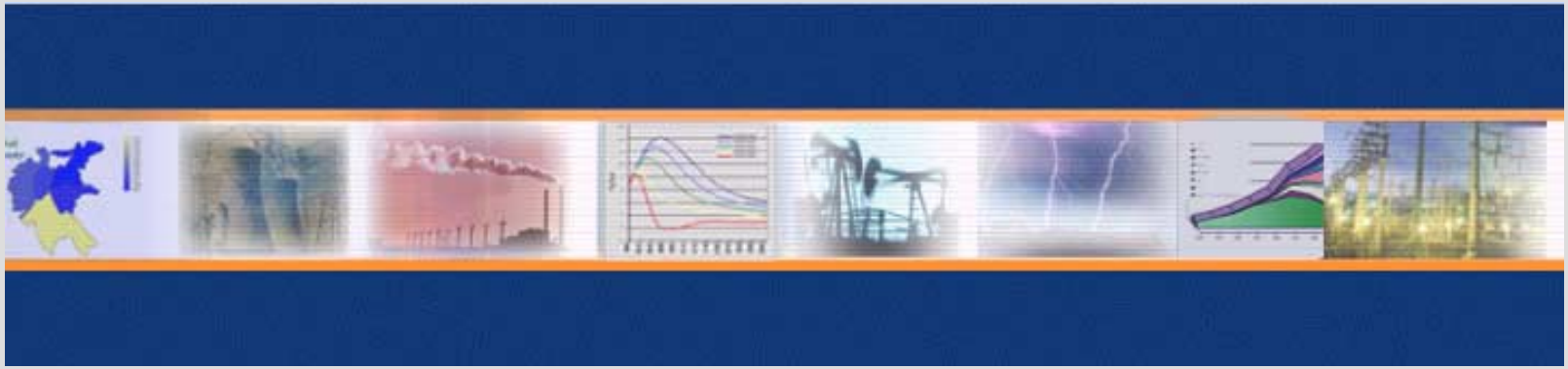
INDIA'S EXPERIENCE IN MODELING NON-CO_2 GASES



ECONOMIC AND ENVIRONMENTAL MODELING WORKSHOP

Emission Sources: Methane

Enteric fermentation
Manure management
Rice cultivation
Coal mining
Field burning of agriculture residues
Waste (municipal solid waste, waste water)
Fossil fuel combustion
Oil and gas related activities

Emission Sources: Nitrous Oxide

Synthetic fertilizer use
Livestock related emissions
Fossil fuel combustion
Waste (municipal solid waste, waste water)
Crop residue burning
Biological nitrogen fixation

Agriculture sector dominance

Emission mitigation centric modeling for agriculture sector is an emerging area in India

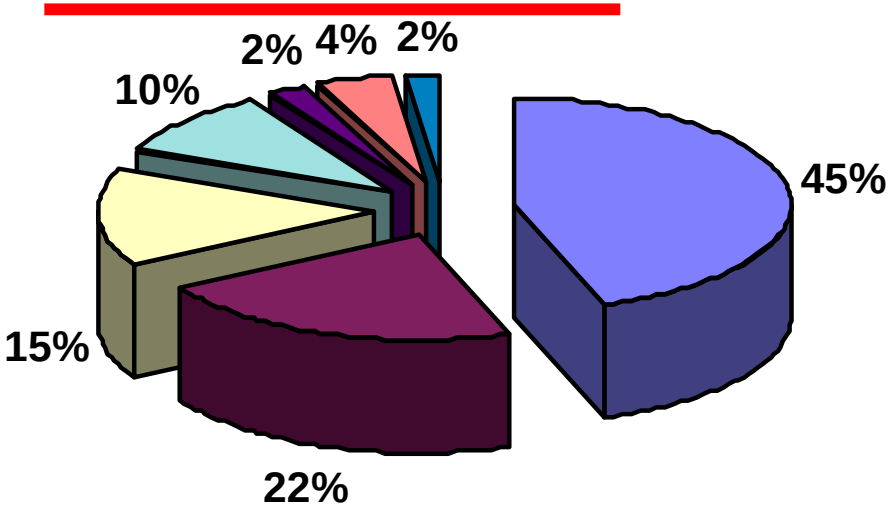
GHG emissions in India

GHG emissions in 2000

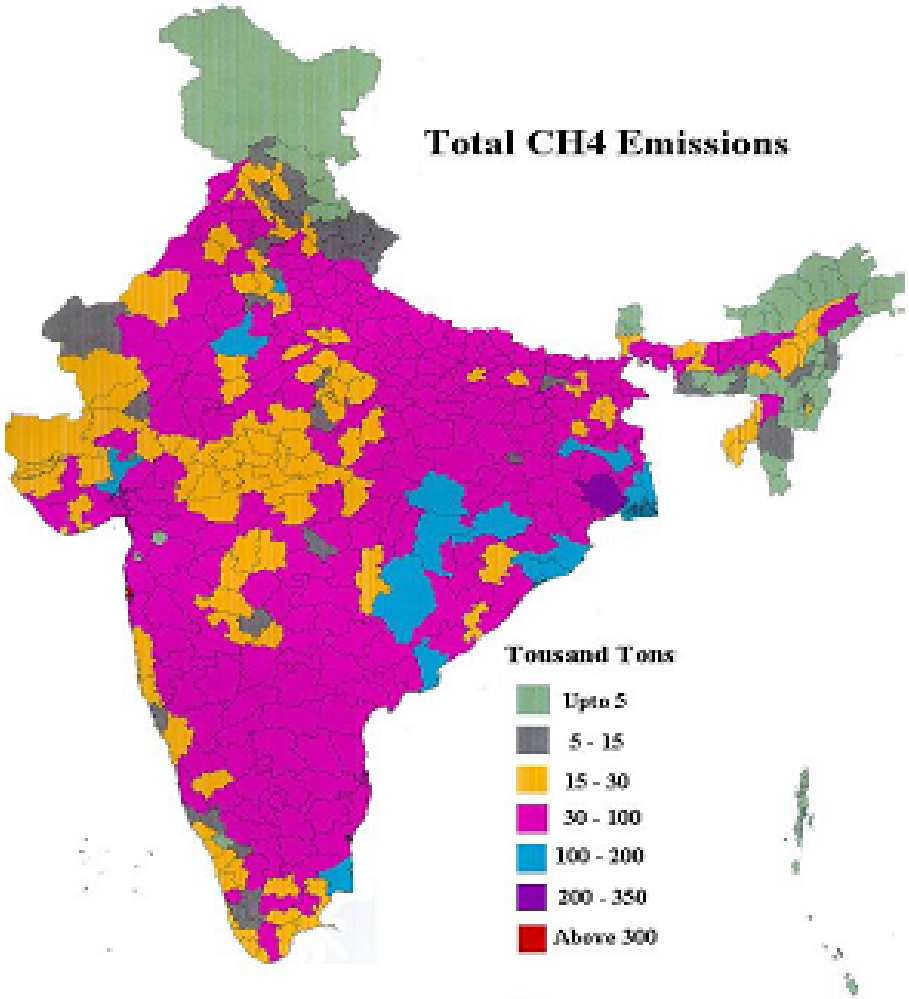
- **CH_4(27%), N_2O(7%)**
- **Agriculture and livestock**
  - **65% to CH_4 emissions**
  - **above 90% to N_2O emissions**

Emissions	Tg	Tg-CO_2 eq
CO_2	983	983
CH_4	18.63	391
N_2O	0.308	95
CO_2 equivalent GHG		1469

Methane Emissions



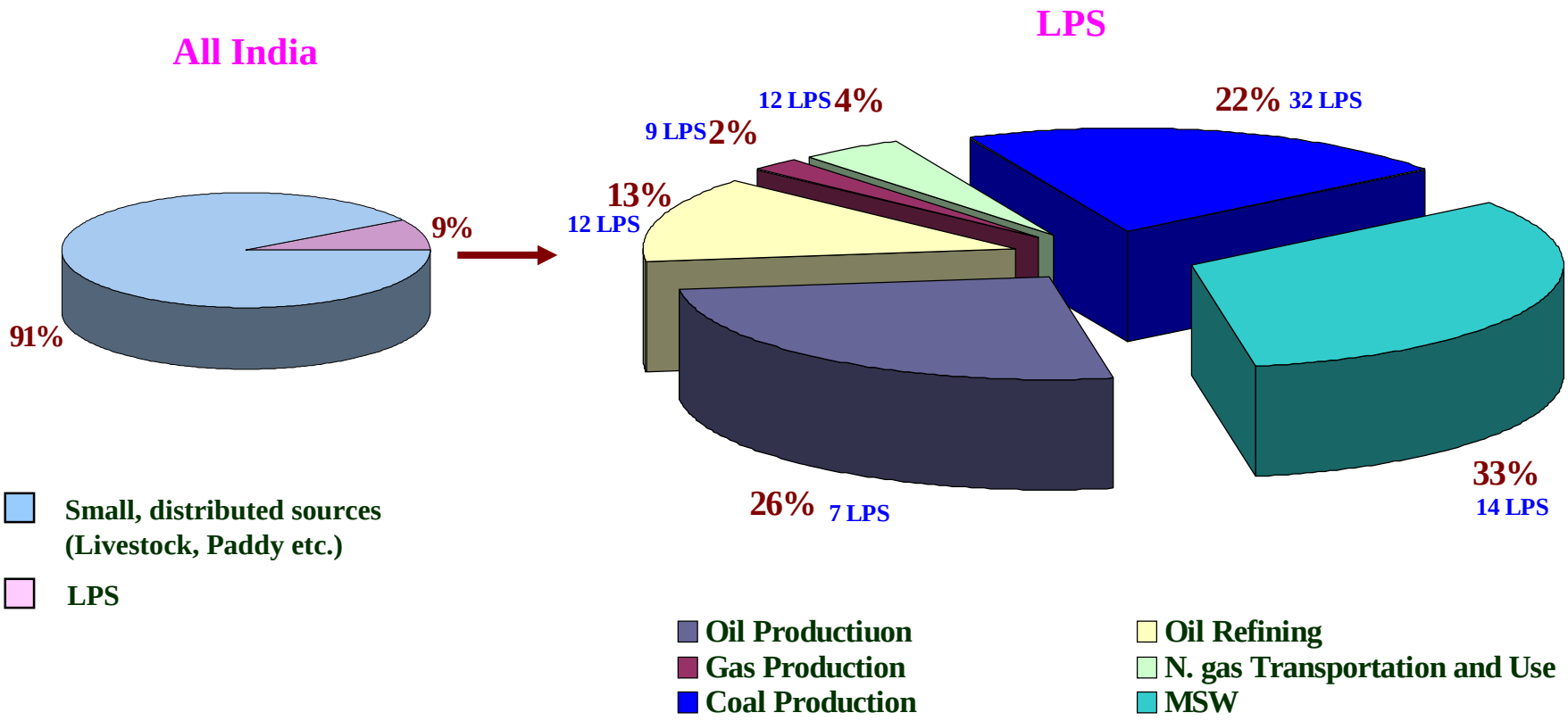
- Livestock
- Paddy cultivation
- Biomass burning
- Municipal solid waste
- Waste water
- Oil & gas production & transportation
- Coal production



