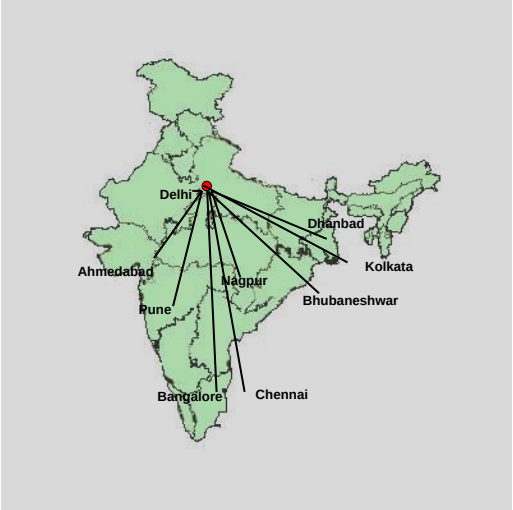
IE: Geographical Institutional Distribution



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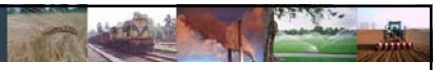

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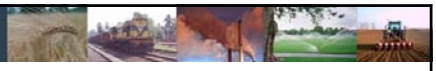

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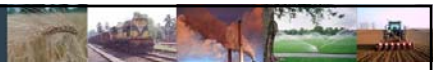

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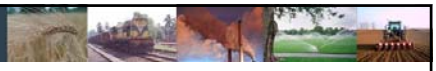

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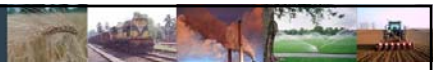

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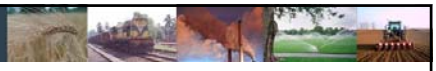

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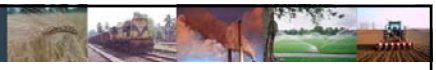

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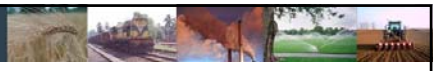

Good Practice Guidelines

The Indian NATCOM has adopted Quality Control and Quality Assurance practices to the extent possible.

- **Data verification from alternate sources**
- **Going one level deeper**
- **Review by Indian experts not part of inventory preparation**
- **Inventory validation at three national workshops**

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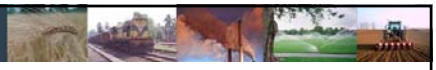


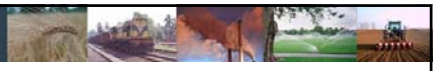
Uncertainty Reduction in Greenhouse Gas Emissions

Statistical Definition: An uncertainty is a parameter, associated with the result of measurement that characterises the dispersion of the values that could be reasonably attributed to the measured quantity (e.g. the sample variance or coefficient of variation).

Inventory definition: A general and imprecise term which refers to the lack of certainty (in inventory components) resulting from any causal factor such as unidentified sources and sinks, lack of transparency etc.

Source: IPCC Good Practice Guidelines

Indian GHG Emission Inventory Preparation



Uncertainty Reduction in Greenhouse Gas Emissions

- **Top down and bottom up estimates of national activity data have variations due to aggregation errors**
- **Existing activity data reporting formats are not meant for inventory reporting purposes**
- **IPCC default emission coefficients may not be representative of India specific coefficients**
- **Regional and sectoral variability exists in emission coefficients across a large country like India**
- **Wide technology diversity complicates estimation of India specific estimates (new and vintage technologies co-exist)**
- **Methodological issues**

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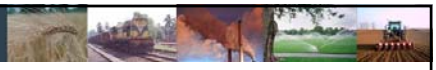
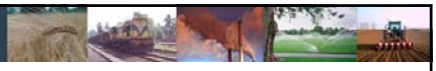


Possible Reasons for Variation in Some Coefficients

Coefficient type	Possible reasons for variation of Indian coefficients from IPCC default values
CH_4 from Municipal Solid Waste	Waste composition, waste collection levels and mechanisms, dump management, reduction technologies
CO_2 from coal combustion	Coal composition, boiler/ combustion efficiency, regional variations across the country, coal definition issues
Industrial process emissions	Technological variability in level and extent of control processes
CH_4 from enteric fermentation	Thinner cattle, not so rich feed type
CH_4 from rice paddy cultivation	Irrigation practices, fertilizer and soil types in India are not conducive to high CH_4 production



