
# Emissions Inventory and Modelling in India

## Analysis Using Asia-Pacific Integrated Model

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For AIM India Team



# Presentation Agenda

- Emissions Inventory for India
- National Applications with New Indian Scenarios
  - Indian Scenarios
  - $CO_2$ Emissions and Large Point Source Analysis (with AIM/Local Model)
  - Non-CO2 Gas Emissions (with AIM/Local Model)
  - Integrated Environment Analysis (with AIM/Material Model)
- Urban Application (with AIM/Local Model)
- Innovative Application (with AIM/Local Model)
- Future Direction

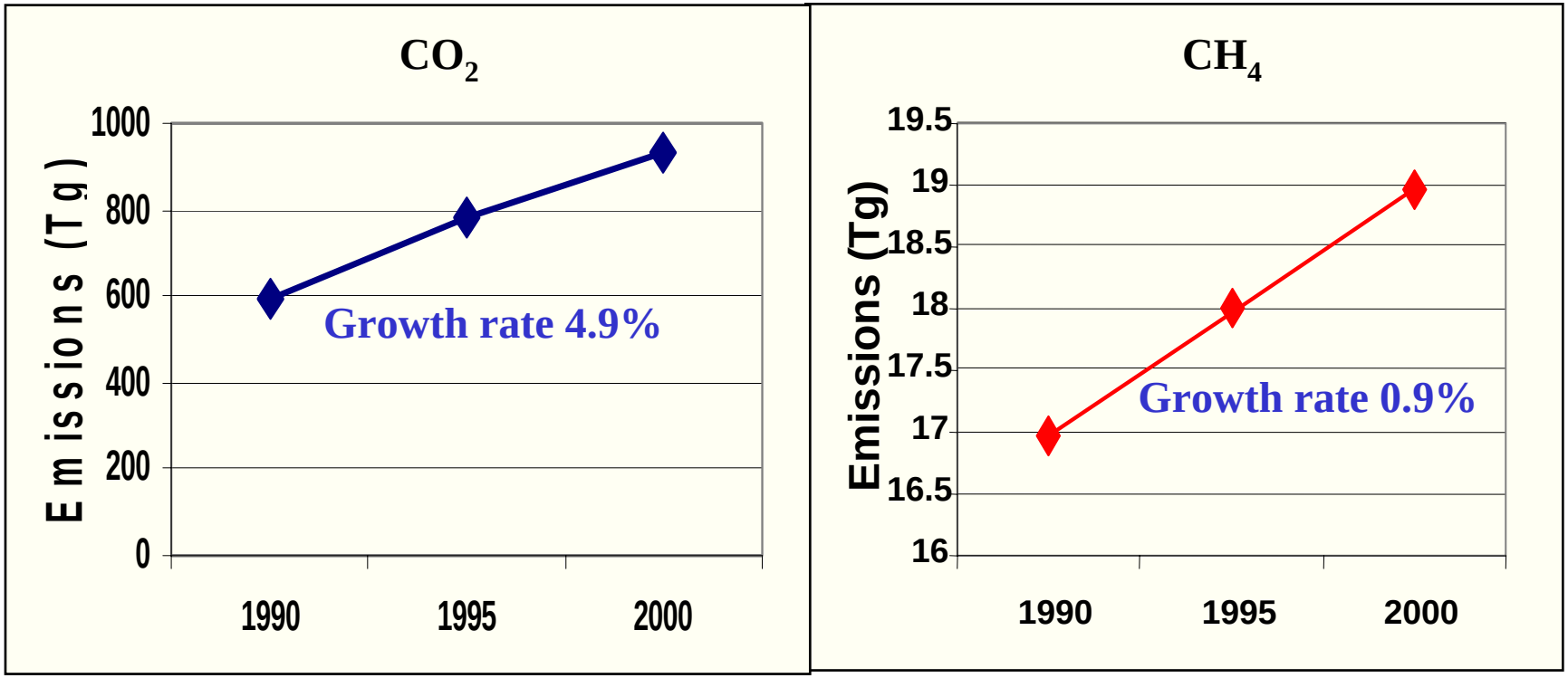
# Emissions Inventory for India

# Indian Emission Trends

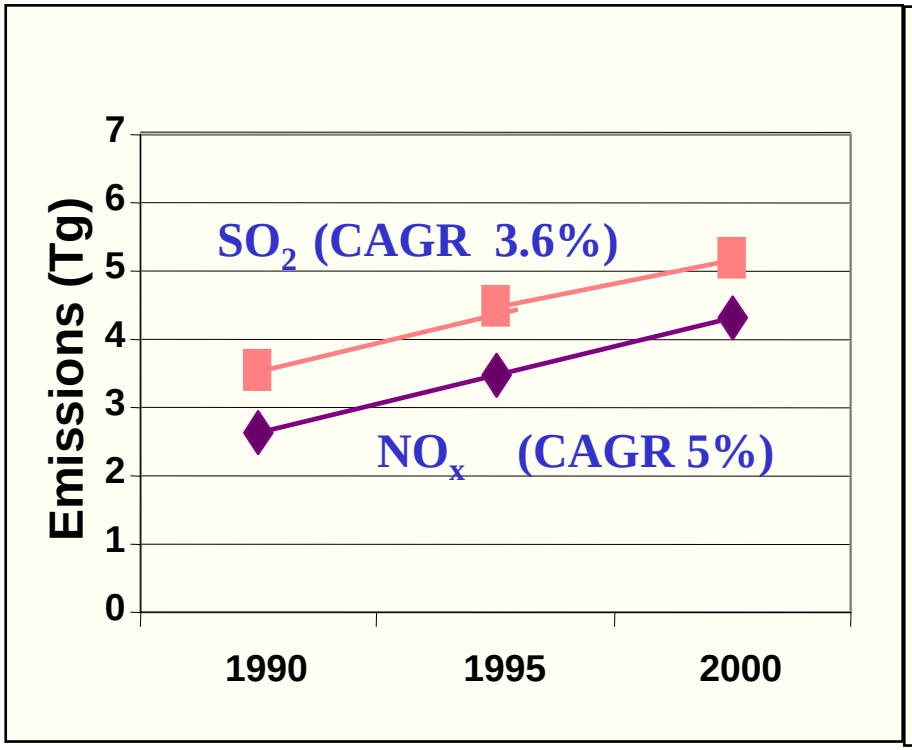
| Emissions (Tg) | 1990 | 1995 | 2000 | CAGR * |
|---|---|---|---|---|
| Carbon dioxide | 593 | 778 | 956 | 4.9 |
| Methane | 16.98 | 17.82 | 18.63 | 0.9 |
| $N_2O$ | 0.213 | 0.251 | 0.308 | 3.8 |
| $SO_2$ | 3.54 | 4.64 | 5.02 | 3.6 |
| $NO_X$ | 2.64 | 3.46 | 4.30 | 5.0 |
| $CO_2$ equivalent GHG | 1016 | 1234 | 1454 | 3.6 |

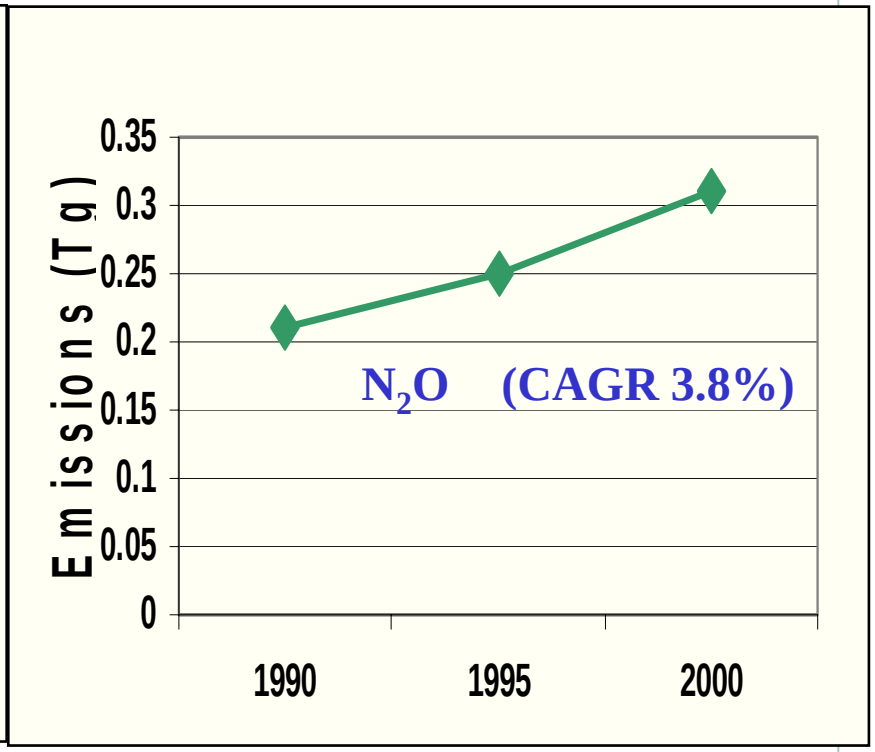
* Compounded Annual Growth Rate over 1990-2000 (%)