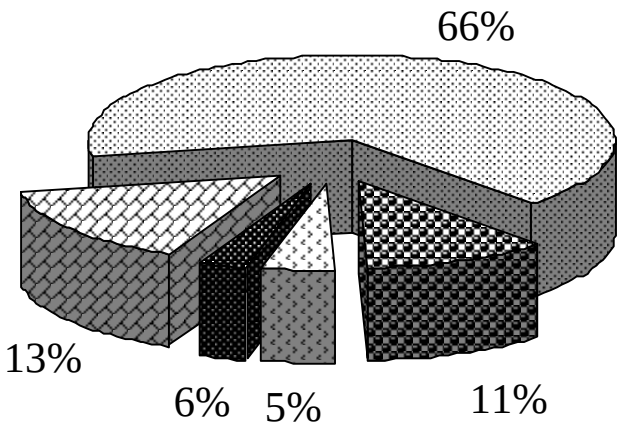
27% contribution to India's CO_2 Equivalent GHG emissions in 2000

CH_4 Contribution from Large Point Sources

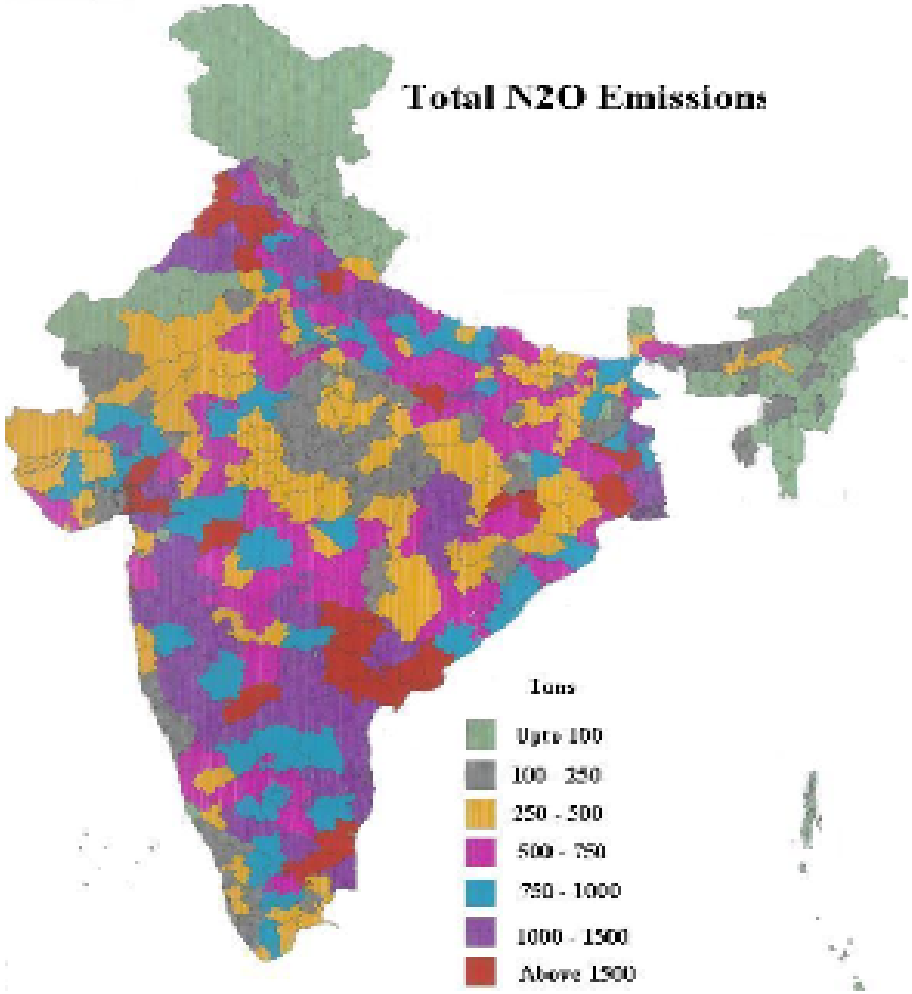
All India Emissions in 2000 = 18.6 MT



N_2O Emissions

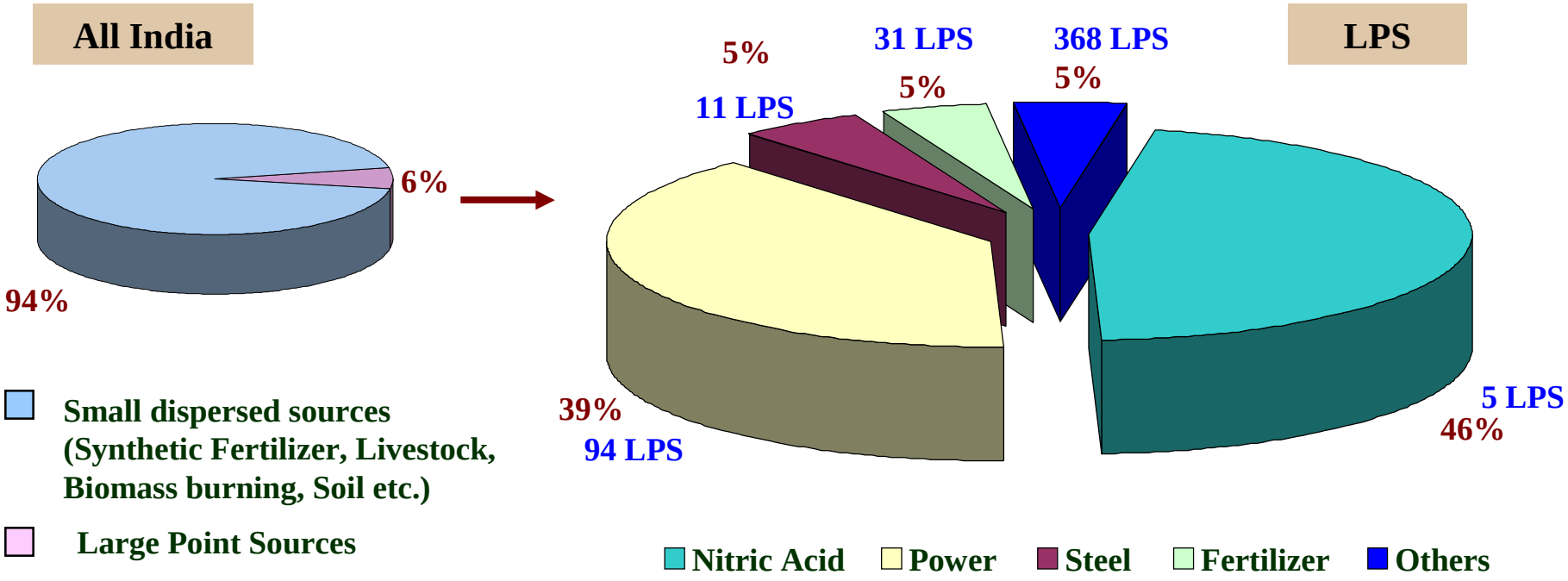


- Nitrogen fertilizer use
- Livestock
- Others
- Biomass burning
- Large Point Sources



7% contribution to India's CO_2 Equivalent GHG emissions

N_2O Contribution from Large Point Sources



All India Emissions in 2000 308 kT

Framework of the AIM/Enduse Model

Energy

- Oil
- Coal
- Gas
- Solar
- (Electricity)

Energy Technology

- Boiler
- Power generation
- Blast furnace
- Air conditioner
- Automobile

Energy Service

- Heating
- Lighting
- Steel products
- Cooling
- Transportation

Energy Consumption
CO2 Emissions

Technology

Service Demand

Energy Database

- Energy type
- Energy price
- Energy constraints
- CO2 emission factor

Technology Database

- Technology price
- Energy consumption
- Service supplied
- Share
- Lifetime

Emission Scenarios

- Population Growth
- Economic Growth
- Urbanization pattern
- Land reforms
- Technological change

Framework of the AIM/Enduse Model for Methane

Energy-economy database
Optimization model of technology systems in energy supply and demand sectors in the economy

→ CO_2, SO_2, NO_x emissions; Technology-mix; Energy-mix; Costs

Demands for services;
Supply of fossil fuels

↓

Methane database
Optimization model of methane generating activities in the economy

→ CH_4, N_2O emissions; Activity-mix; Costs

- Bottom-up type model
- Minimize total system cost for each year
- Stock for each technology is transferred to next period