Uncertainties in Inventory Estimates

Uncertainties can be resolved through:

- Examination of Activity Data
- Development of Indigenous Emission Coefficients

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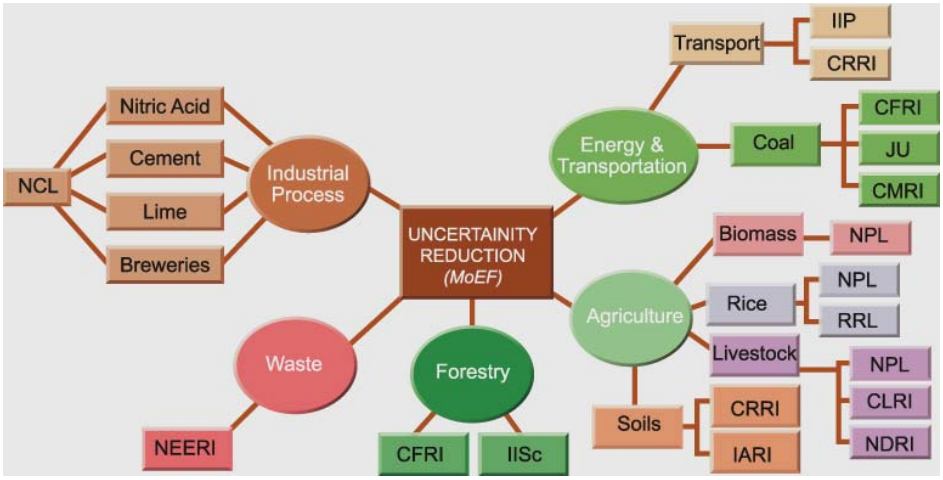
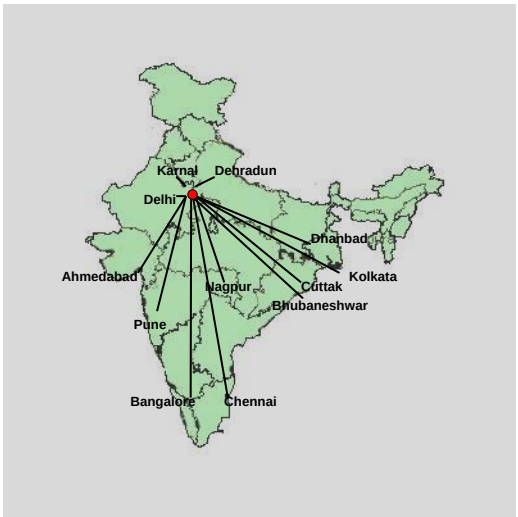
UR: Institutional Arrangement



UR: Geographical Institutional Distribution



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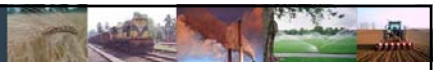


Key Source Categories: Energy & Transformation sector

Uncertainty in Activity data & emission coeff.

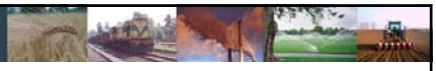
- **Road Transport**
  - **Car/ taxi**
  - **2W/3W**
  - **MCV/HCV**
  - **LCV**

Uncertainty in NCV & CO_2 emission coeff.

- **Coal Combustion**
  - **Coking coal**
  - **Non coking**
  - **Lignite**

Uncertainty in CH_4 emission coeff.

- **Coal mining**
  - **During mining**
    - **Surface mining**
    - **Degree1**
    - **Degree2**
    - **Degree3**
  - **Post Mining**
    - **Surface mining**
    - **Degree 1**
    - **Degree 2**
    - **Degree 3**



Key Source Categories: Industrial Process sector

- **Cement production**
- **Lime production**
- **Lime stone and dolomite use**
- **Ammonia production**
- **Nitric acid production**

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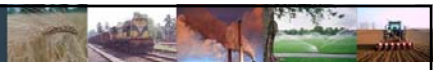

Key Source Categories: Agriculture sector

➢Rice Cultivation

- ❖Upland
- ❖Rain fed (Flood Prone)
- ❖Rain fed (Drought Prone)
- ❖Irrigated (Continuously Flooded)
- ❖Intermittently Flooded-Single Aeration
- ❖Intermittently Flooded-Multiple Aeration
- ❖Deep Water

➢Enteric Fermentation

- ❖Cattle
  - ▪Dairy
- ❖Non-Dairy
  - ▪Below 1yr
  - ▪1-3 yrs
  - ▪Others
- ❖Cross bred
  - ▪Dairy
- ❖Non-dairy
  - ▪Below 1yr
  - ▪1-3 yrs.
  - ▪Others
- ❖Buffalo
  - ▪Dairy
- ❖Non-Dairy
  - ▪Below 1yr.
  - ▪1-3 yrs.