# Indian Emission Trends



# Indian Emission Trends



# National Applications

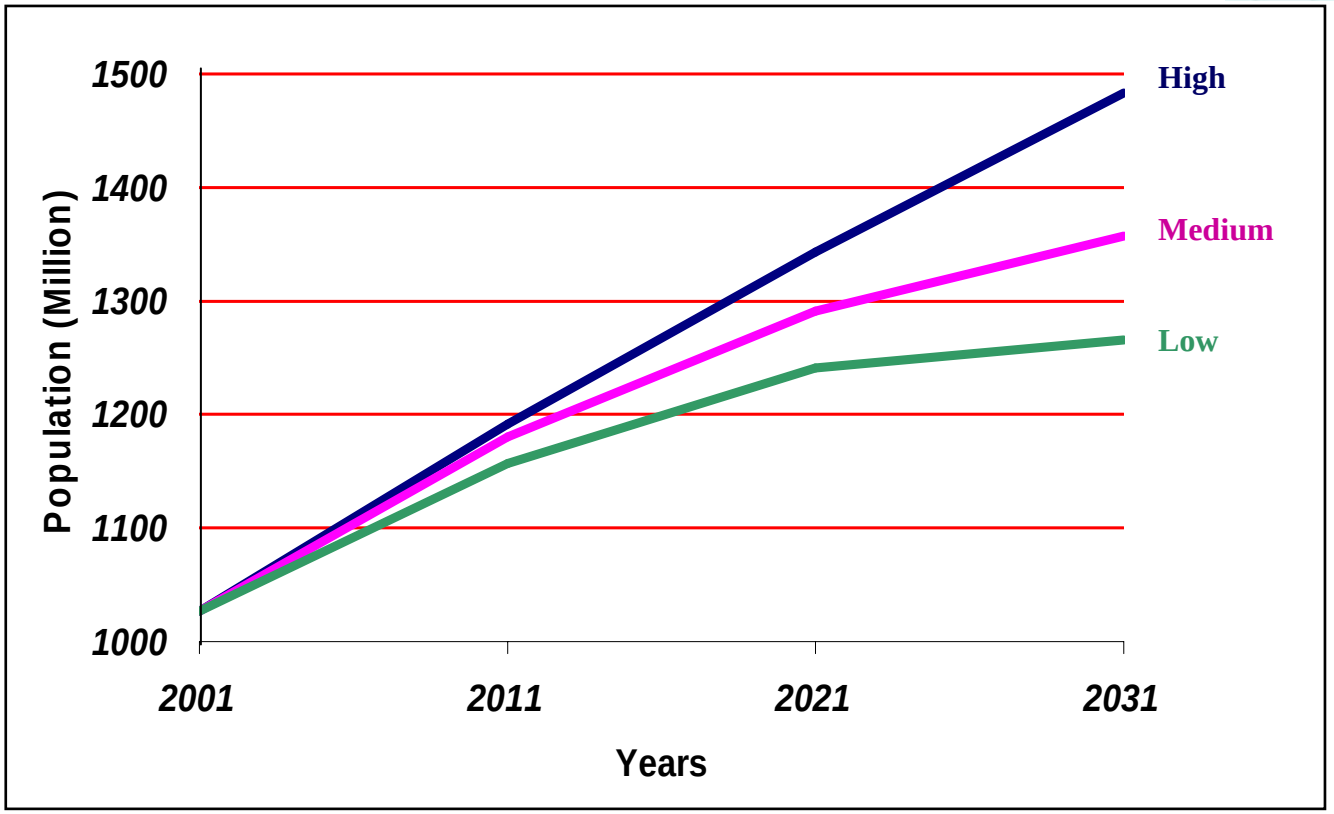
- Indian Scenarios

# Indian Scenarios

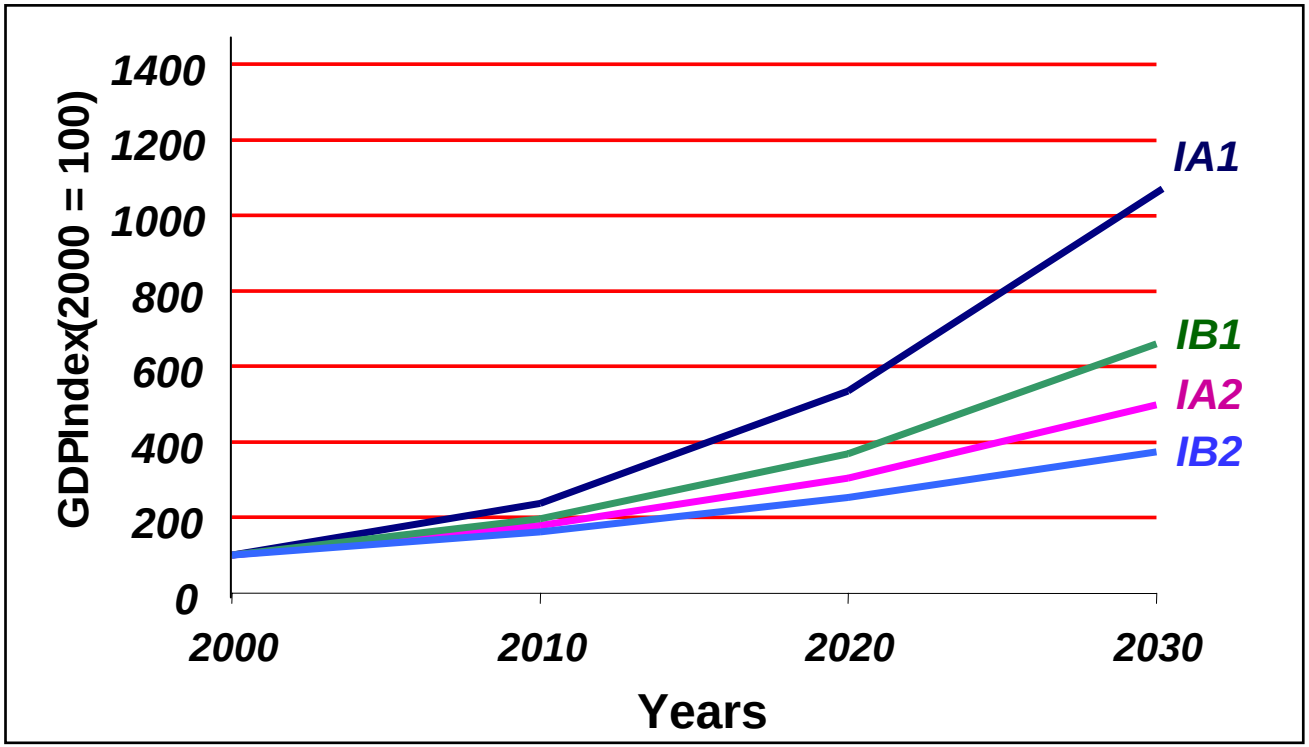
*Market integration*

| *Governance* | Integrated | Fragmented |
|---|---|---|
| Centralization | IA1<br>China | IA2<br>Pre-reform<br>(Mixed Economy Model) |
| Decentralization | IB1<br>Sustainable Development | IB2<br>Self Reliance Model |