Methane database for India

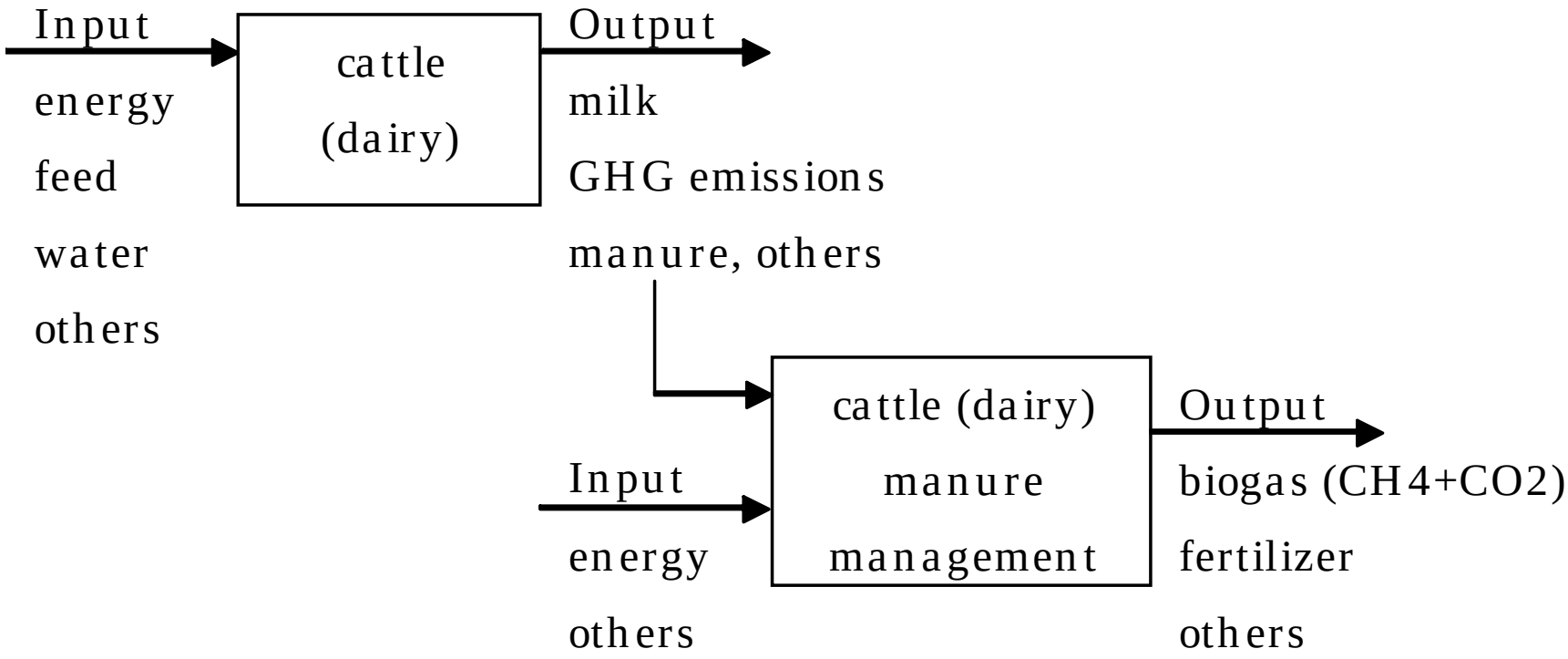
Database for 1990, 1995 and 2000 (partially) set up

Database of methane abatement options set up based on EMF estimates, being updated for Indian conditions and costs

Forecasts of methane generating activities based on drivers from energy-economy database and sectoral expert interactions

Non-CO_2 gas mitigation technologies database

Characteristics of device, Input and output of device, Cost (capital, O&M, lifetime), Reference



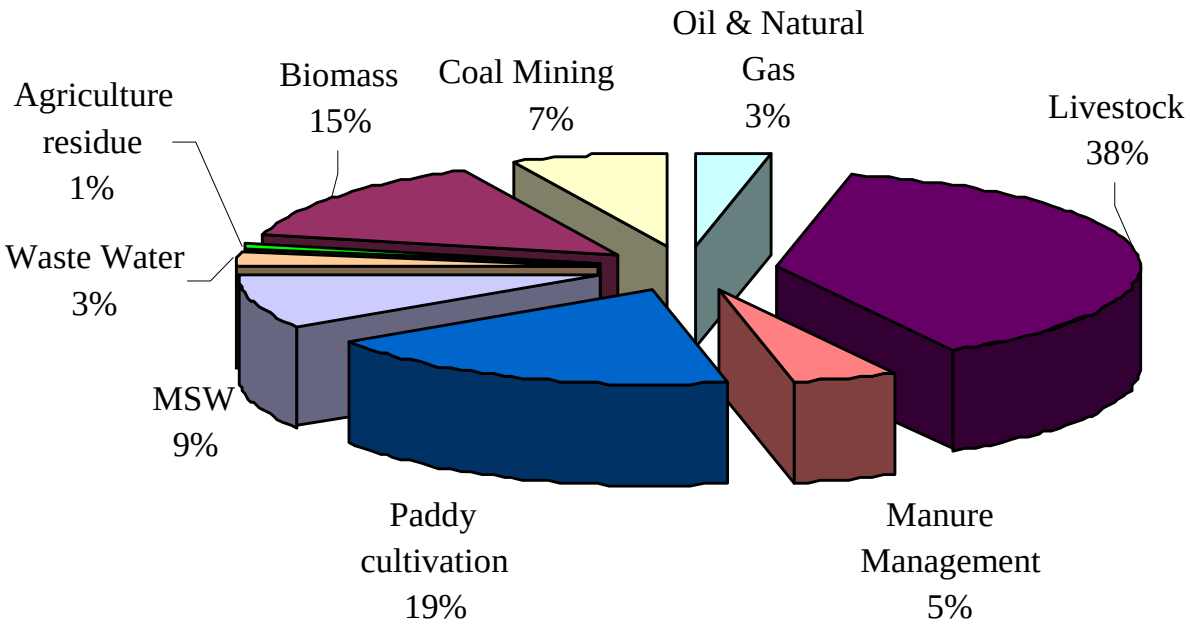
Cumulative Methane Emissions Under IA2 (2000-2030), Million TCE

Cumulative methane emissions 723 Million tons (4143 MTCE) over 2000-2030

Coal mining 290 MTCE

MSW 375 MTCE

Agriculture 3150 MTCE

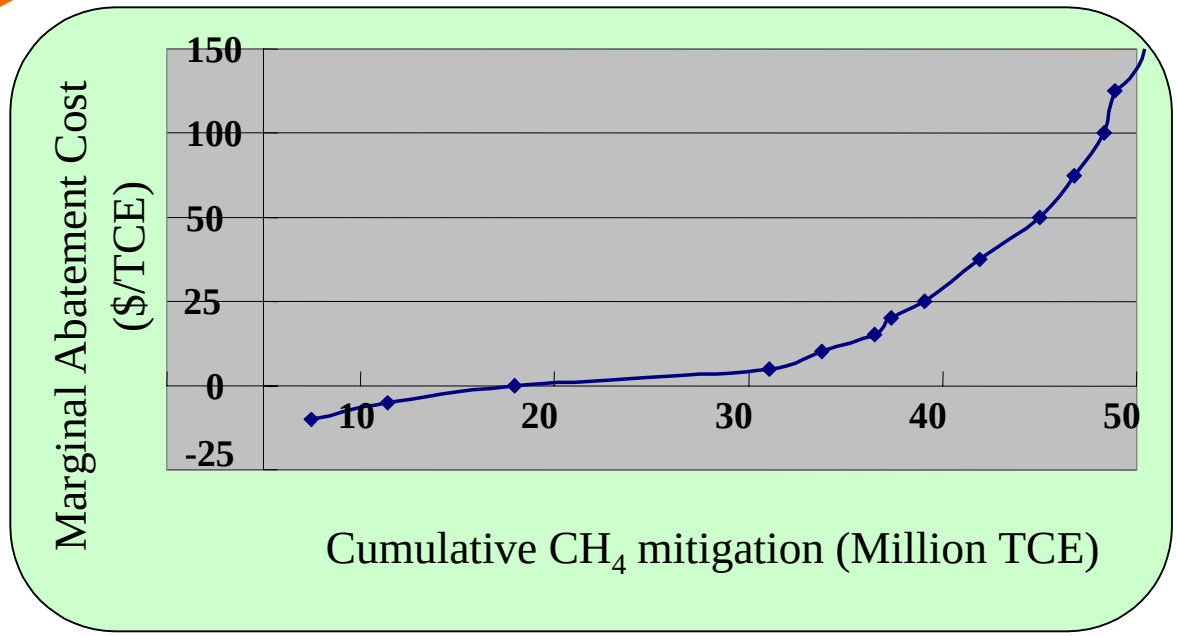


Non-CO_2 gas mitigation

Initial conditions:
- non-CO_2 gas price
-mitigation amount
-mitigation cost

Main model

Mitigation Cost curve



Mitigation amount
Mitigation cost

Indian Emission Scenario Key Drivers

IA1: High Growth

- 7.7% GDP growth for next three decades
- Enhanced all-round infrastructure
- Accelerated market reforms
- High access to global finance & technologies
- Technology, information & industry driven

IA2: Business-As-Usual

- 5.5% GDP growth for next three decades
- Fragmented infrastructure development
- Slower market reforms
- Low globalization and liberalization
- Heavy-industry driven