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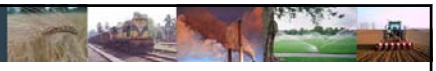

Key Source Categories: Agriculture sector (Contd.)

➢Manure Management

- ❖ Dairy Cattle
  - ▪Indigenous
  - ▪Cross bred
- ❖Non Dairy Cattle indigenous
  - ▪Below 1yr
  - ▪1 to 3 yrs
  - ▪Adults
- ❖Non Dairy Cattle Cross Bred
  - ▪Below 1yr
  - ▪1 to 2.5 yrs.
  - ▪Adults
  - ▪Dairy Buffaloes
- ❖Non Dairy Buffaloes
  - ▪Below 1 yr
  - ▪1 to 3 yrs.
  - ▪Adults

➢Crop Residue

- ❖ Residue to crop ratio
  - ▪Rice
  - ▪Wheat
  - ▪Maize
  - ▪Millet
  - ▪Jute
  - ▪Cotton
  - ▪Groundnut
  - ▪Sugarcane
  - ▪Rapeseed and Mustard

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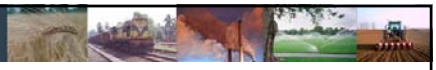
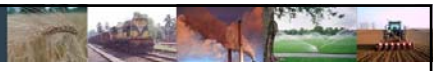


Key Source Categories: Agriculture sector (Contd.)

- **Soils**
  - **EF1(fraction of N input kg N2O-N/kg N)**
  - **EF2(organic soil)kg N2O-N ha/yr**
  - **EF4 (Nitrogen deposition)kg N2O-N/kg NH3-N and Nox-N emitted**
  - **EF5(leached/run-off N from fertilizer and manure)kg N2O-N/kg N leaching/run-off**
  - **Frac.GASF (gas loss through volatilization from inorganic fertilizer)kg NH3-N + Nox-N/kg of synthetic fertlizer N applied**
  - **Frac.GASM (gas loss through volatilization from manure) kg NH3-N + Nox-N/kg of N excreted by livestock**
  - **Frac.leach (Leaching loss of N from applied fertilizer and manure) kg N/kg fertilizer or manure N**



Key Source Categories: Land Use, Land Use Change & Forestry

- **Changes in forest and other woody biomass**
- **Annual forest and grass land conversion**
- **Abandonment of managed lands**
- **CO_2 emission or uptake from soils**

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Key Source Categories: Waste

➢**Municipal Solid Waste : Okhla**

Uncertainty Reduction: Emission Coefficients Measurements

•Coal	CO_2
•Power and Steel(Coal)	CO_2
•Road transport	CO_2, N_2O
•Biomass burning	CH_4, N_2O
•Cement, Nitric acid, Lime	CO_2, N_2O, CH_4
• Enteric fermentation in animals	CH_4
•Manure management	CH_4, N_2O
•Rice paddy cultivation	CH_4
•Soils	N_2O
•Municipal Solid Waste	CH_4

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Emission Coefficient: Research Methodologies

Sector/ Source	Methodology
Road transport	Emission coefficient determined by exhaust gases sampling through constant volume methodology. Vehicles are tested using Chassis dynamometer assembly. CO_2 and CO - using non-dispersive infrared absorption type CO_2 analyser; HC - using Flame Ionization detector type analyser; NOx – using chemiluminescent (CLA) type analyser
Calorific values of Indian coals	Assessment of NCV and GCV of various Indian coals such as Coking, Bituminous and Lignite based on their moisture, carbon and hydrogen contents
Coal mining	CH_4 emission measurements using Haldane Mine Air Analysis Apparatus and gas chromatographs. Chamber method used for the first time in India for open cast mine measurements

Research Methodologies (Contd.)