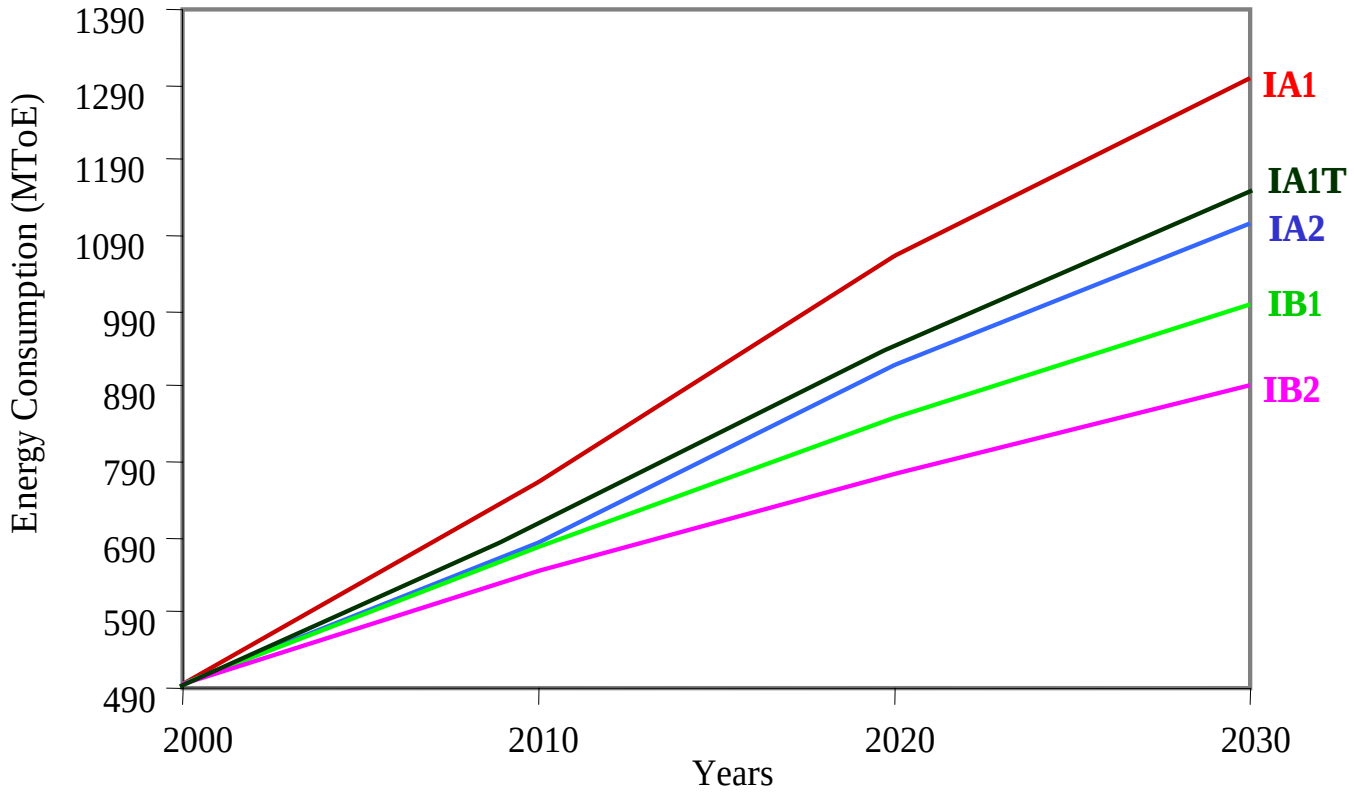
# India: Population Projection



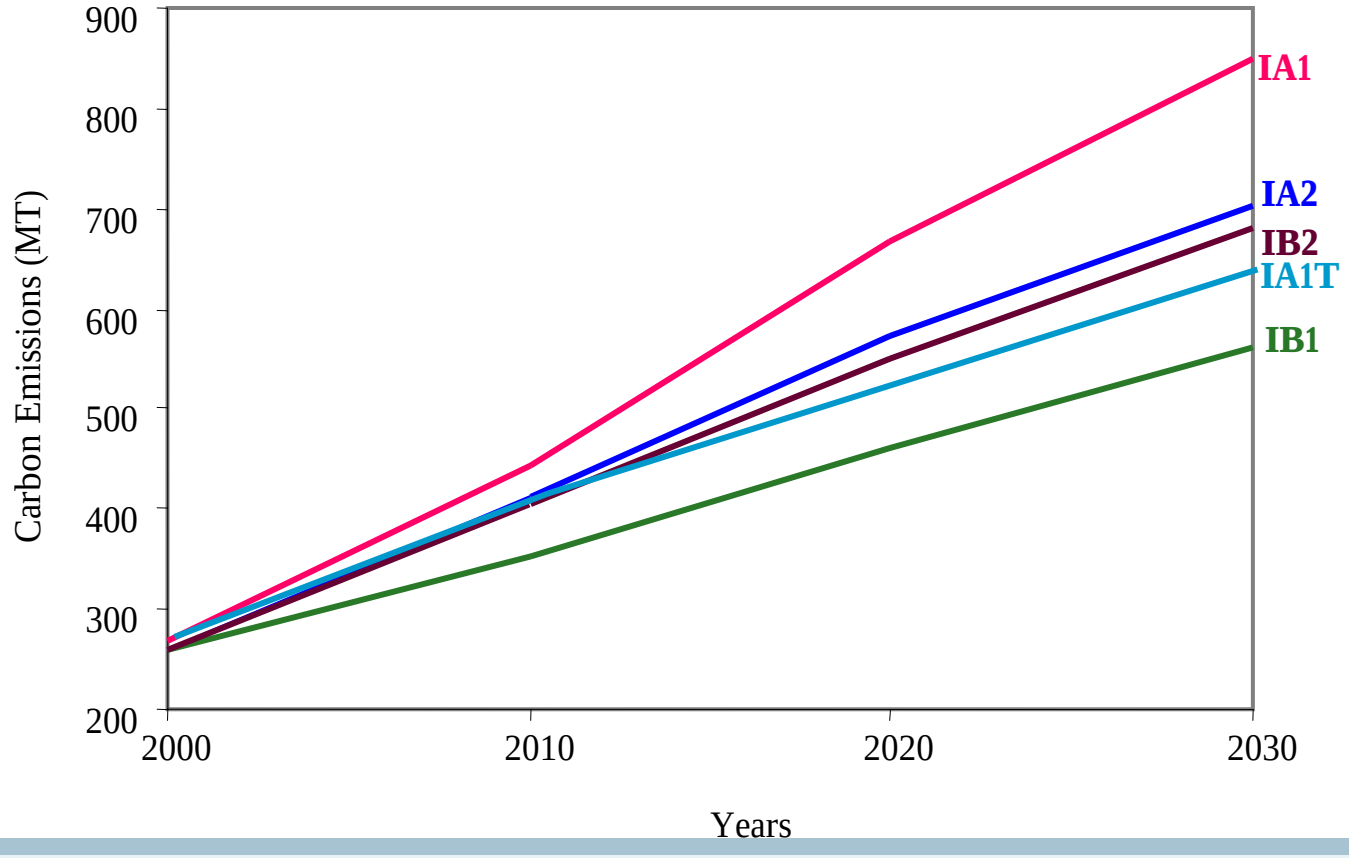
# India: GDP Projection



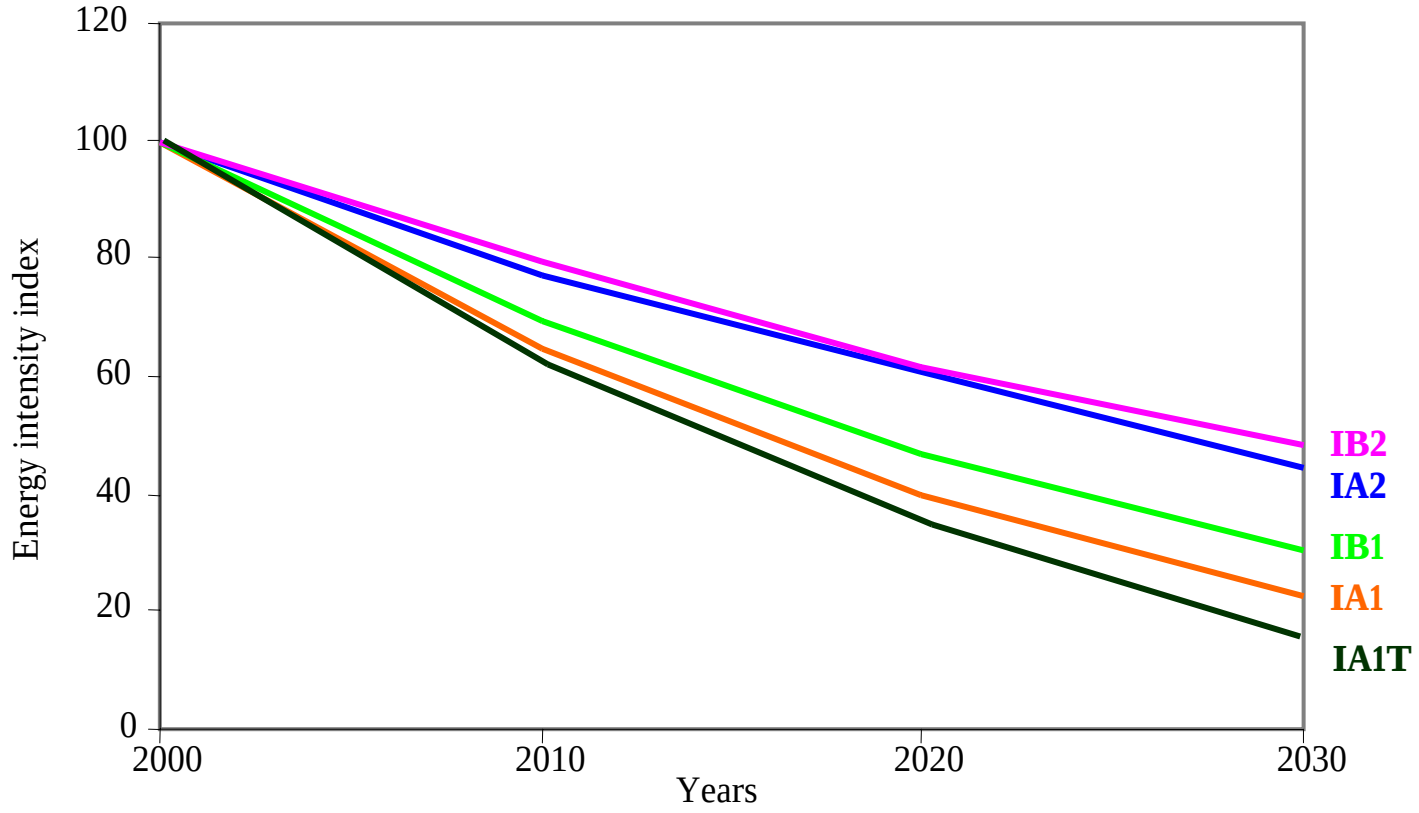
# Energy Consumption



# Carbon Emissions (MT)



# Energy Intensity of GDP (Index Year 2000 = 100)



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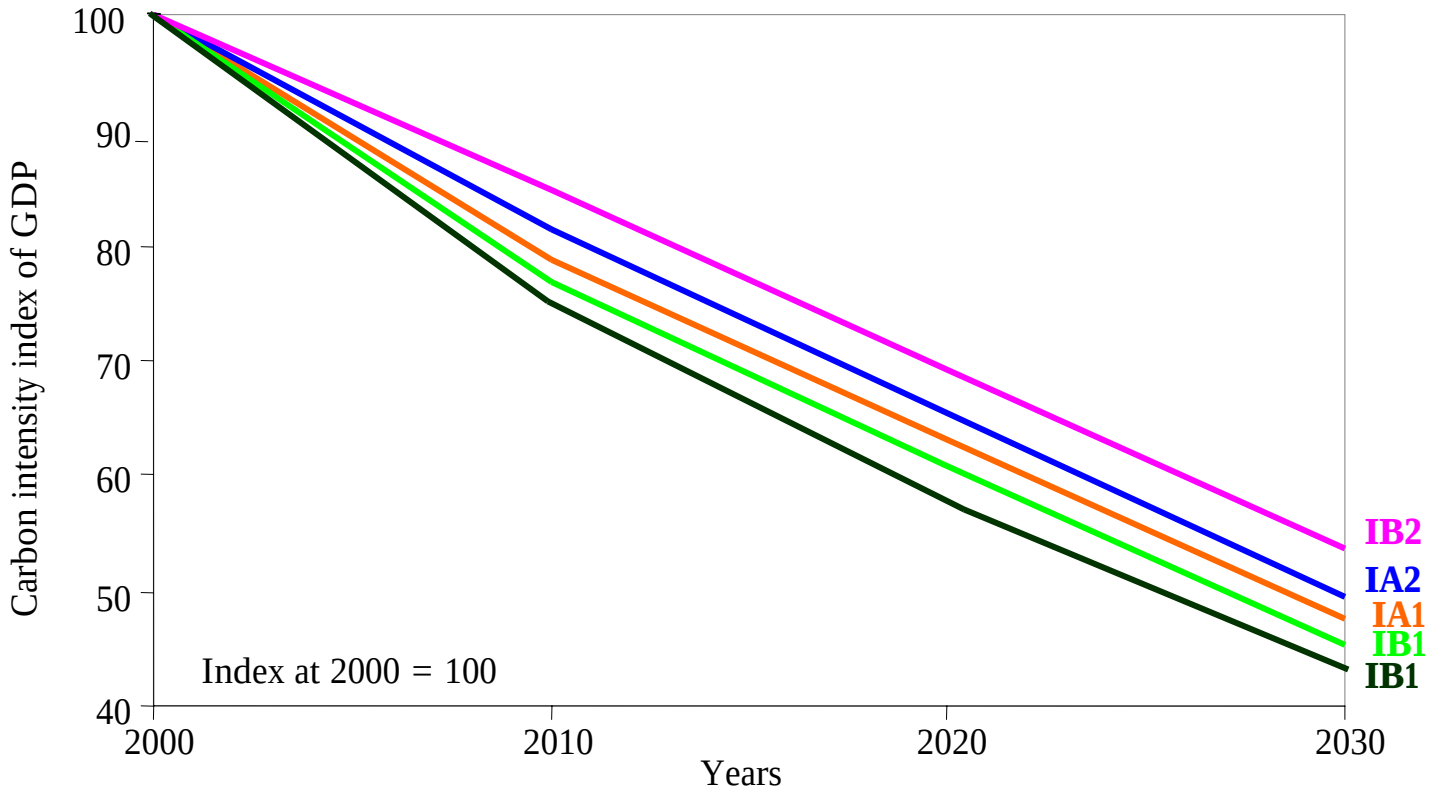
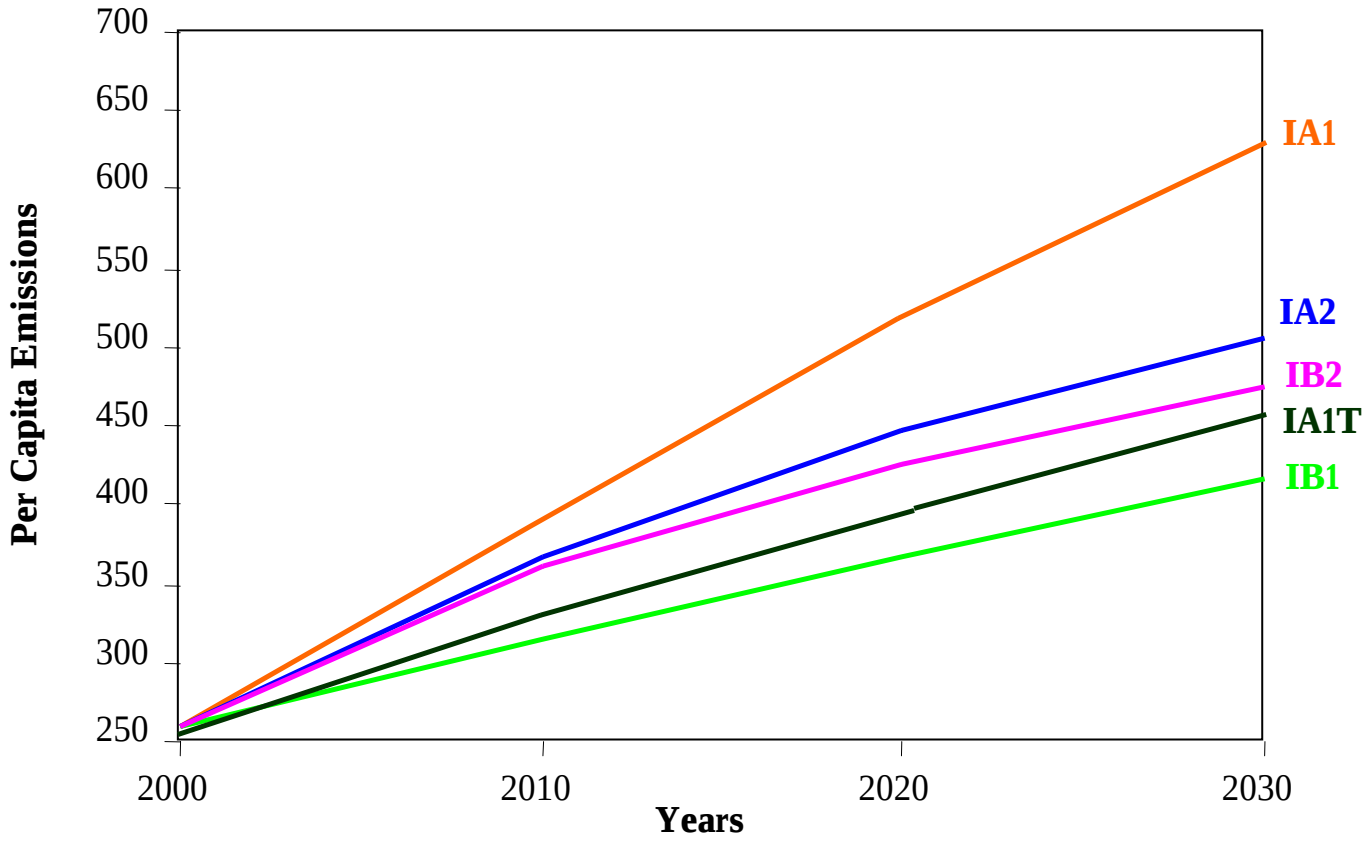
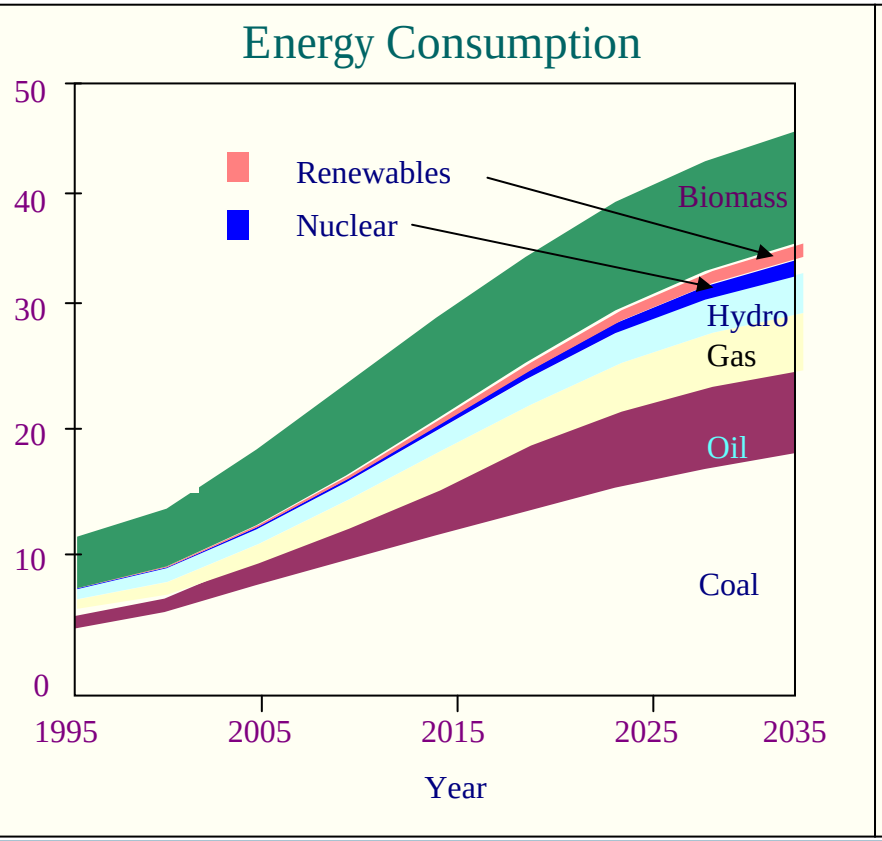
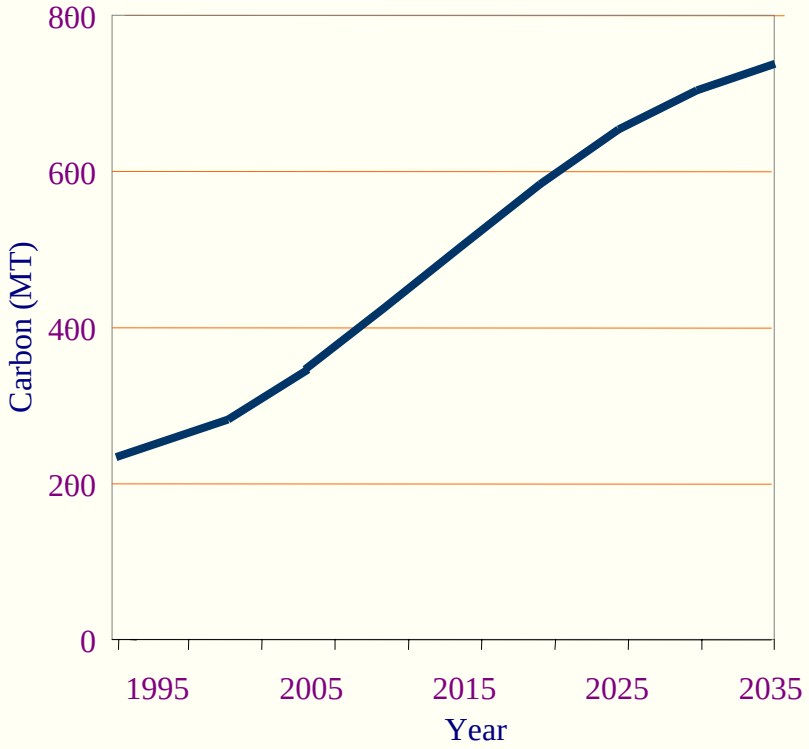