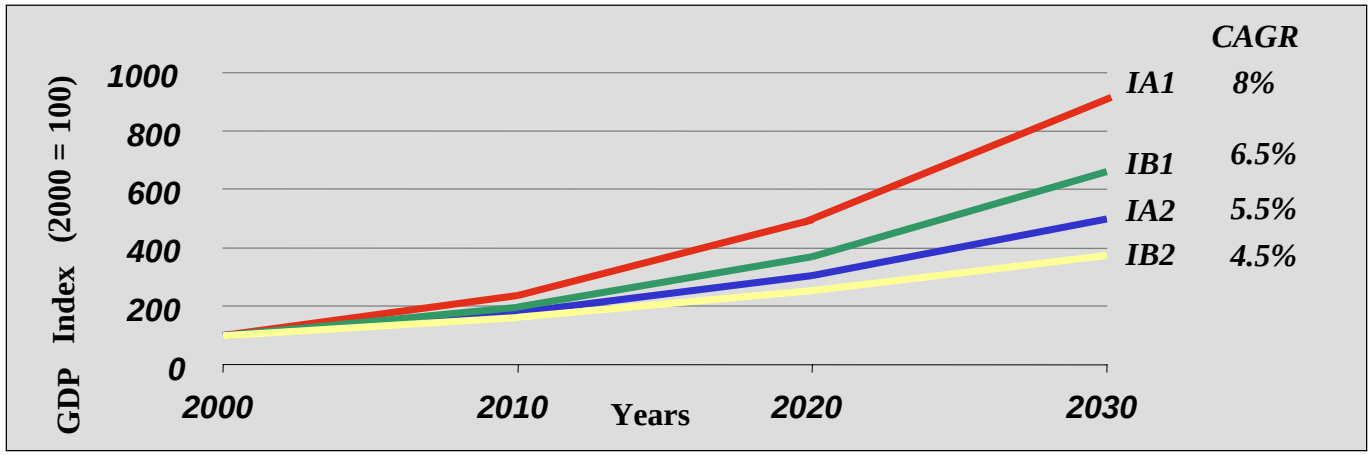
IB1: Sustainable Development

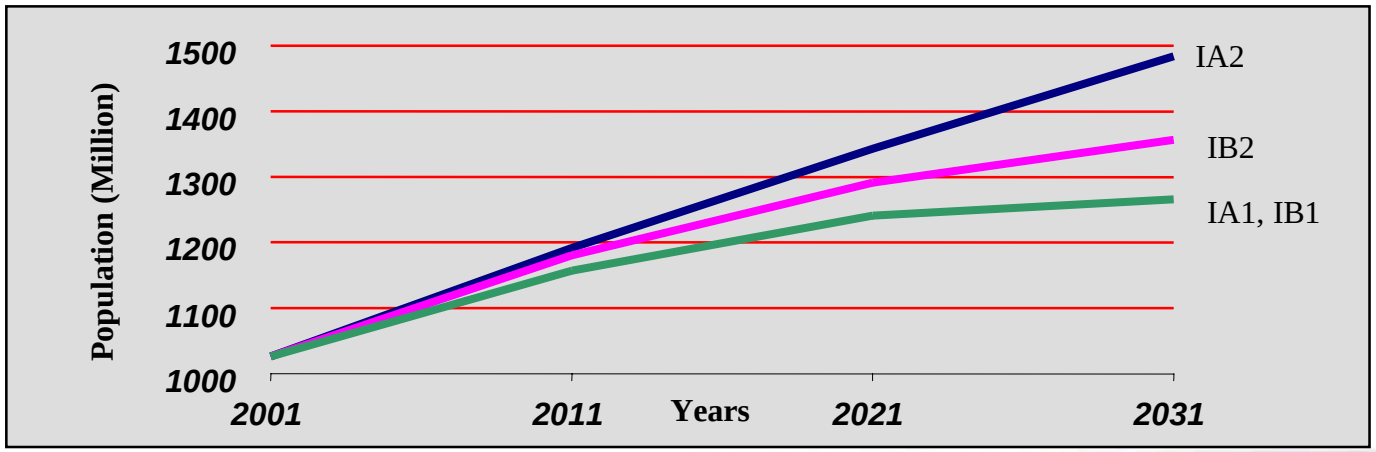
- 6.5% GDP growth for next three decades
- Strong environmental integrity of the economy
- Sustainable consumption all-round
- Dematerialization, renewable energy thrust
- Enhanced all-round infrastructure
- Lower income disparities
- High access to global finance & technologies

IB2: Regional Development

- 4.5% GDP growth for next three decades
- Fragmented infrastructure development
- Inward looking policies
- High regional disparities in development levels
- Slower shift away from agriculture
- Slower technology improvements

India: GDP and Population Projections





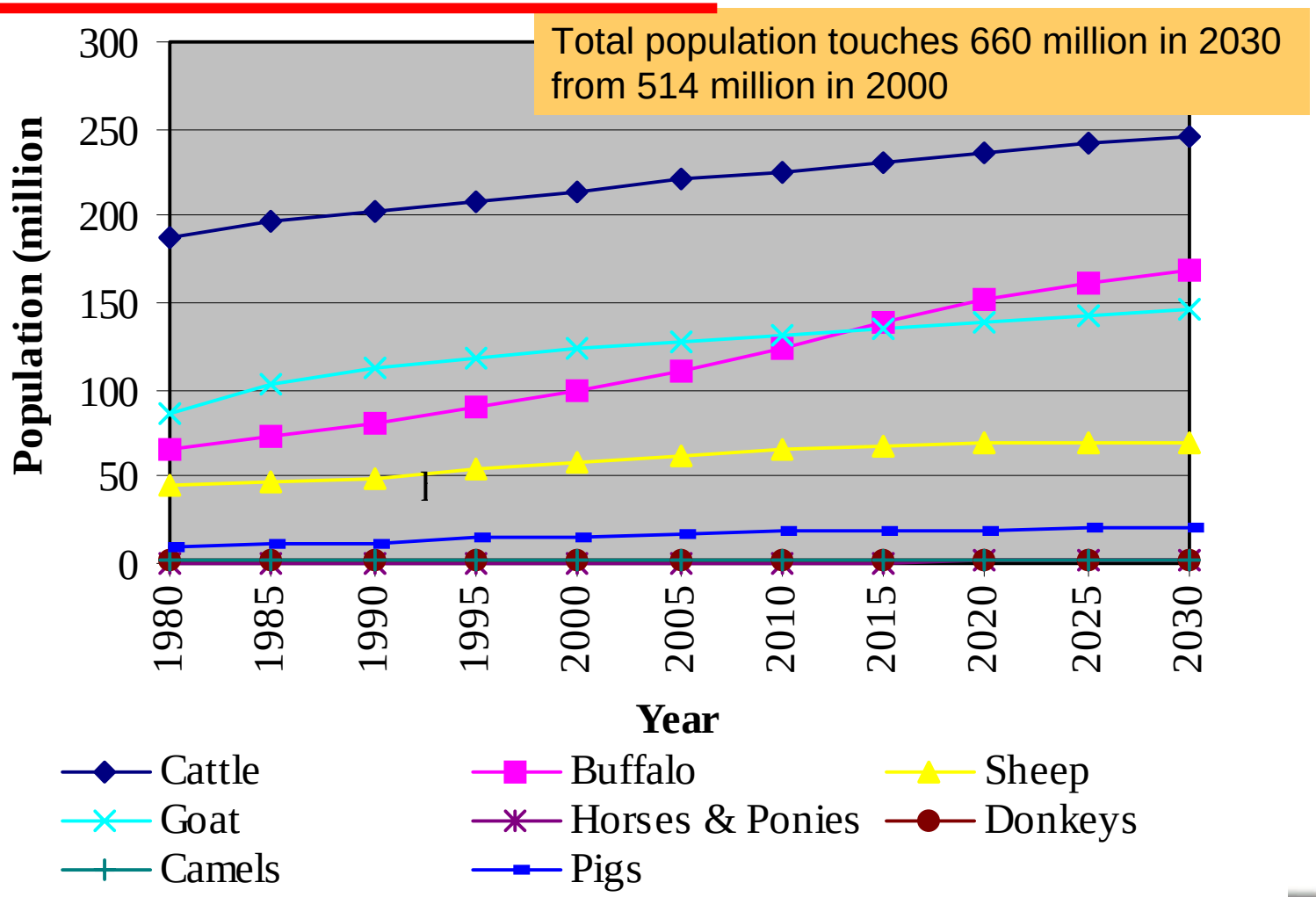
IA2 (BAU) scenario assumptions

- Current official policies of the government
- Forecasts of macro-economic, demographic and agriculture sector indicators
- Includes many pro-environmental measures
  - structural changes in the Indian economy
  - autonomous energy efficiency improvement in various technologies
  - increased penetration of cleaner and new technologies

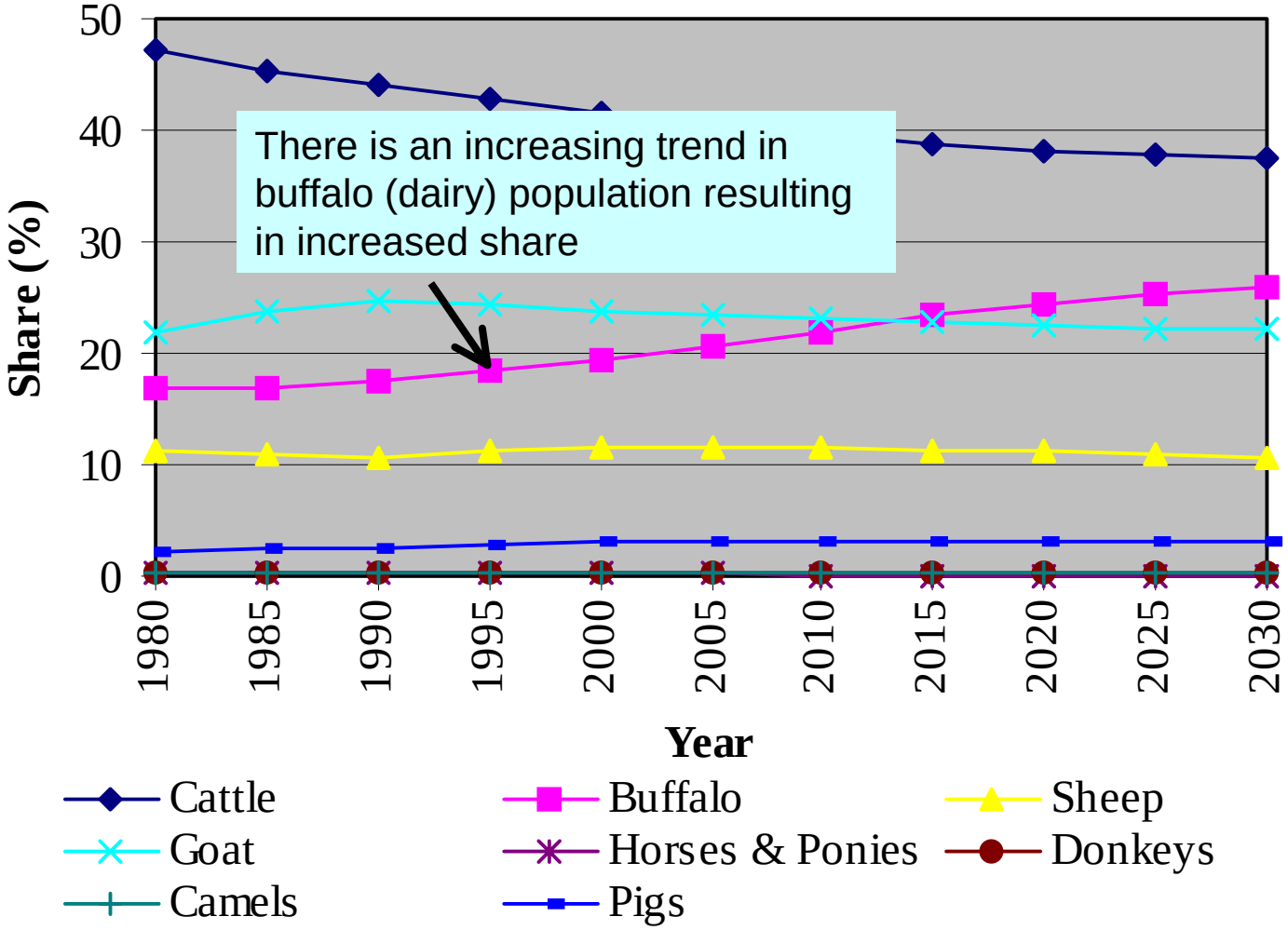
Key Driving forces for CH_4 and N_2O emissions projections