Sector/ Source	Methodology
Coal combustion in power plants	CO_2 Emission factor estimates through primary data collection on fuel feed rate, quality parameters, sampling of coal, fly and bottom ash and Direct measurement of gases at different stack heights. Analysis using gas chromatographs with standard gas samples. Suspended Particulate Matter - The Whatman glass fibre filter paper Respirable Suspended Particulate Matter - The Whatman glass fibre filter paper Sulphur Dioxide – Sodium Tetrachloromercurate method Nitrogen Dioxide – Sodium Hydroxide method Ambient CO_2 and Photosynthesis rate – Portable Photosynthesis System Leaf Area – Leaf Area Meter
Coal combustion in steel plants	CO_2 Emission factor estimated through primary data collection on quantity and type of fuel consumption, quantity of reducing agents, carbon in ore, pig iron and steel, production of pig iron and steel along with direct measurement of flue gas. Analysis using gas chromatographs with standard gas samples.

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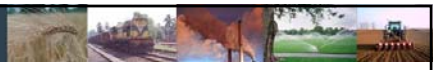
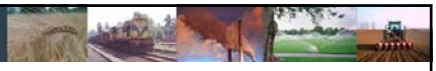


Research Methodologies (Contd.)

Sector/ Source	Methodology
Coal Combustion in cement plants	CO_2 Emission factor estimates through primary data collection on raw material consumption, its composition, content of clinker and CaO, limestone content, cement kiln dust and direct measurement of gases for Dry, Semi-Dry and Wet Technologies. Analysis using gas chromatographs with standard gas samples.



Research Methodologies: Industrial Processes

Sector/ Source	Methodology
Nitric acid production	Analysis of N_2O samples using Portable Infra Red gas analyzer collected from Selective catalytic reduction (SCR), at feed to SCR, at feed to Non-SCR, and from Non-SCR at stack levels.
Lime production	Based on lime production data and standard IPCC methodology
Cement production	CO_2 emission coefficient derived from the analysis of CaO and MgO in raw material, clinker, and finished cement samples. Analysis is carried out by atomic absorption spectrophotometer (AAS)

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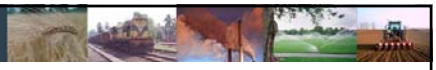
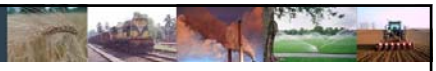


Research Methodologies: Agriculture

Sector/ Source	Methodology
Rice cultivation	Collection of CH_4 samples at different types of fields with different water regimes, amendments, cultivars for the entire one year. Analysis using gas chromatographs with standard gas samples.
Biomass combustion	Measurement of emission factors through collection of gases for different samples of bio mass Analysis using gas chromatographs with standard gas samples.
Enteric fermentation	Determination of emission factor of CH_4 through Measurement of CH_4 due to enteric fermentation in dairy cows Estimate of CH_4 emission factors using activity data on feed intake, feed energy, etc.



Research Methodology: LULUCF

Based on literature survey and appropriate for Indian plantation types

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Research Methodologies: Waste

Sector/ Source	Methodology
Municipal Solid Waste	**Actual CH_4 measurement at one landfill site in Delhi**
	Estimation of Waste water generated per category of industry; maximum methane production capacity and methane emission factor per kg of COD

Workshops conducted

- Workshop on Good Practices in Inventory Development (Nov 27-30, 2001), New Delhi
- Seminar on Reducing Uncertainties in Inventory Estimates (November 28, 2001), New Delhi
- Workshop on Inventory Development (December 3-5, 2001), Ahmedabad
- National Communication Workshop on LULUCF Scoping (February 7-8, 2002), Bangalore
- Finalization of Emission Coefficients (March 4-5, 2003), New Delhi
- Finalization of GHG Emission Inventories (March 27, 2003), New Delhi
- Finalization of GHG Emission Inventories from Agriculture sector (April 2, 2003), Delhi
- Finalization of GHG inventory in LULUCF Sector (May 6-7, 2003), Dehradun

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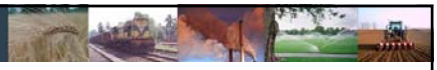

Conclusions

- **Activity Data**
  - **Robustness**
  - **Uncertainty Reduction**
  - **Depth**
  - **Completeness**
- **Emission Factors**
  - **Some key source categories**
  - **Sampling plan**
  - **Calibration**
  - **Reproducibility**