# Per Capita Carbon Emissions (kg C/person)

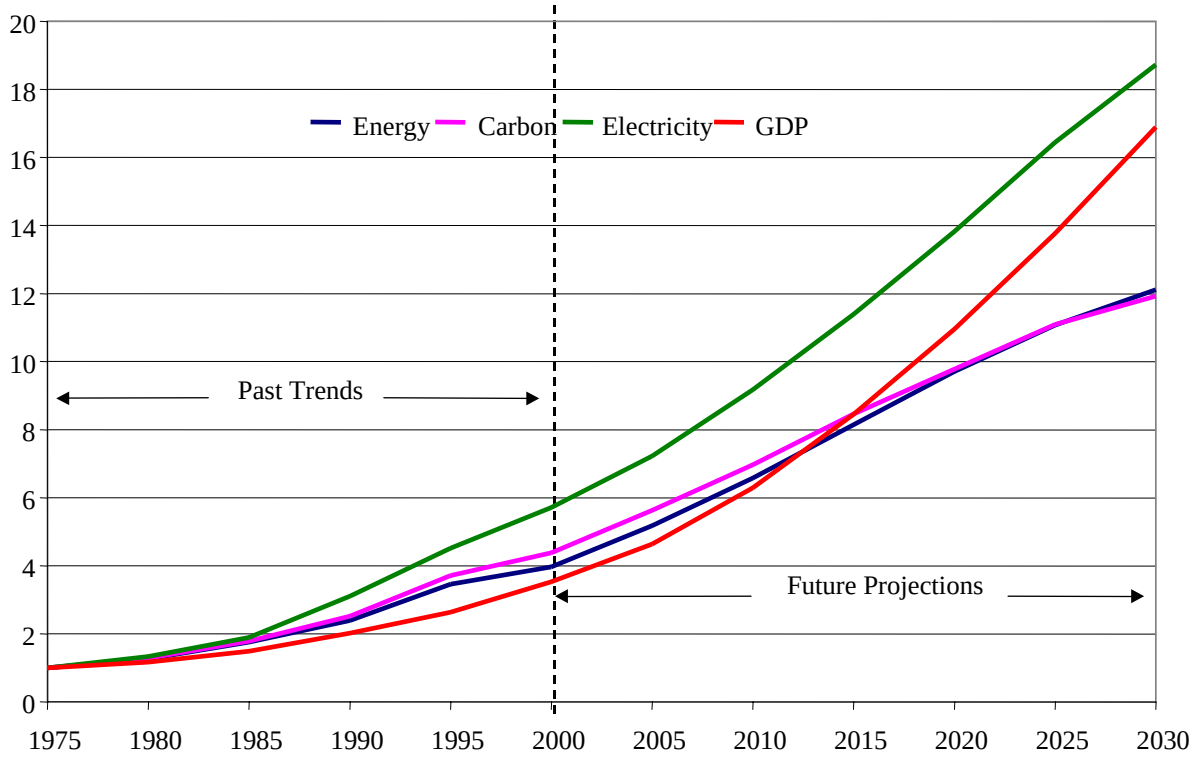


# Energy and Carbon Emissions for India (IA2 Scenario):
## Analysis with AIM/Models

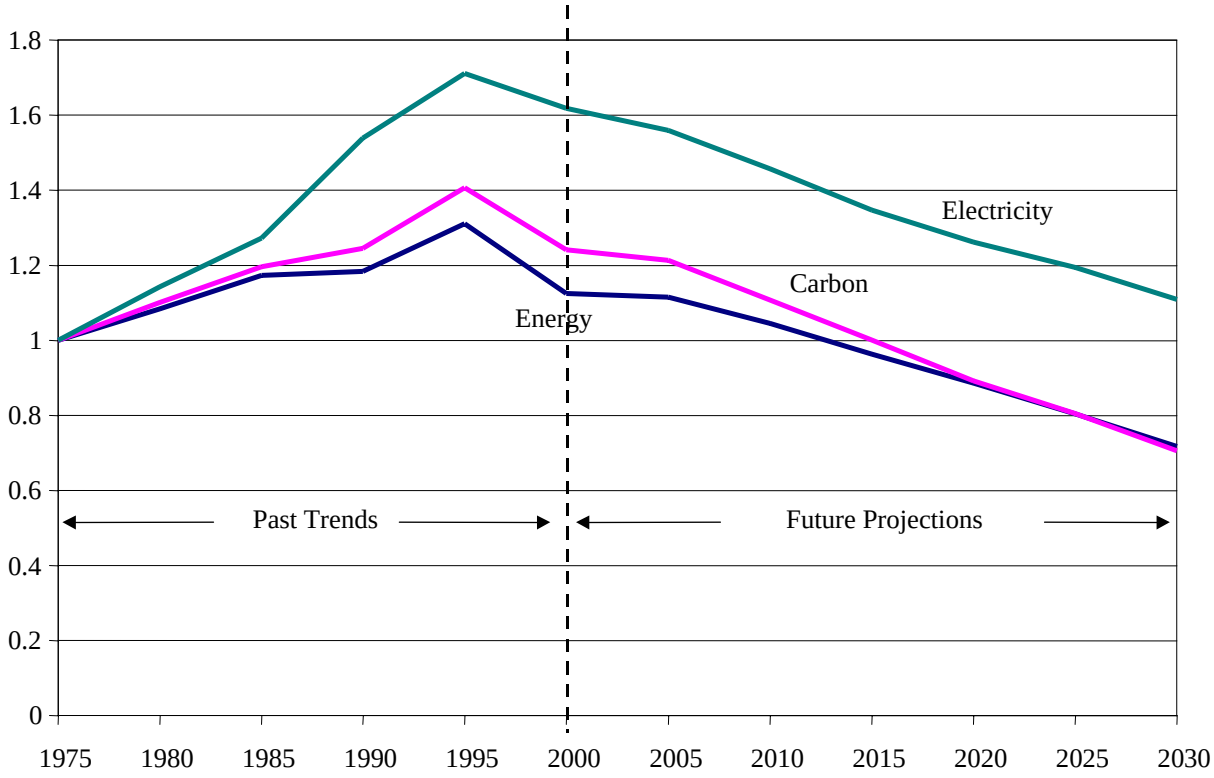


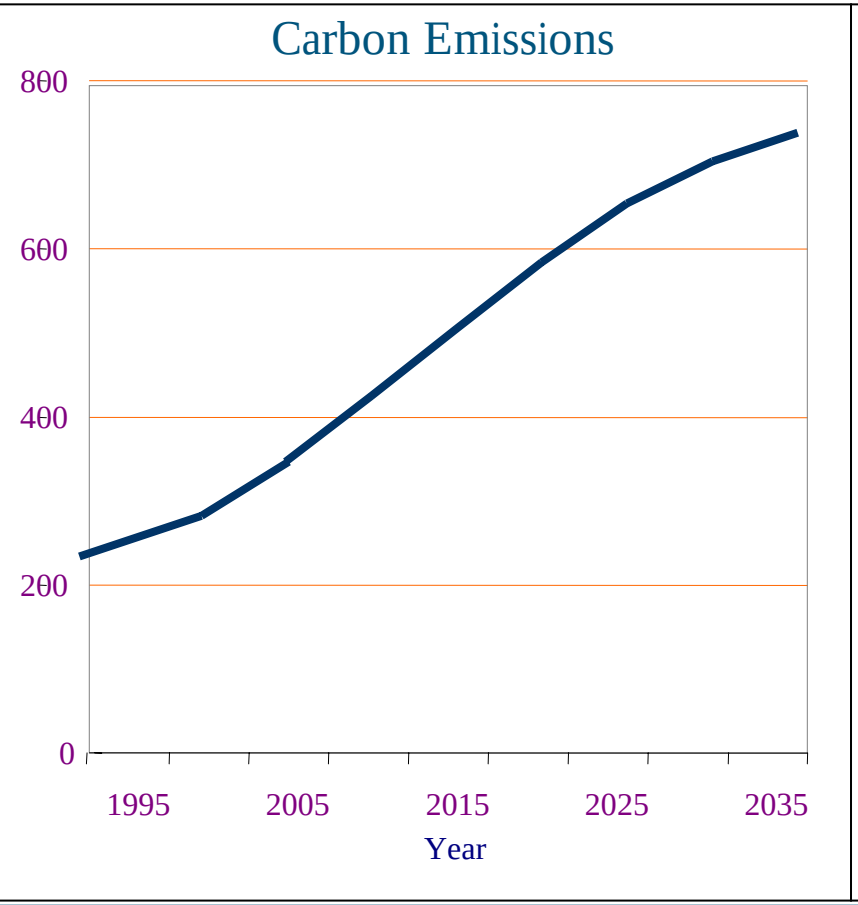
# Energy, Carbon, Electricity and GDP
## (IA2 Scenario)

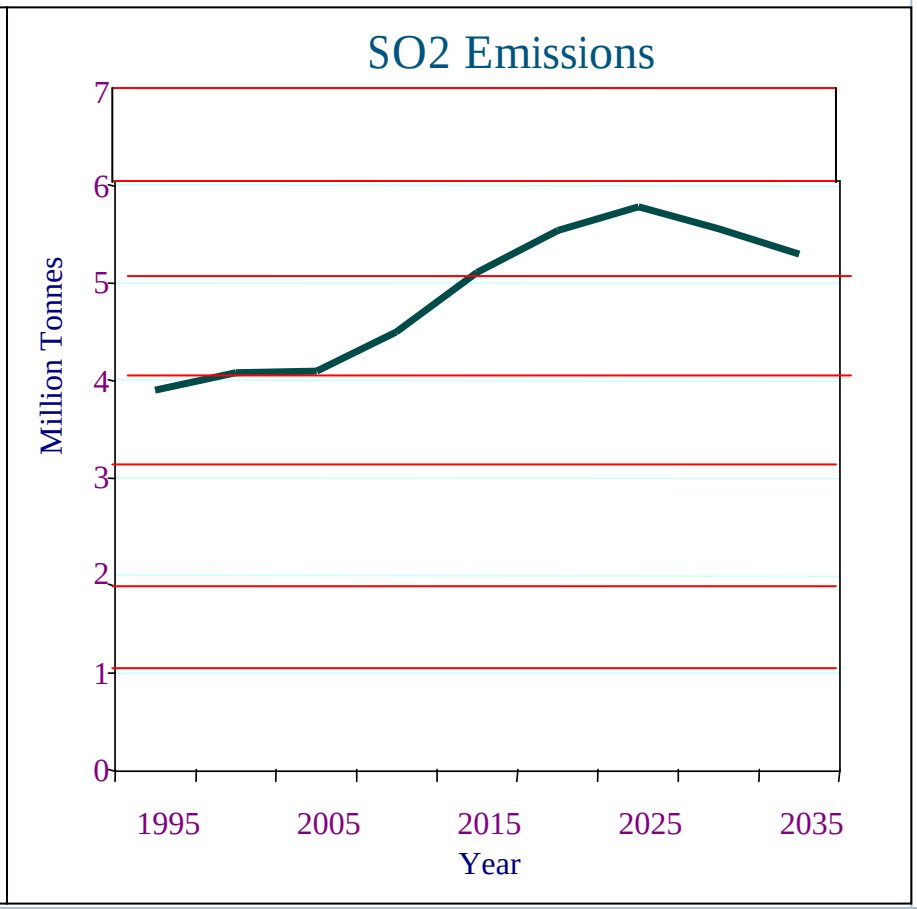


# GDP intensities of Energy, Electricity and Carbon (IA2 Scenario)



# GHG versus Local Emissions in India

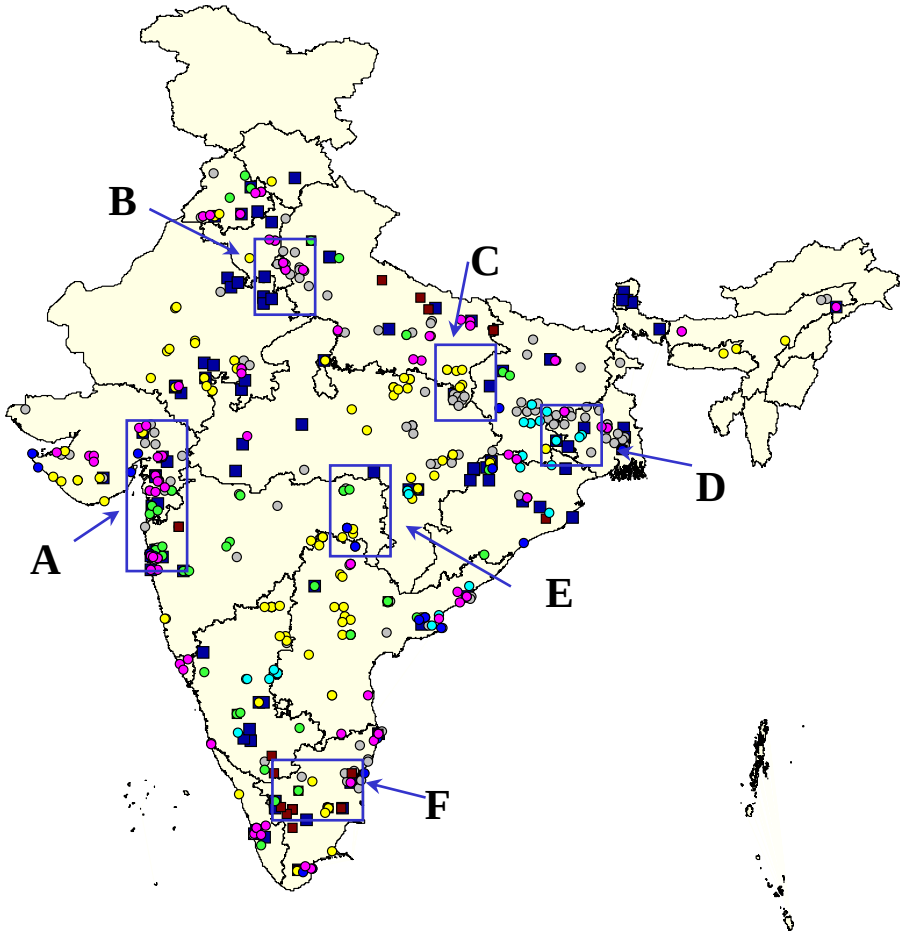


# National Applications

- **$CO_2$ Emissions and Large Point Source Analysis**
  (with AIM/Local Model)