- Economic growth
- Livestock population
- Urbanization patterns and human population
- Agriculture practices and fertilizer use
- Technological progress
- Global climate change regimes

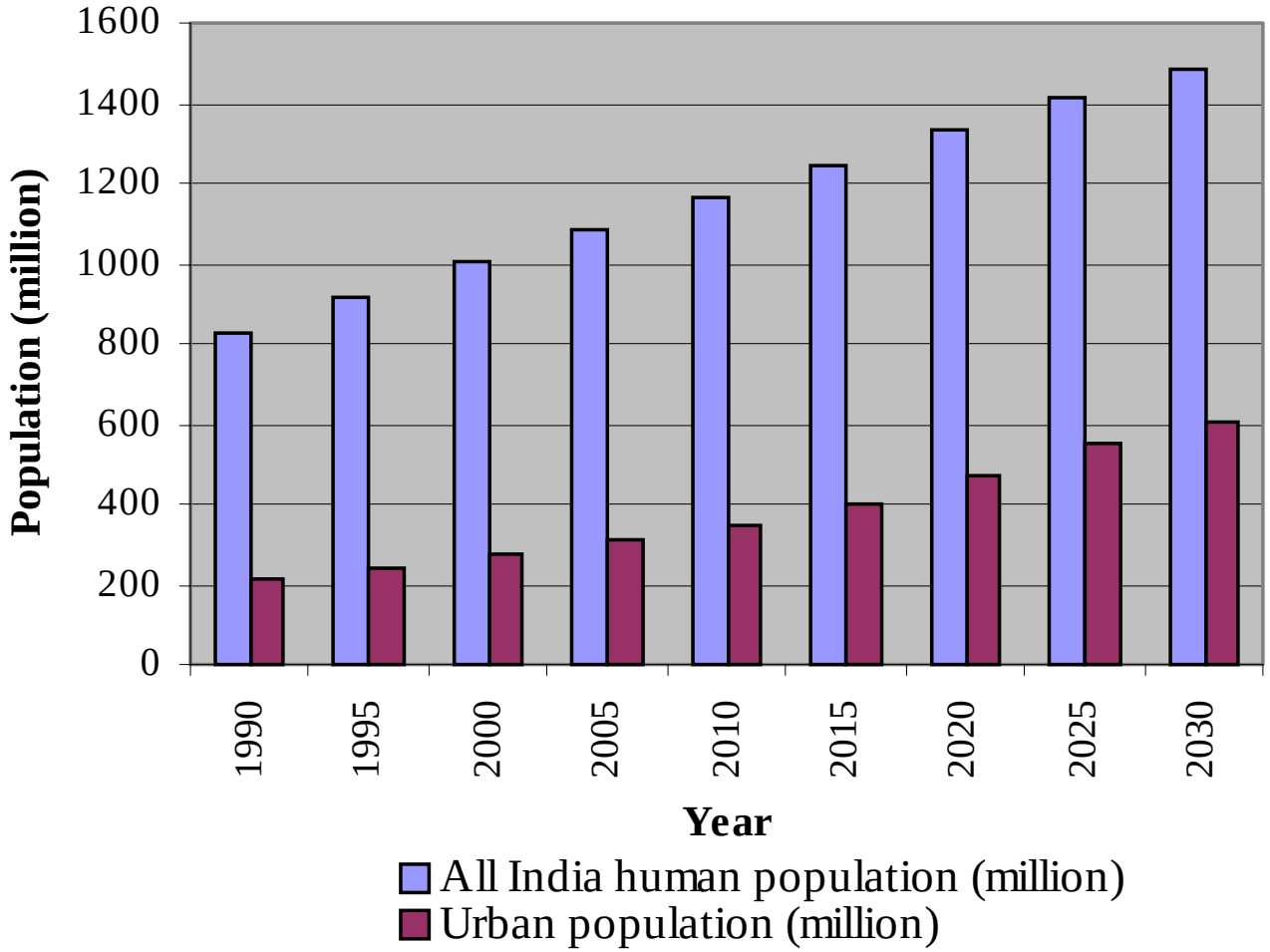
Livestock population projections, IA2



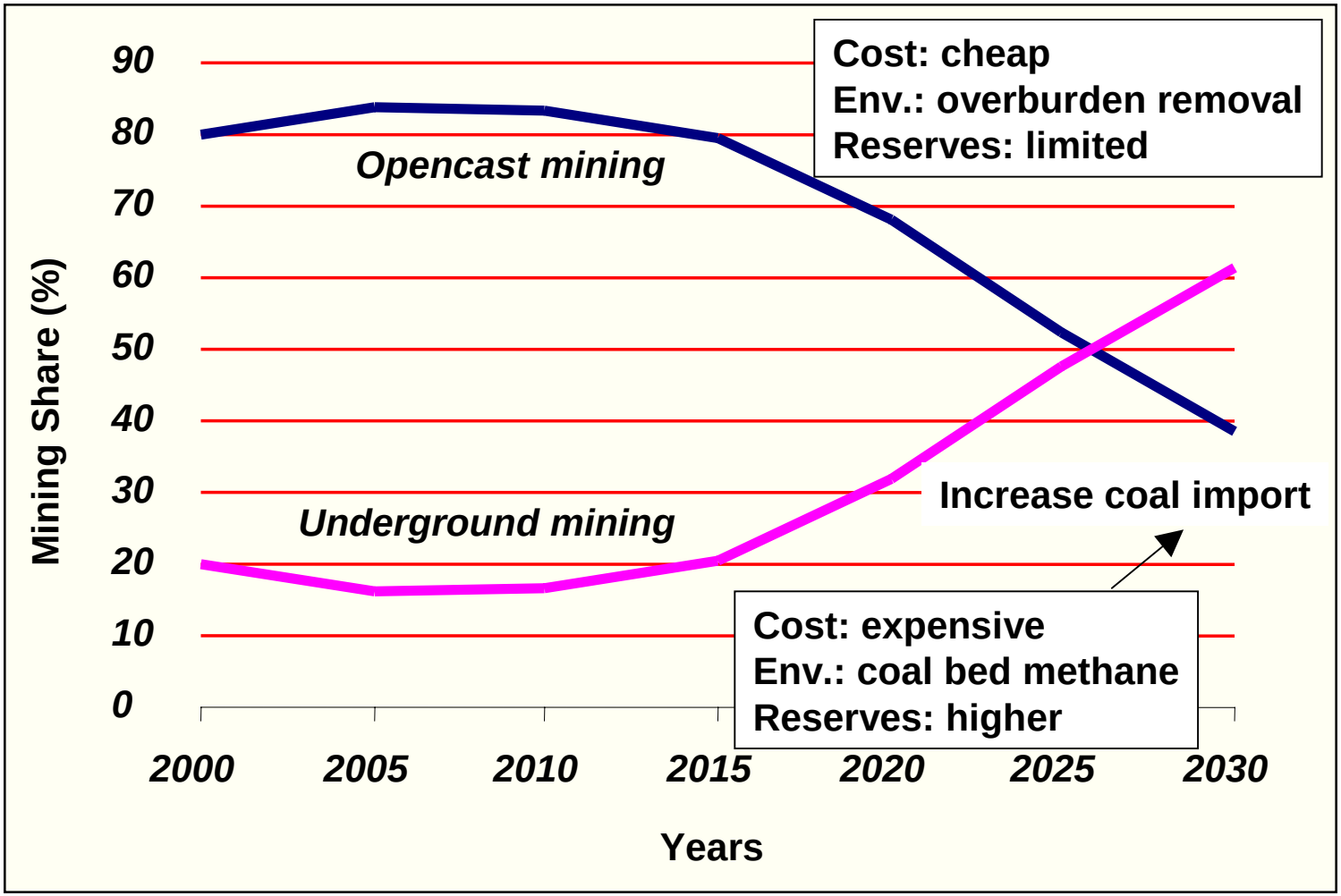
Livestock population share projections



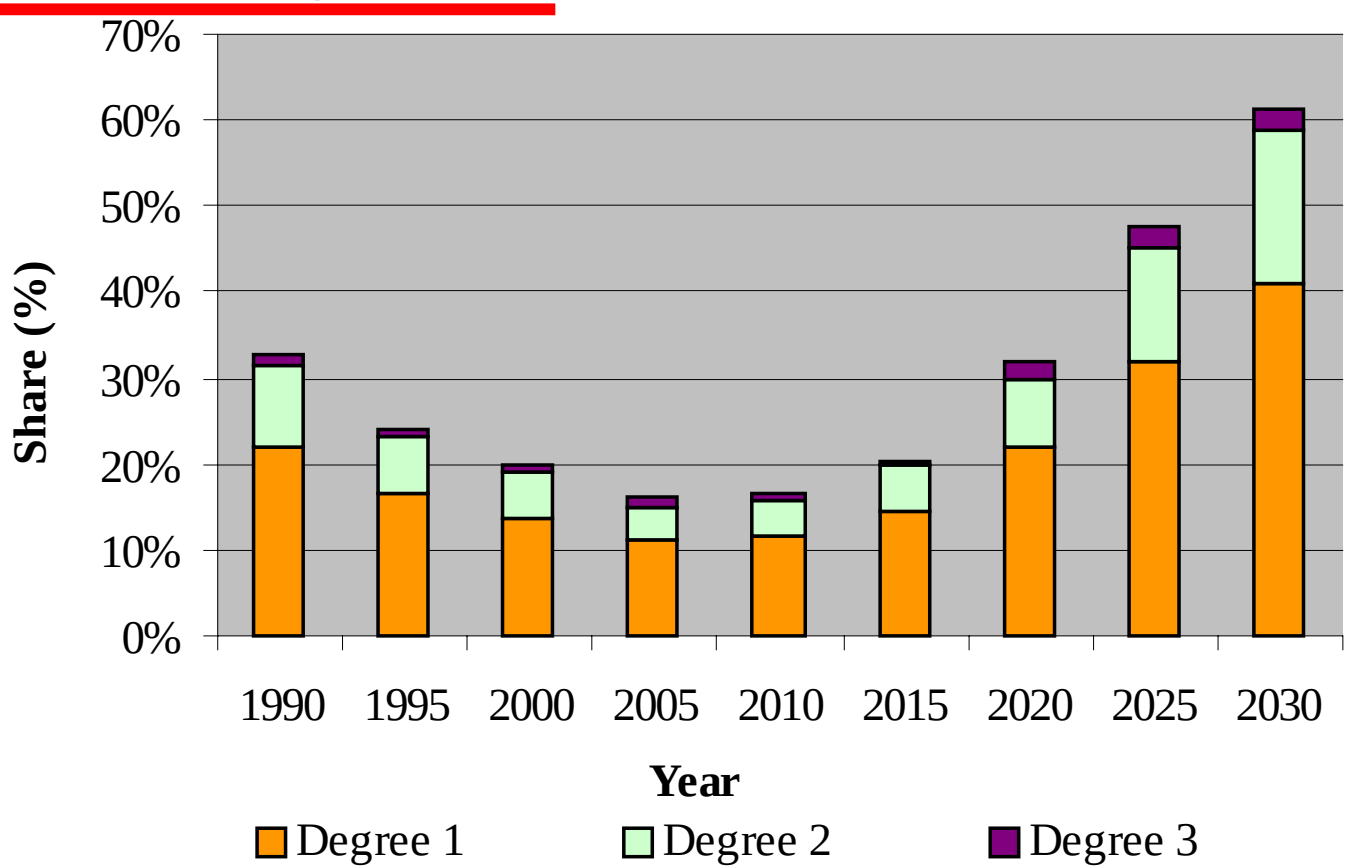
Urbanization, IA2



Shares of opencast and underground mining, IA2

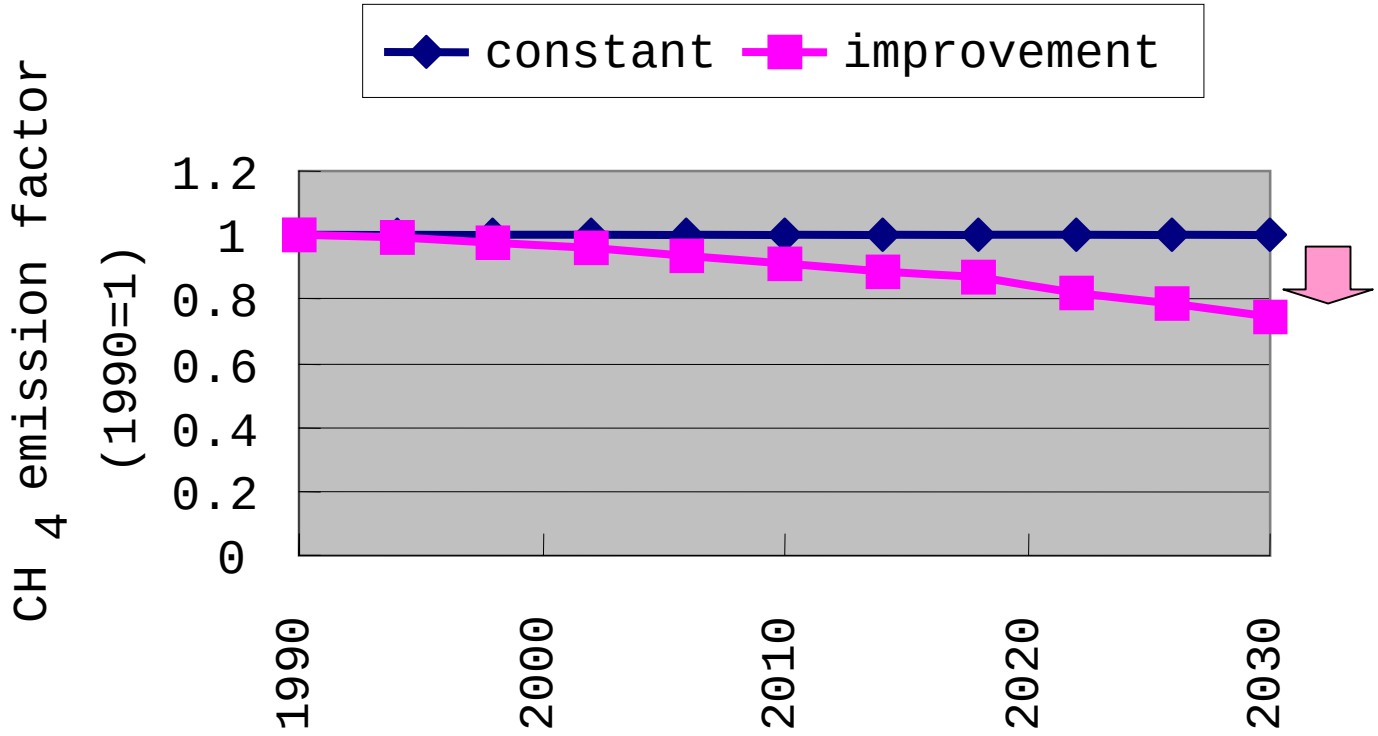


Underground mining shares



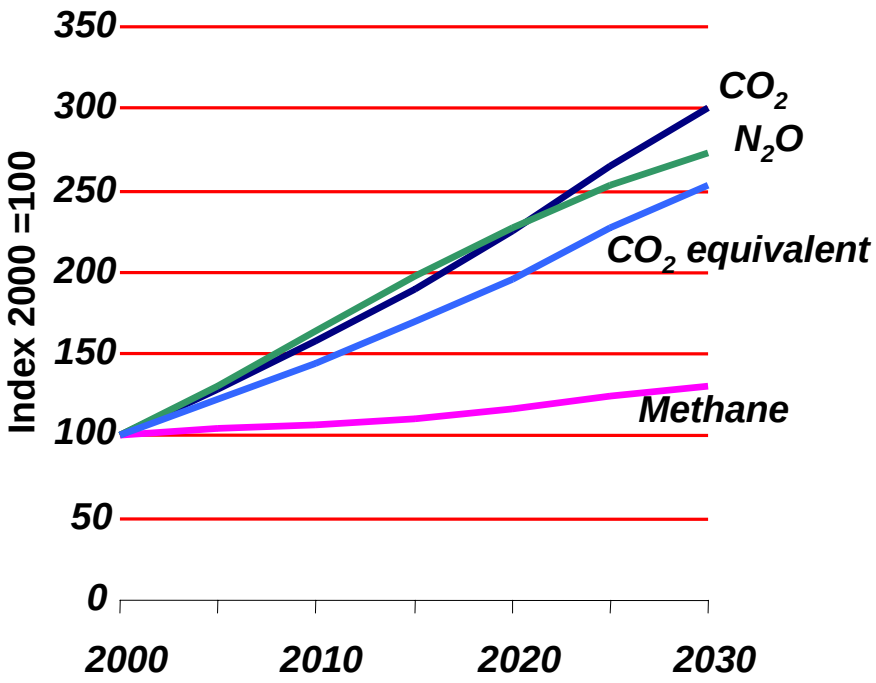
Penetration of mechanized coal loading technologies like side discharge loader (SDL) and load haul dump (LHD) increases in underground mining over the years