# Regional Spread of Large Point Sources



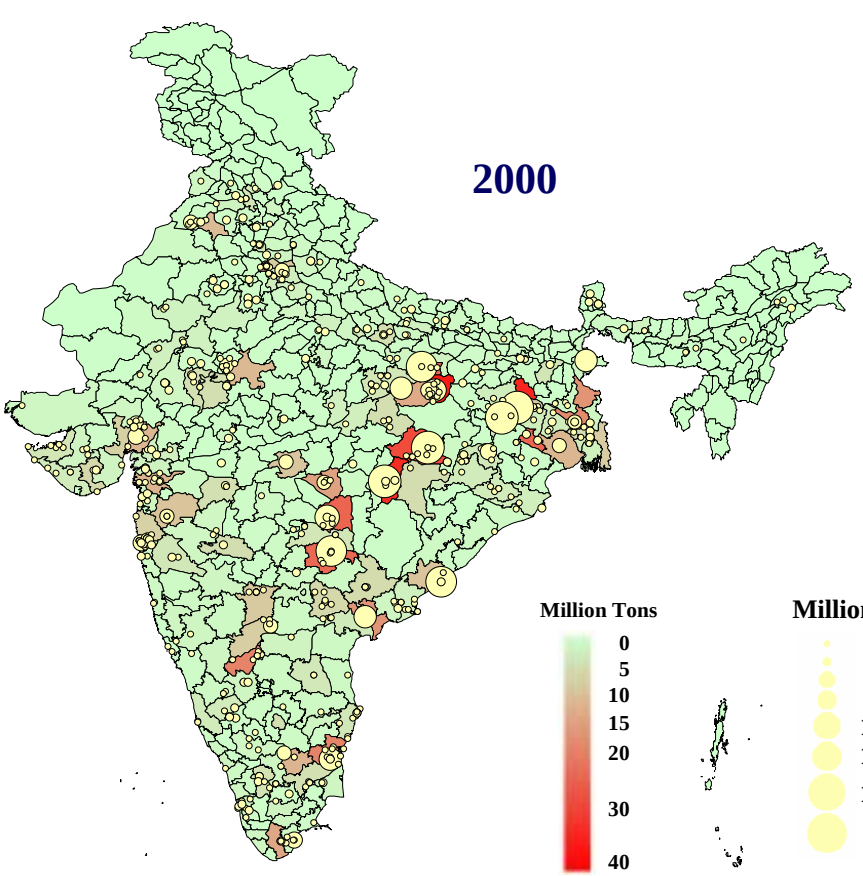

- Power
- Paper
- Steel
- Sugar
- Cement
- Caustic soda
- Fertilizer
- Others

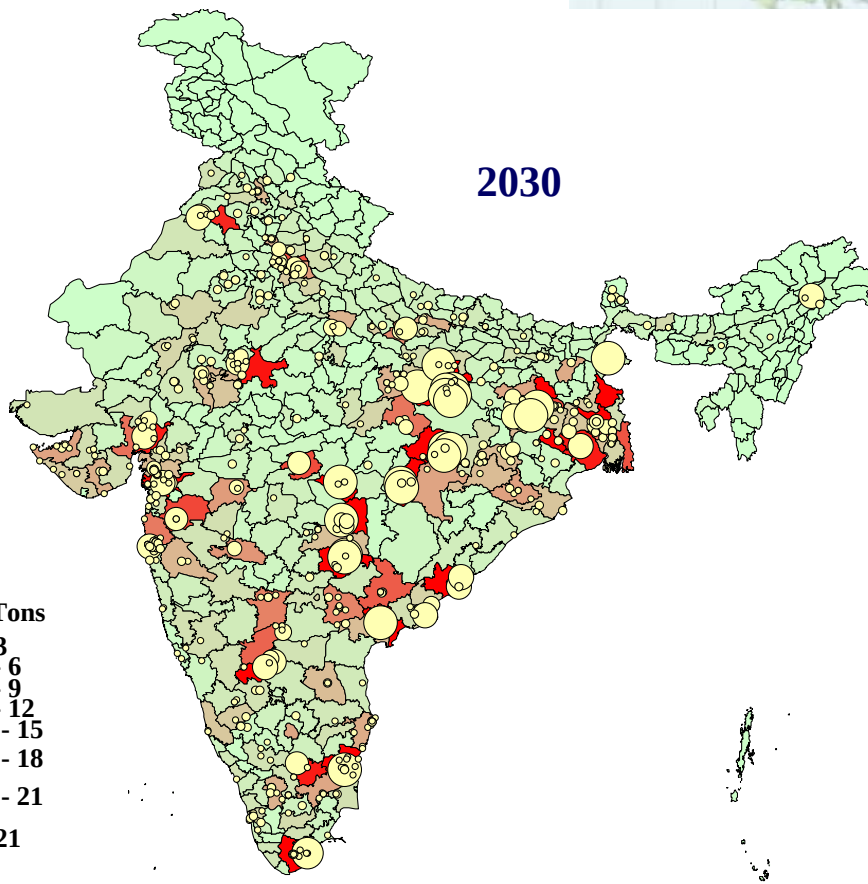
| Regional Details | |
|---|---|
| A | Golden corridor |
| B | Delhi |
| C | Northeast India coal mine |
| D | East India coal mine |
| E | Central India coal mine |
| F | Southern region |

# LPS Coverage

| Sector | Sub-sectors | LPS covered | | | |
|---|---|---|---|---|---|
| | | 2000 | 2010 | 2020 | 2030 |
| Energy | Power (coal & Oil) | 82 | 111 | 131 | 150 |
| | Power (natural gas) | 12 | 17 | 20 | 23 |
| | Steel | 11 | 17 | 23 | 29 |
| | Cement * | 85 | 98 | 110 | 123 |
| | Fertilizer | 31 | 41 | 52 | 62 |
| | Paper | 33 | 38 | 43 | 48 |
| | Sugar | 28 | 28 | 29 | 30 |
| | Caustic Soda | 19 | 21 | 23 | 26 |
| Industrial processes | $H_2SO_4$ manufacturing | 63 | 64 | 66 | 68 |
| | Aluminium (Al) | 3 | 4 | 5 | 5 |
| | Copper ore smelting (Cu) | 8 | 9 | 10 | 11 |
| | Lead ore smelting (Pb) | 5 | 6 | 7 | 8 |
| | Zinc ore smelting (Zn) | 3 | 4 | 5 | 5 |
| **Total** | | **383** | **458** | **524** | **588** |

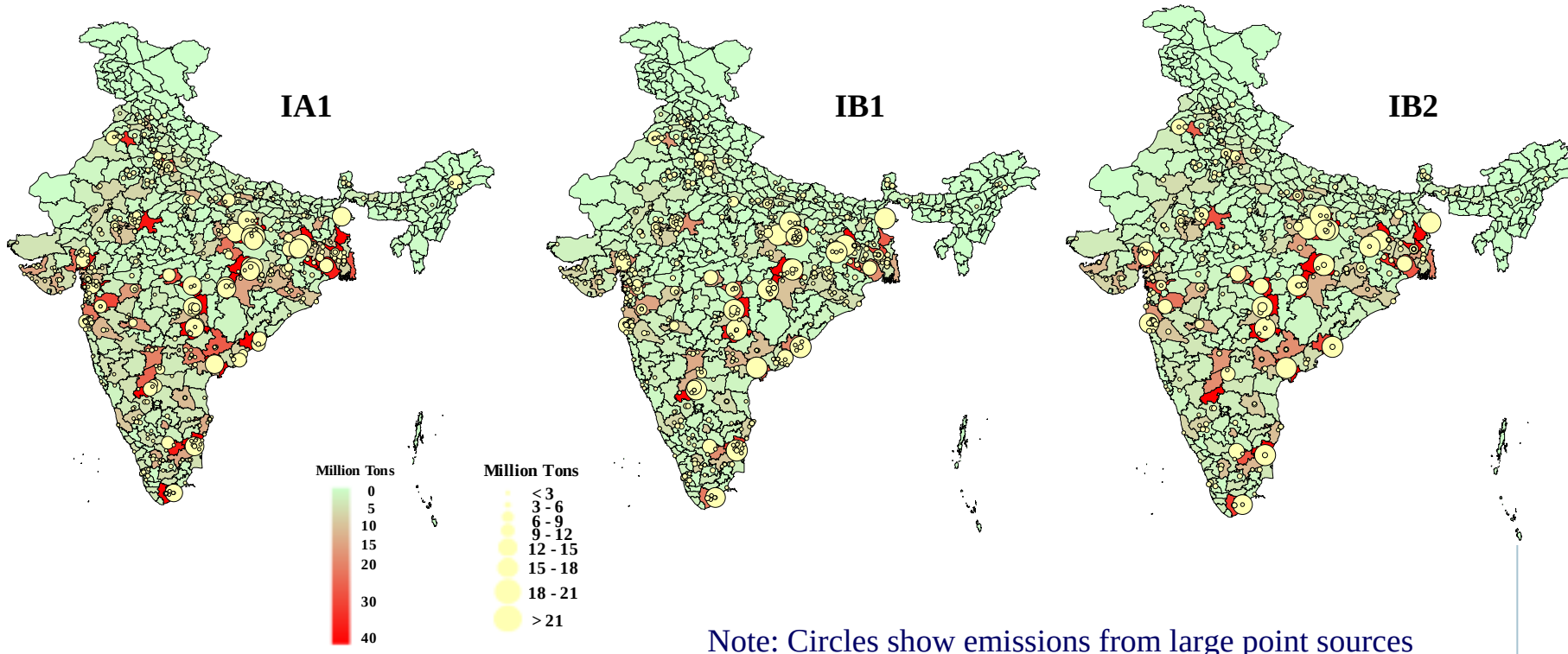
# Regional distribution of $CO_2$ emissions for IA2 Scenario