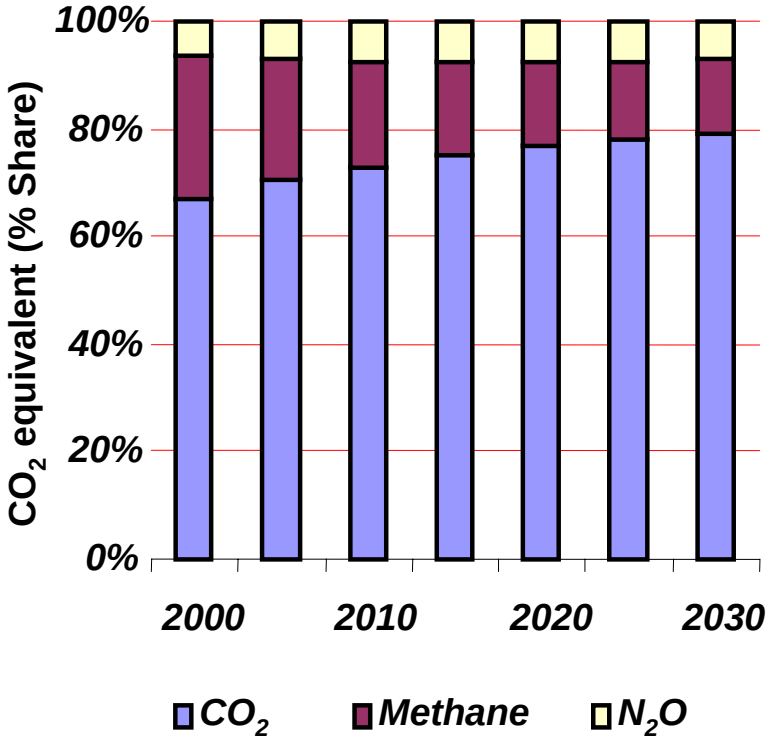
Future non-CO_2 gas emission factors



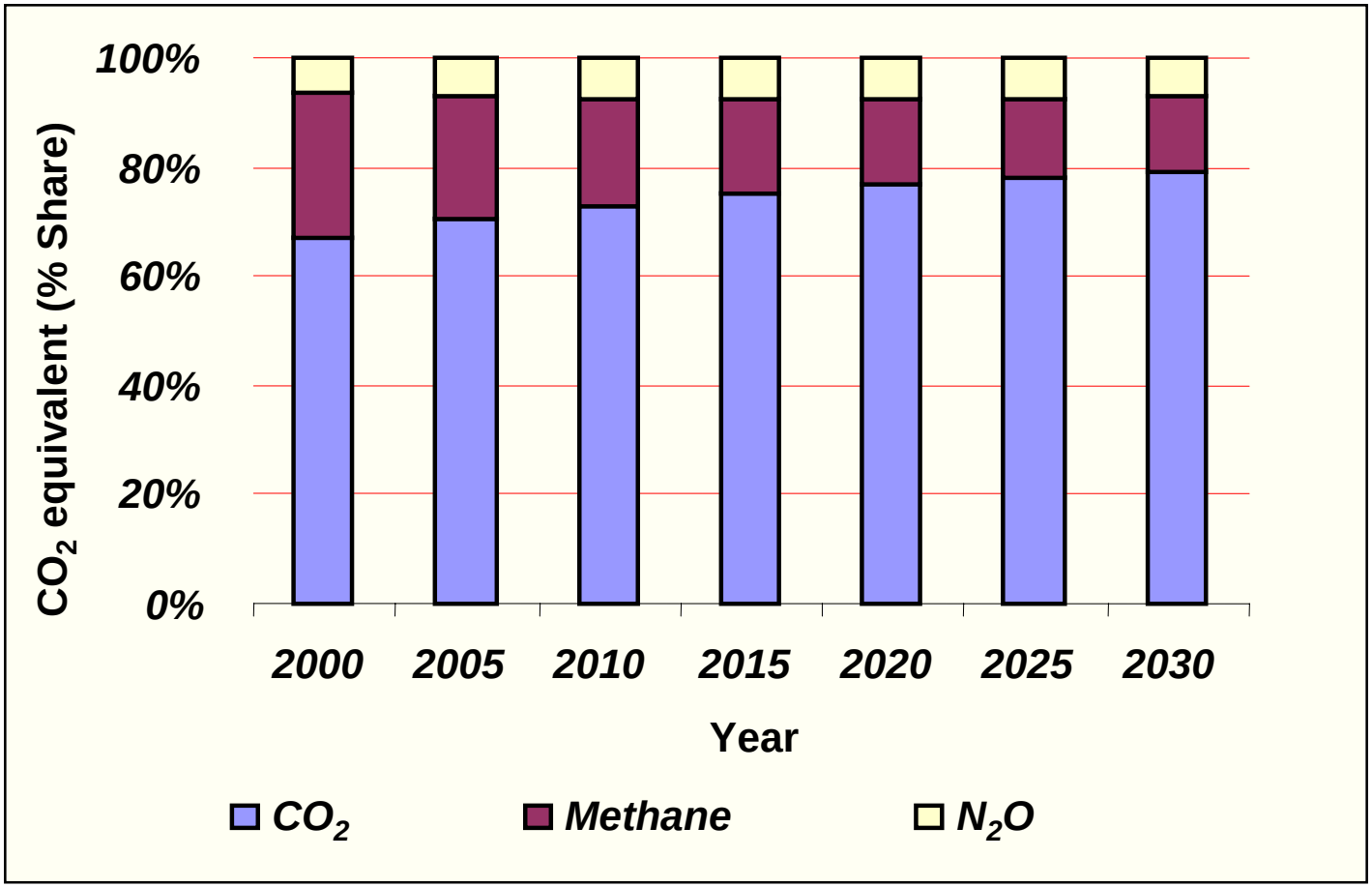
- **Income growth will cause autonomous non-CO_2 gas emission factor improvement (eg. Kuznets effect on SO_2, NO_X)**
- **Endogenous technological improvement**

CO_2, CH_4, N_2O and CO_2 Equivalent GHG Emissions (IA2)

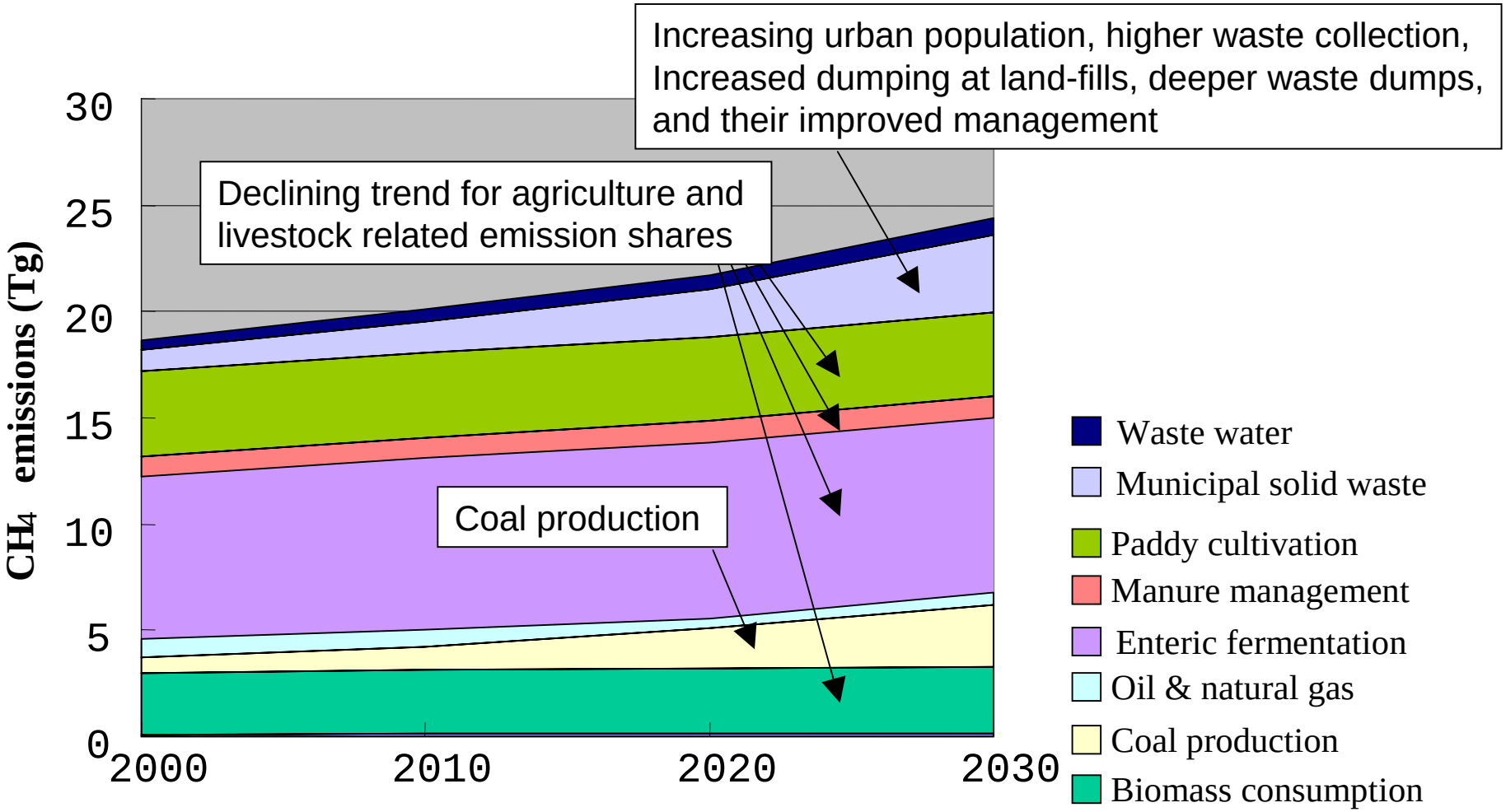




Share of CO_2, CH_4 and N_2O in CO_2 Equivalent GHG Emissions, IA2

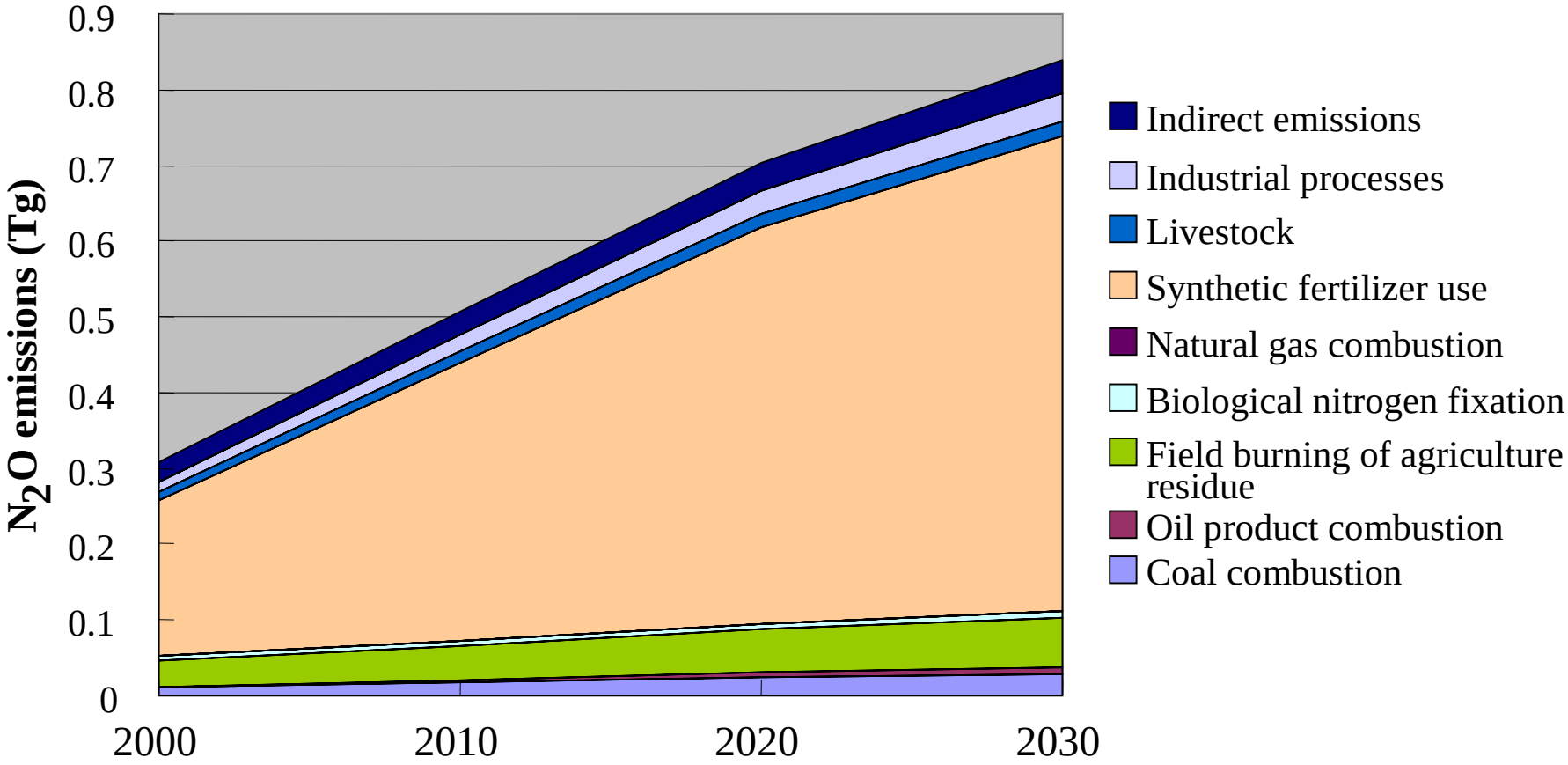


CH_4 Emissions under BAU Scenario (IA2)



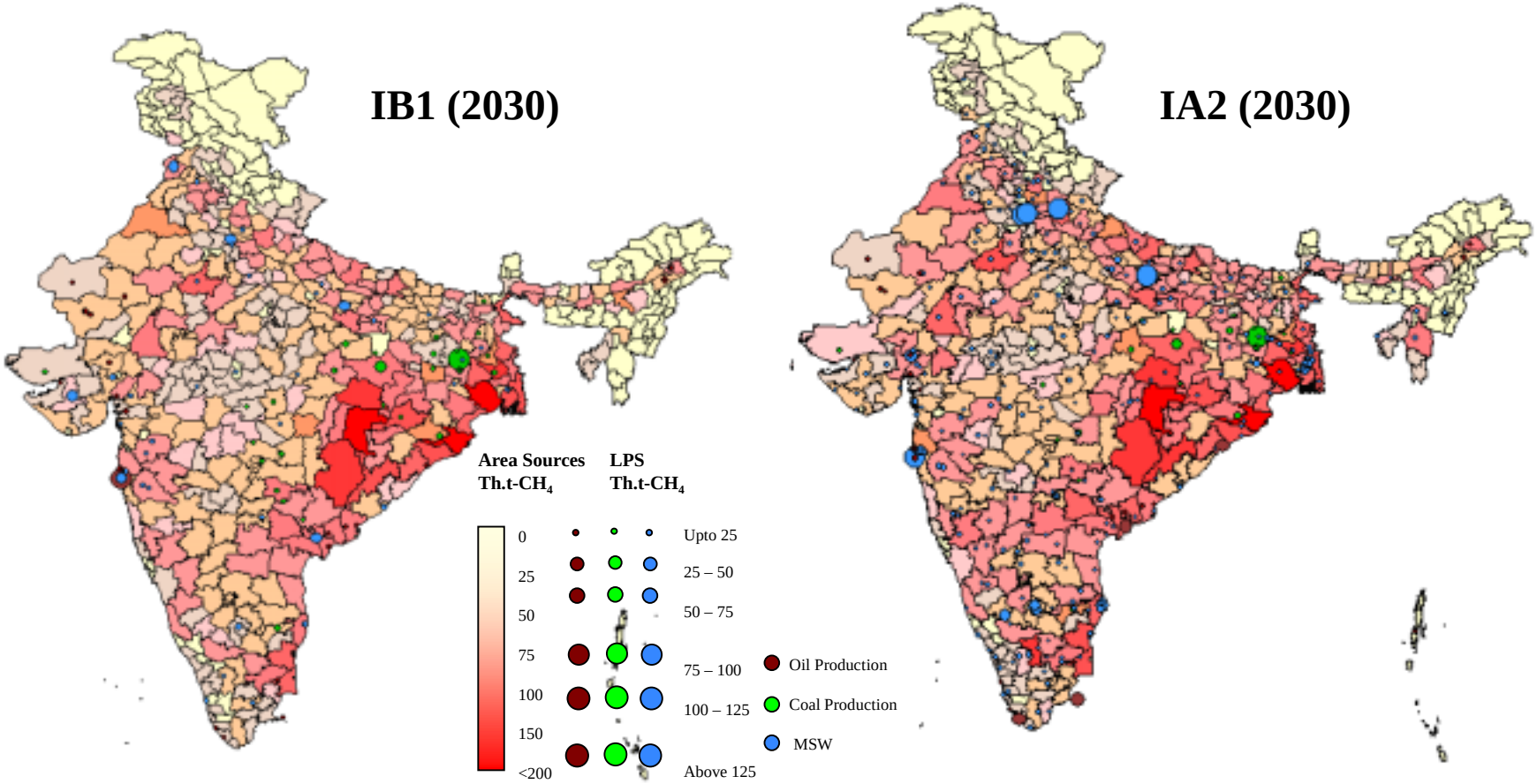
Agriculture resid

N_2O Emissions Under BAU Scenario (IA2)

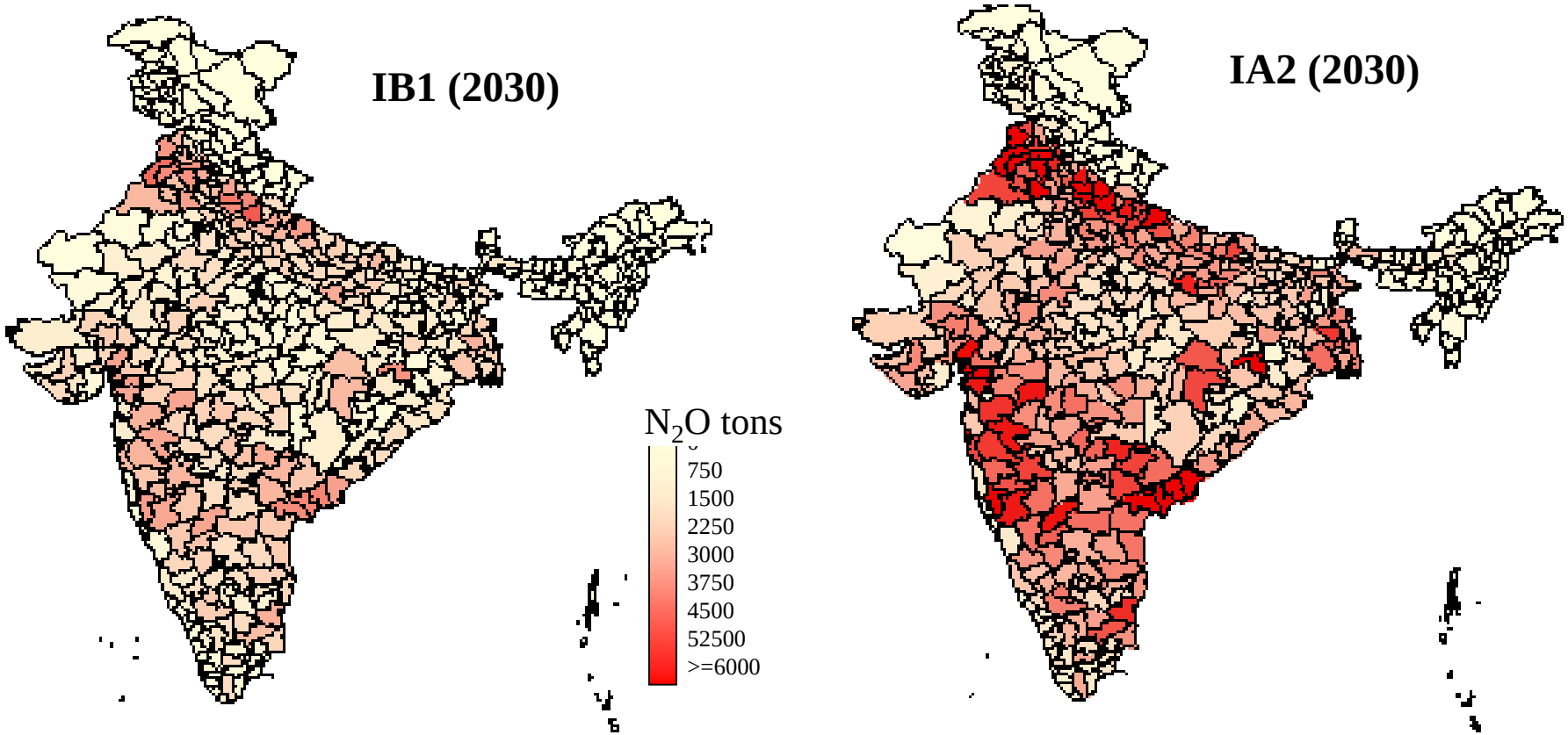


Agriculture sector activities account for more than 90%

Implications of Path Dependence on Methane Emission Spread



Implications of Path Dependence on N_2O Emission Spread



Conclusion

Non-CO_2 modeling in India is in initial stages

Gaps: Technology penetration

Indian data generation (Costs)

Mitigation potential estimates

Institutional collaboration

Thank you