Note: Circles show emissions from large point sources

# Regional distribution of $CO_2$ emissions for Different Scenarios (2030)

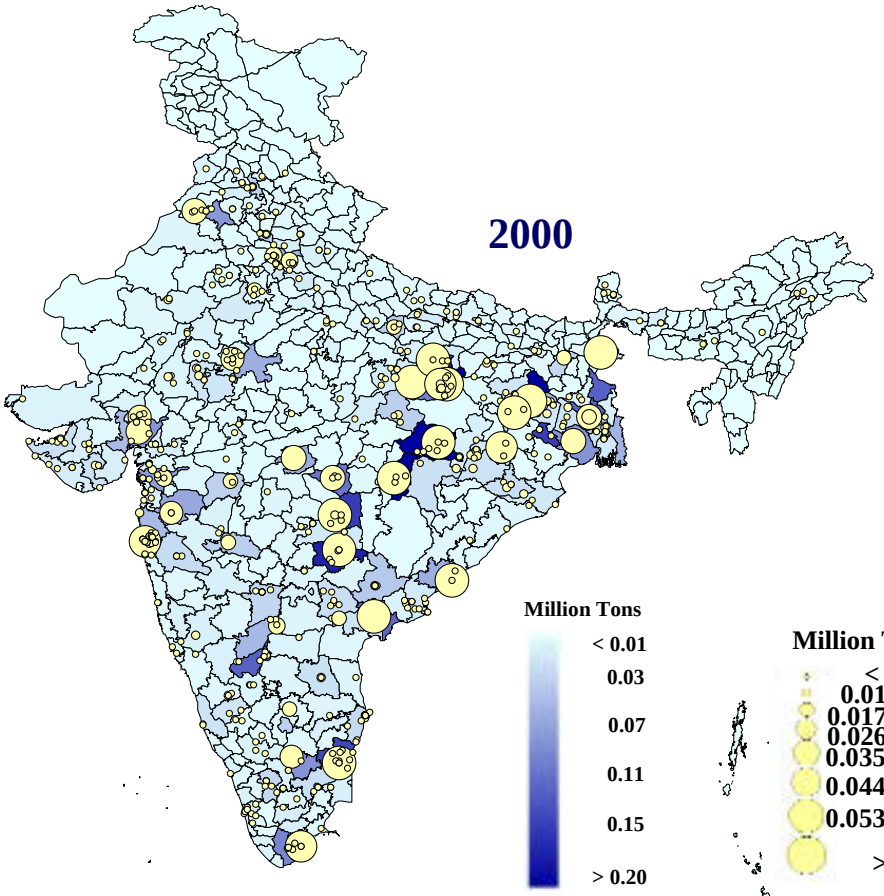


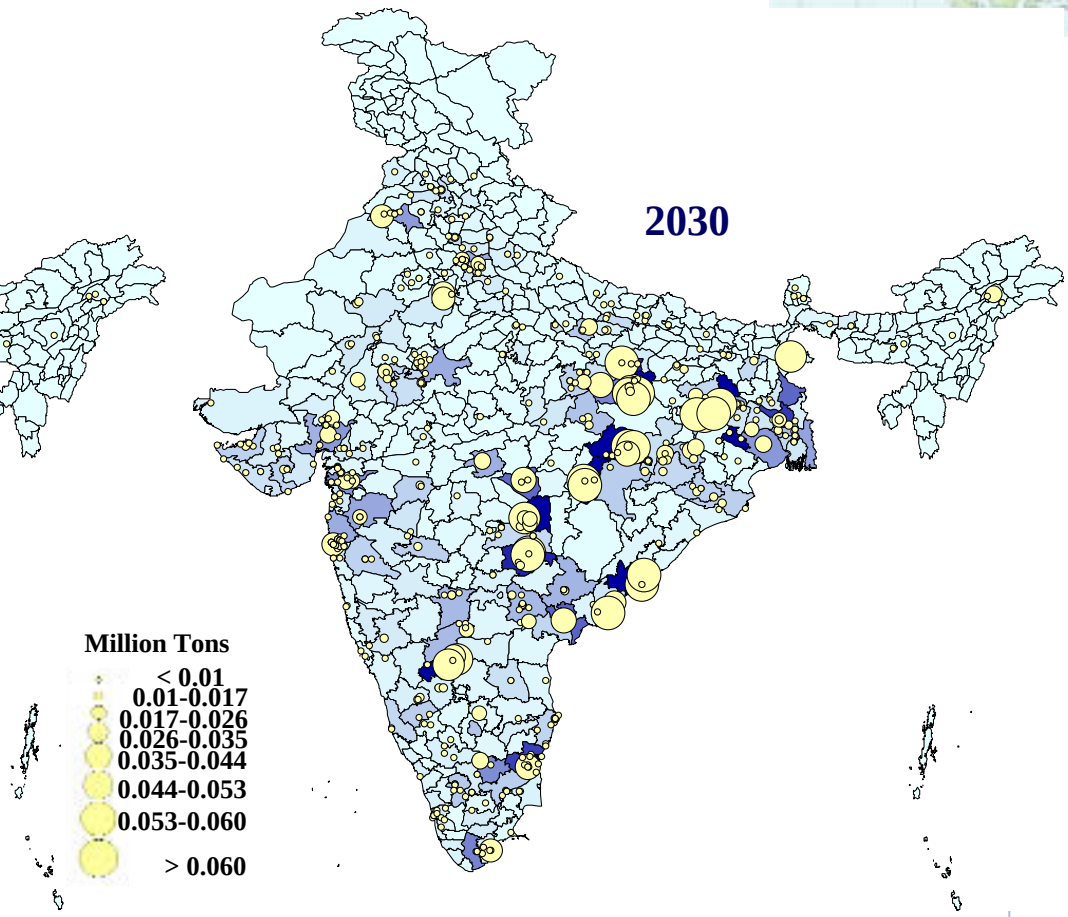

Note: Circles show emissions from large point sources

# National Applications

- **Non-$CO_2$ Gas Emissions**
  (with AIM/Local Model)

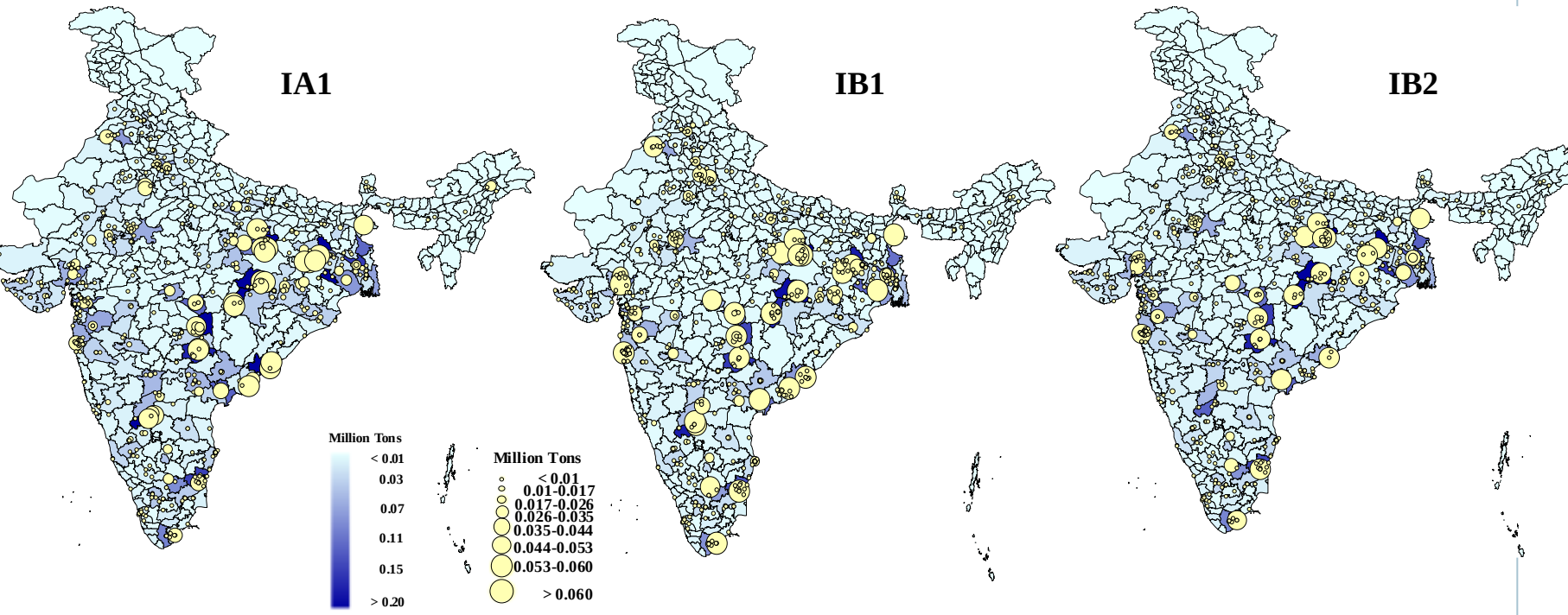
# Regional distribution of $SO_2$ emissions for IA2 Scenario



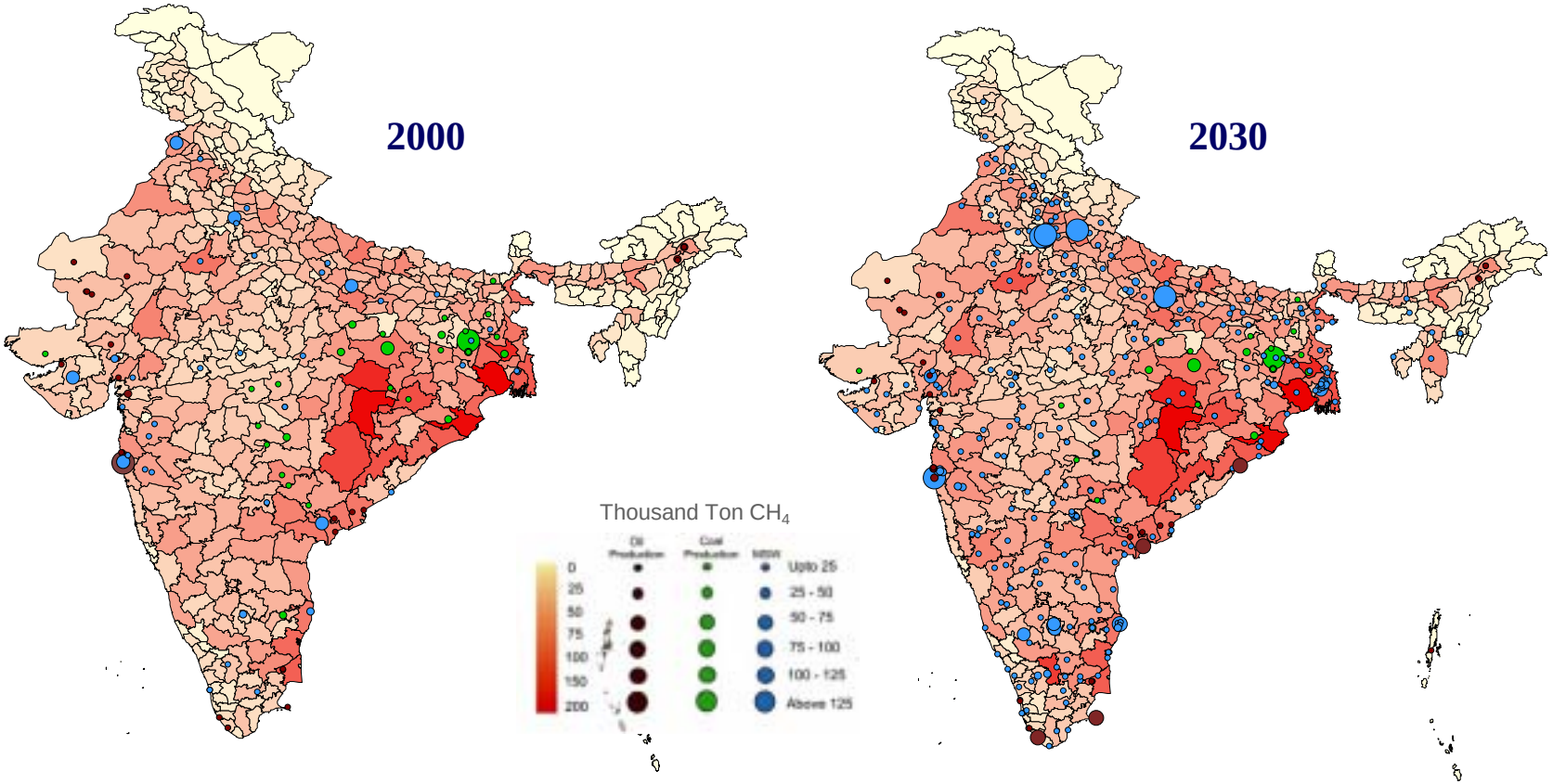

Note: Circles show emissions from large point sources

# Regional distribution of $SO_2$ emissions for Different Scenarios (2030)



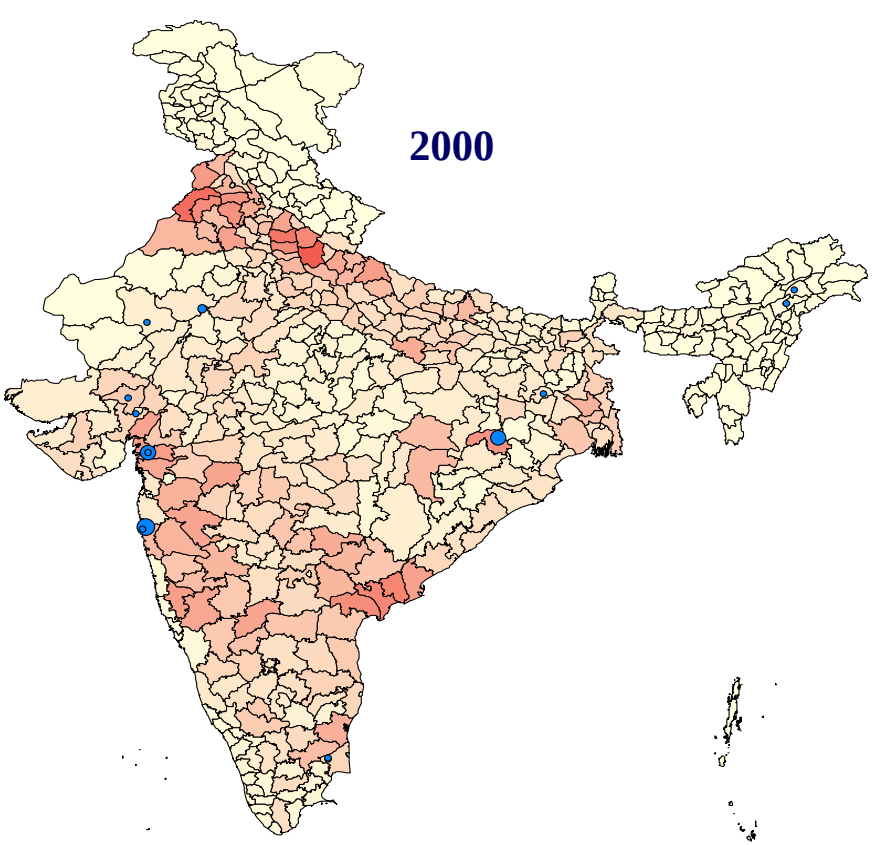

Note: Circles show emissions from large point sources

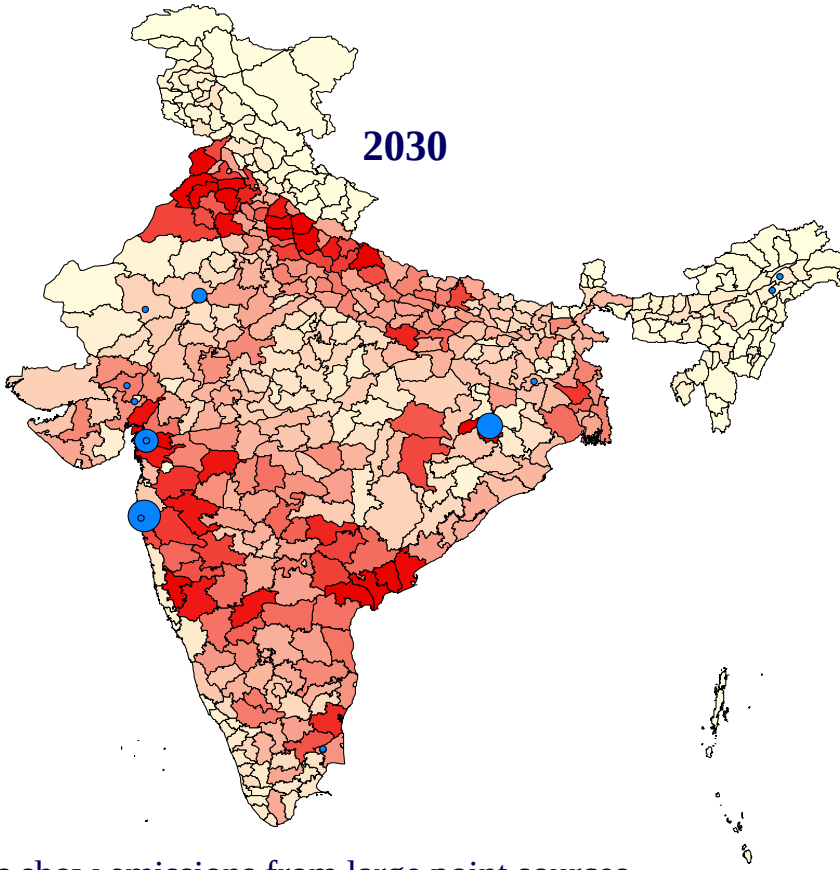
# Regional distribution of $CH_4$ emissions for IA2 Scenario




Note: Circles show emissions from large point sources

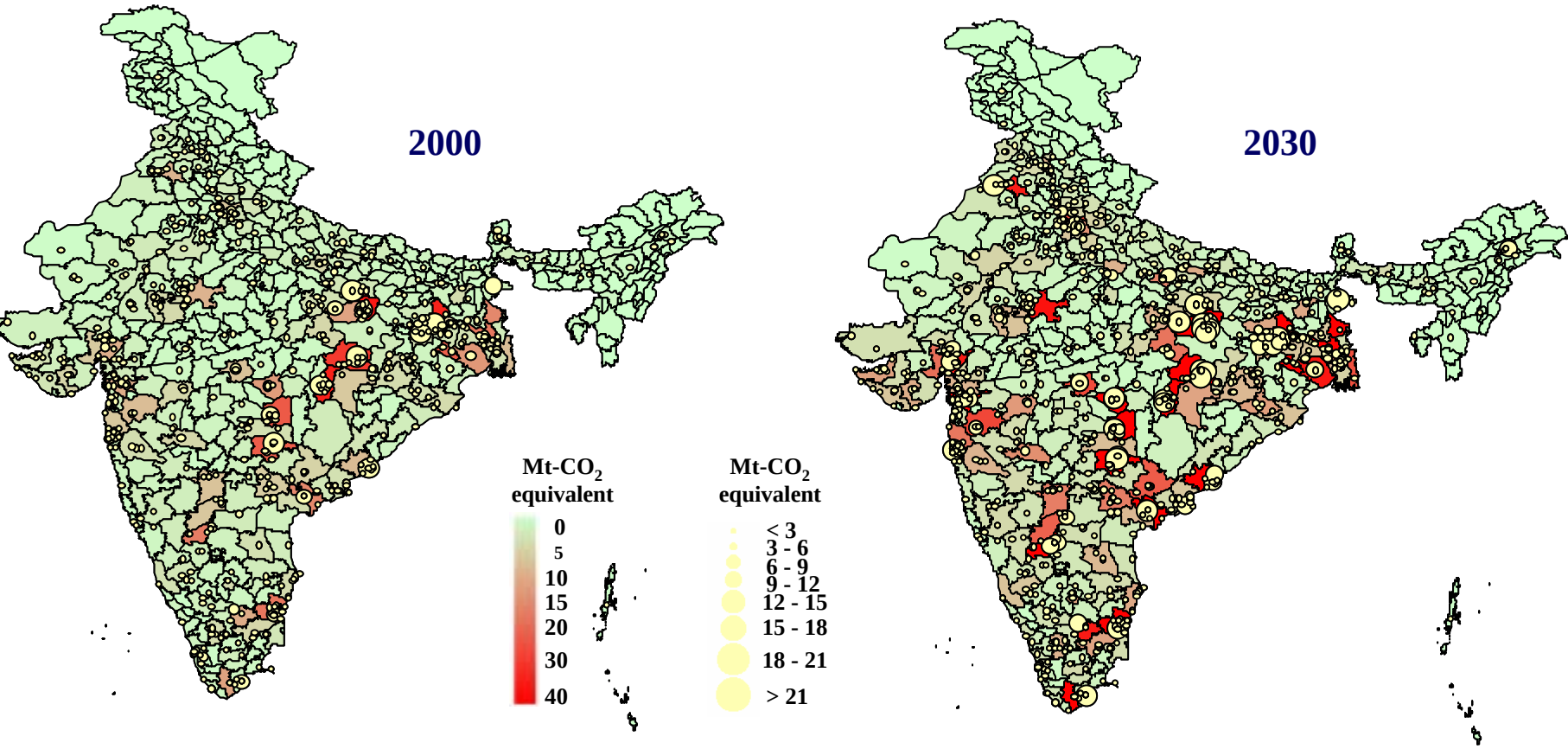
# Regional distribution of $N_2O$ emissions for IA2 Scenario




Note: Circles show emissions from large point sources

# Regional distribution of $CO_2$ Equivalent for IA2 Scenario



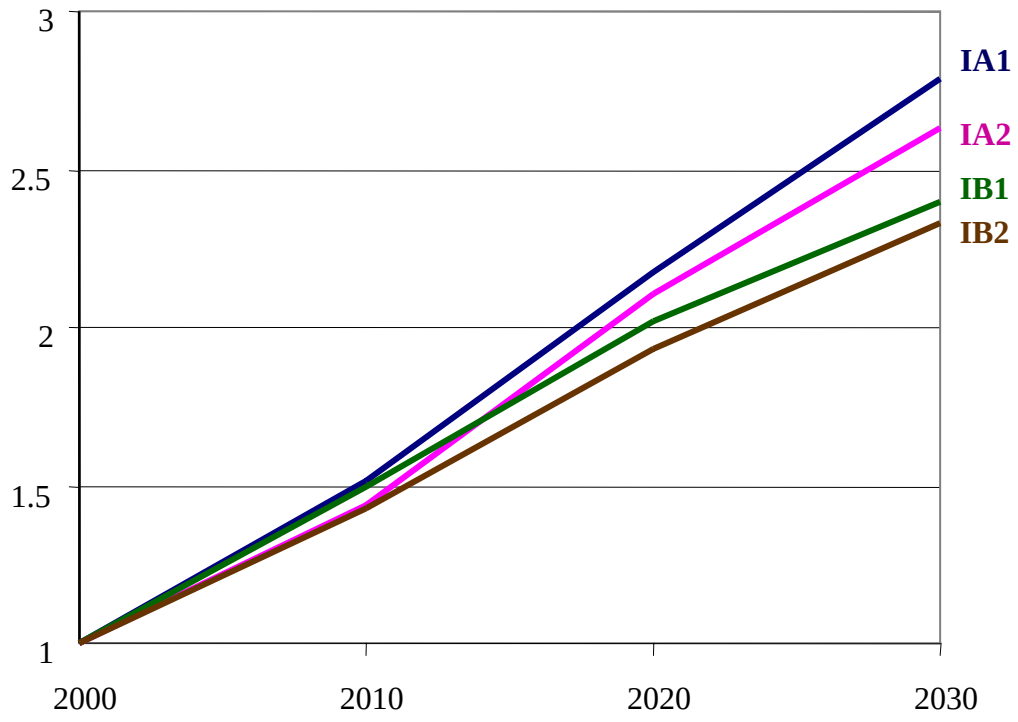
# National Applications

- **Integrated Environment Analysis**

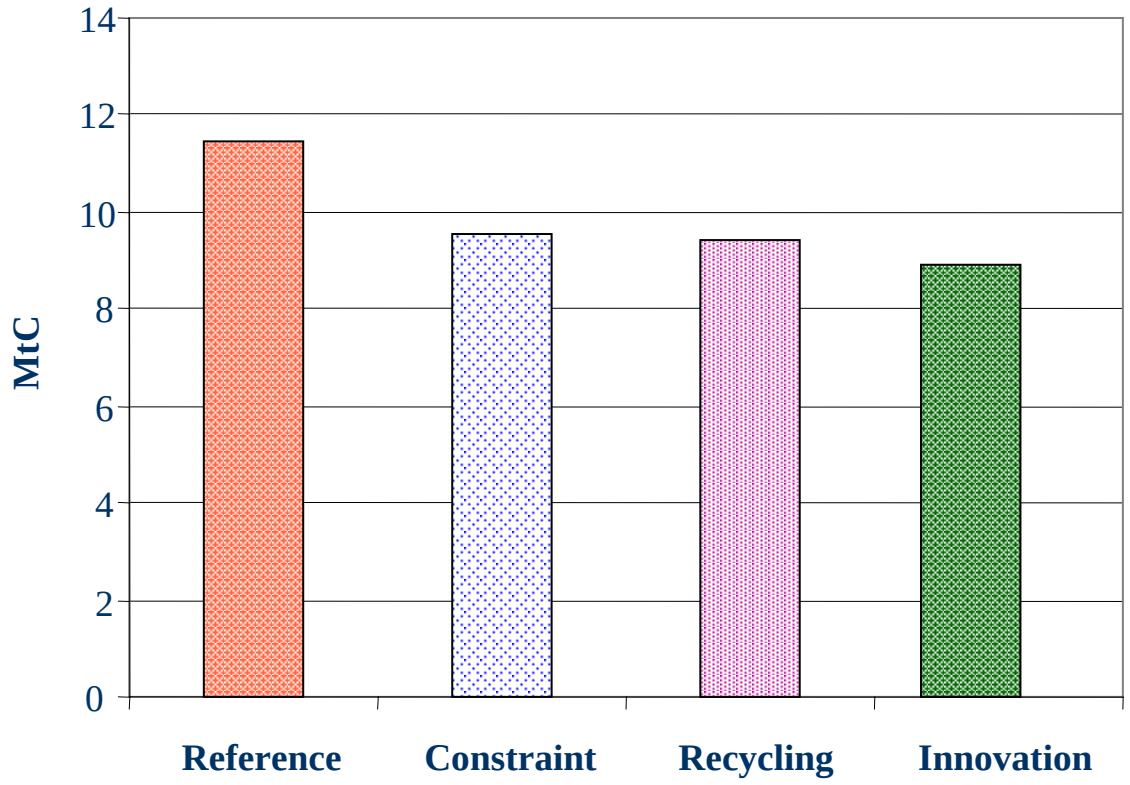
  (with AIM/Material Model)

# Solid Waste Generation for Indian Emission Scenarios

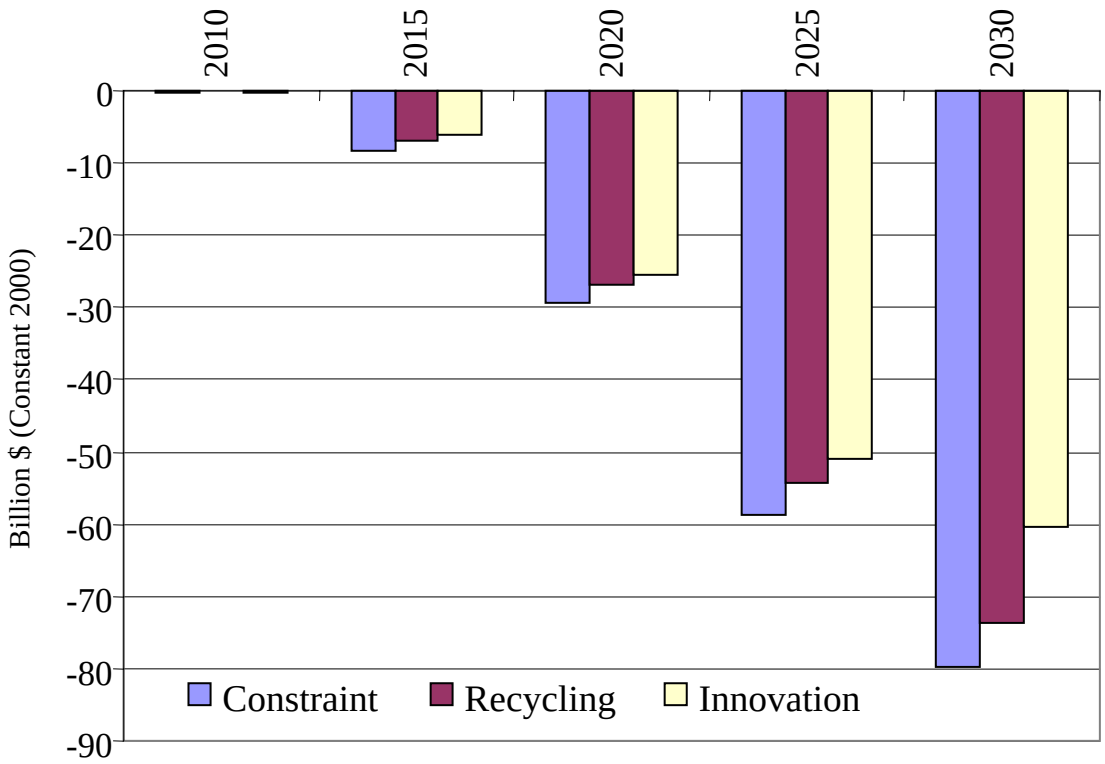
(Index Year 2000 = 1)



# Cumulative CO2 emissions from India (2000-2030)



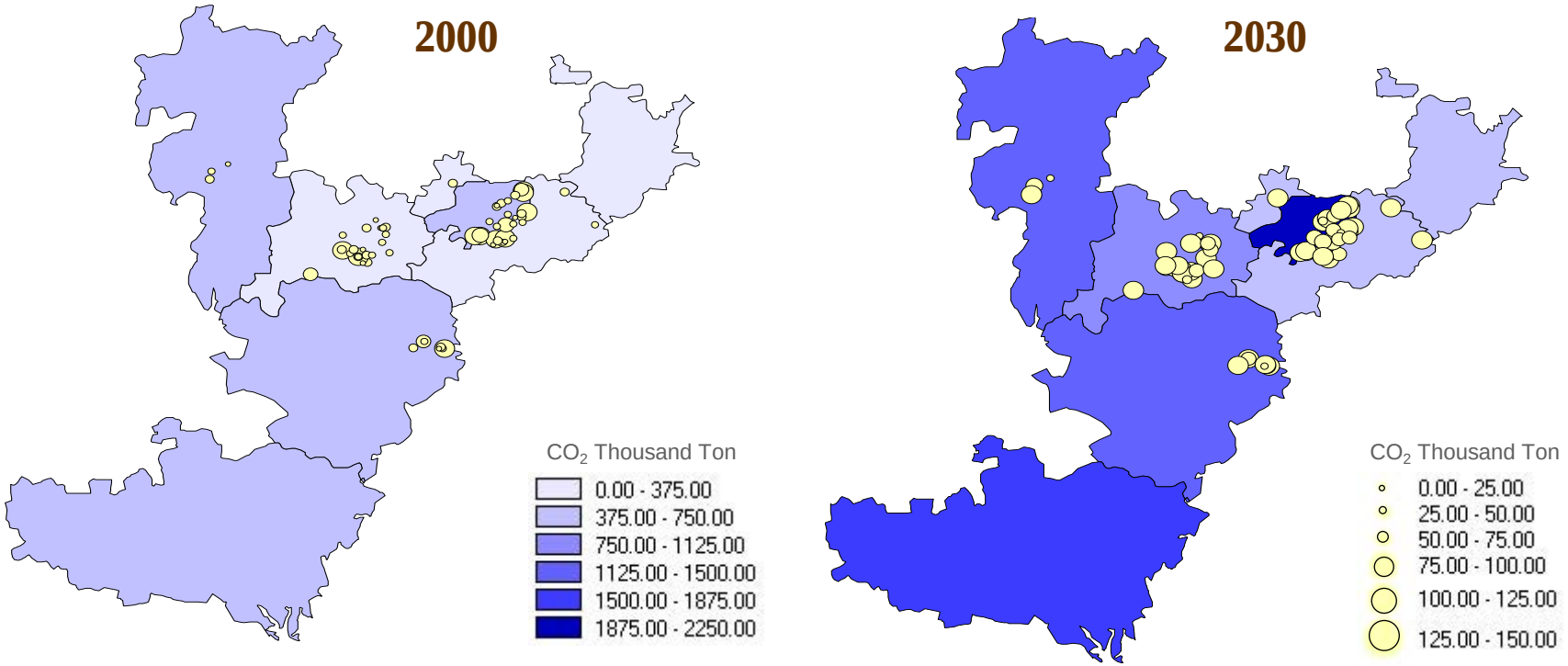
# Change in GDP over Reference (IA2) Scenario



# Urban Applications

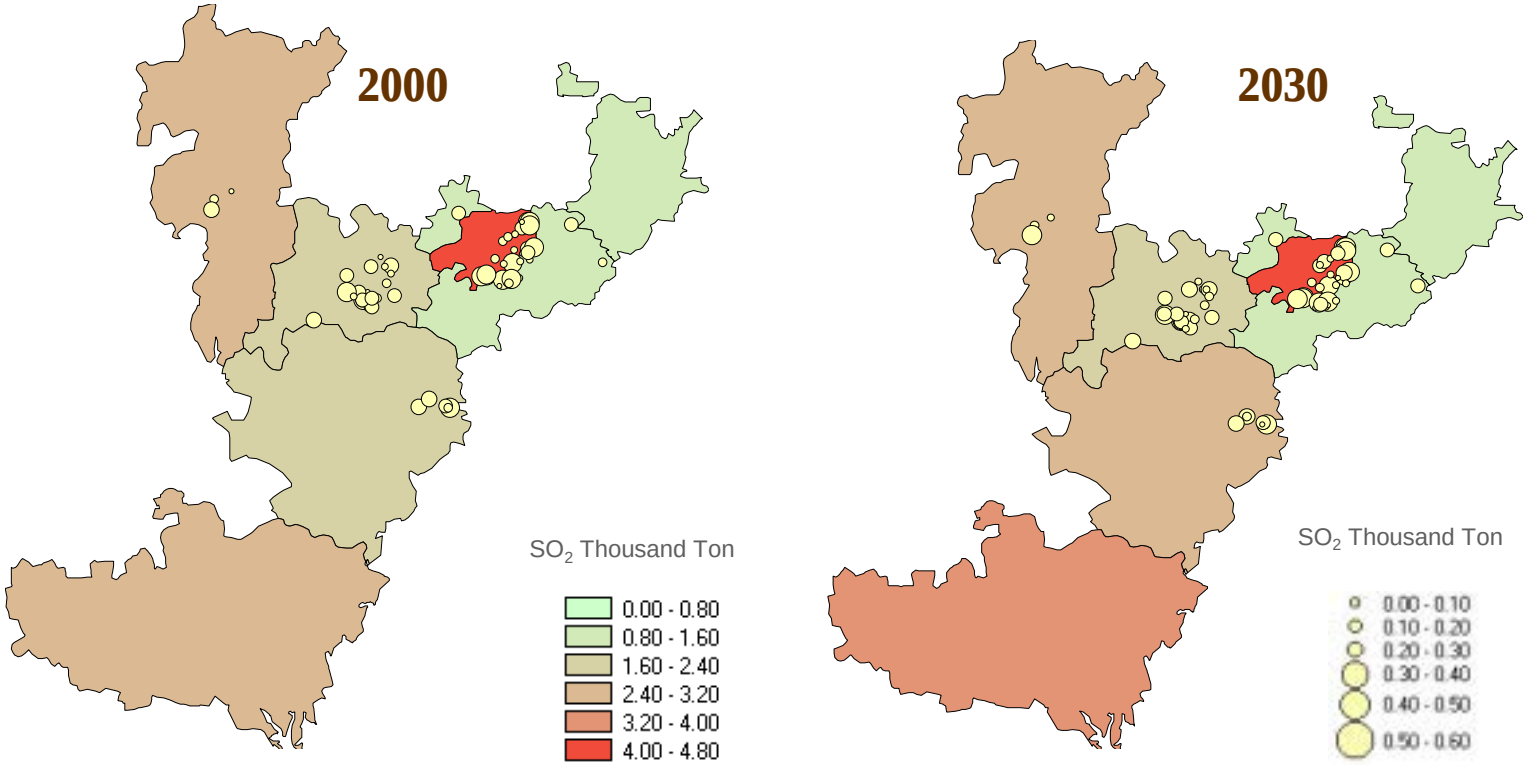
## Analysis with AIM/Local Model

# Regional distribution of $CO_2$ emissions in Ahmedabad District for Reference (IA2) scenario




Note: Circles show emissions from large point sources

# Regional distribution of $SO_2$ emissions in Ahmedabad District for Reference (IA2) scenario




Note: Circles show emissions from large point sources

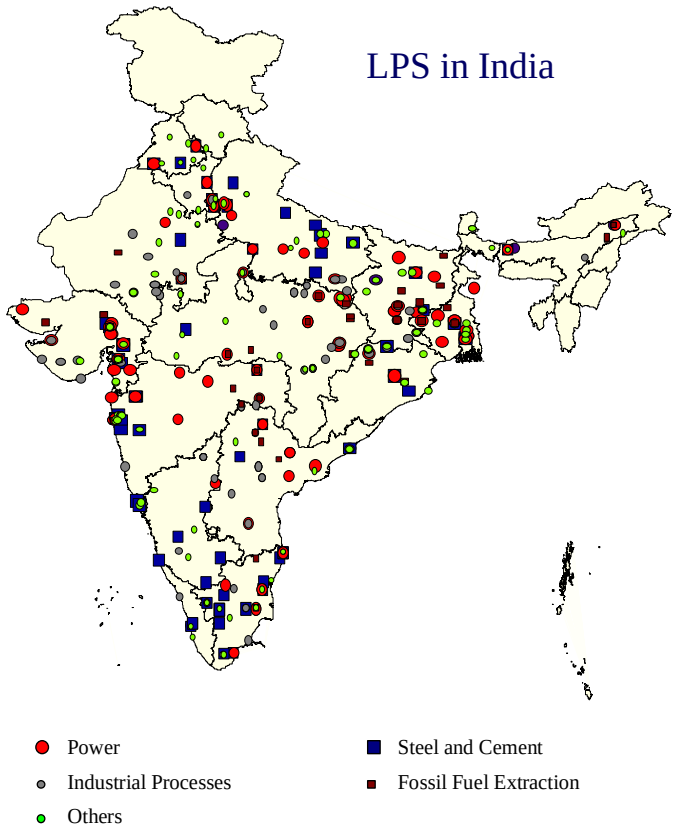
# Innovative Applications

## Analysis with AIM/Local Model

# Managing $SO_2$ Emissions: Case of LPS

## LPS spread in different urban centers

| LPS | Number | Share of all-India $SO_2$ emissions (%) in 1995 |
|---|---|---|
| Power Plants | 94 | 45 |
| Steel | 11 | 7 |
| Cement | 85 | 5 |
| Fertilizer | 31 | 6 |
| Sugar | 28 | 0.09 |
| Paper | 33 | 0.043 |
| Total | 282 | 63.52 |

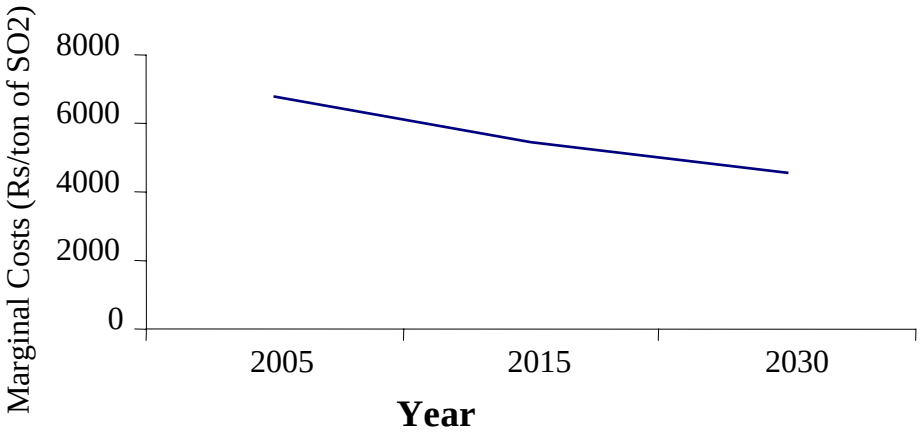



**Need for a national policy as well as local-specific policies**

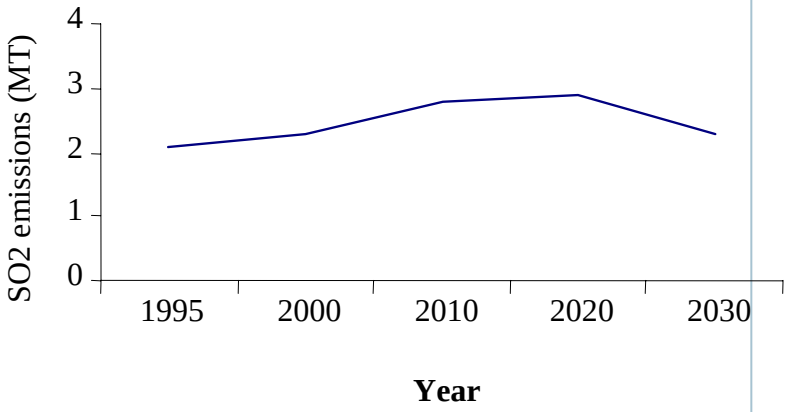
# Emission Cap-and-Trade vis-à-vis Technology Policy

*45% cost- savings over 30 years in the emissions cap and trade instrument*

## Marginal costs for $SO_2$ mitigation




## $SO_2$ Emissions Cap Trajectory




*Annual average cost savings over a 30 year period is Rs. 3600 million ($80 million)*

# Future Agenda 2003-04

- Urban Air Quality Studies with AIM (including innovations scenarios)
- Electricity Sector Modelling with AIM/Local
- Regional Modelling of Non-$CO_2$ emissions and counter measures
- Long-term Technology Strategies for India
- Networking with AIM team for New model with developing country focus (e.g. Urban/Rural, Formal/Informal)
- Mitigation and Stabilization scenarios