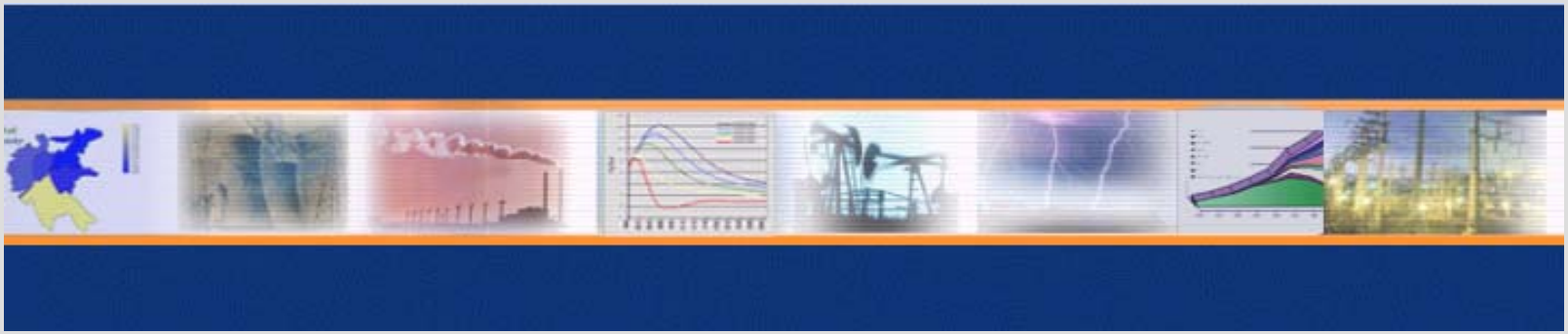
Long-Term Regional Sustainability Scenarios:
Transition Scenarios for India



P.R. Shukla
Indian Institute of Management, Ahmedabad, India

Presentation for the

EMF 22: Climate Policy Scenarios for Stabilization and in Transition

Tsukuba, Japan

December 12-14, 2006

*These are my **principles**. If you don't like them, I have others*

Groucho Marx

*These are my **assumptions**. If you don't like them, I have others.*

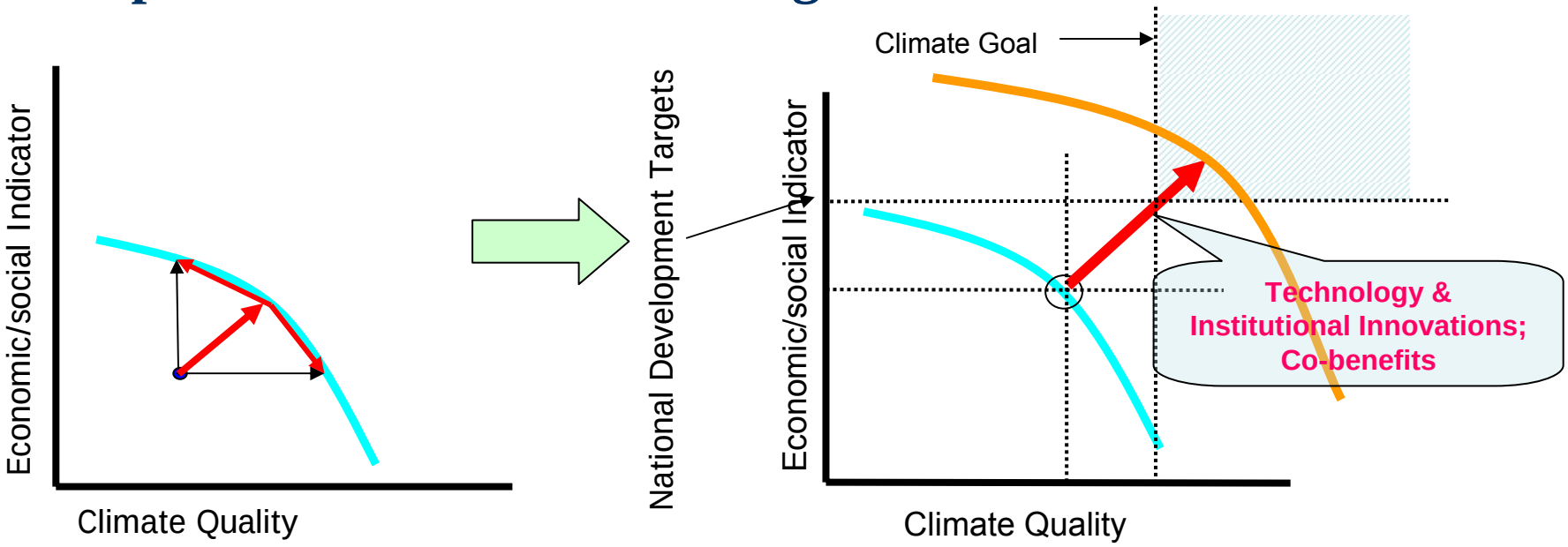
Scenario Drivers (& story of transition)

- **Factors of Production**
  - Labor Supply, Land-Use, Capital (Savings/ Investments)
- **Inputs: Resources supply/ Technologies**
  - Energy
- **Intermediate goods & investments**
  - Infrastructures
  - Energy (& Carbon) Intensive Sectors
- **Final Demand/ Behavior**
  - Private Consumption (Income effects/ preferences)
  - Government expenditure
- **Governance**
  - Rents
  - Taxes
  - Geopolitical Risks
- **Global/ External**
  - Trade
  - Geopolitical Risks

"For developing countries, the 'good news' is that their environment and natural resources policies are often so bad that there are reforms which would be both good for the economy and good for the environment."

Joseph Stiglitz, in Foreword to "Economic Development and Environmental Sustainability: New Policy Options"
Eds. Lopez and Toman, Oxford University press, 2006

Development and Climate: Shifting the Frontier



Shifting development and climate "frontier" though:

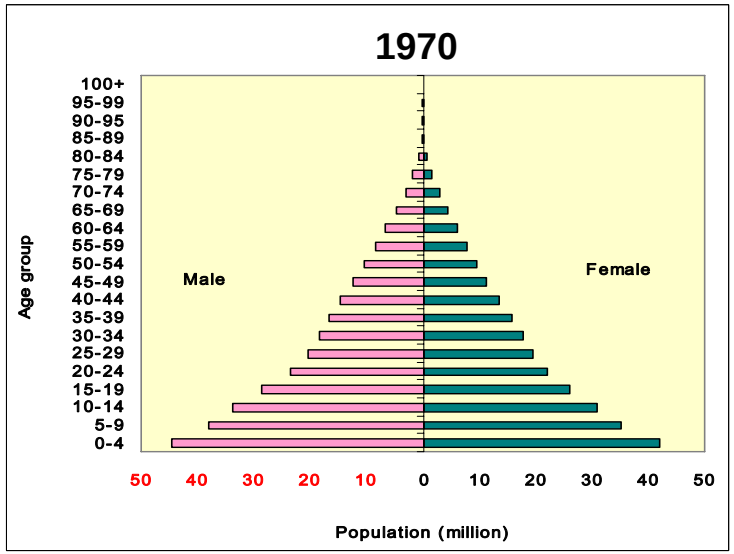
- *Innovations (technology, institutions)*
- *International and regional cooperation*
- *Targeted technology and investment flows*
- *Aligning stakeholder interests*
- *Focusing on inputs rather than outputs (conduct vs.results)*

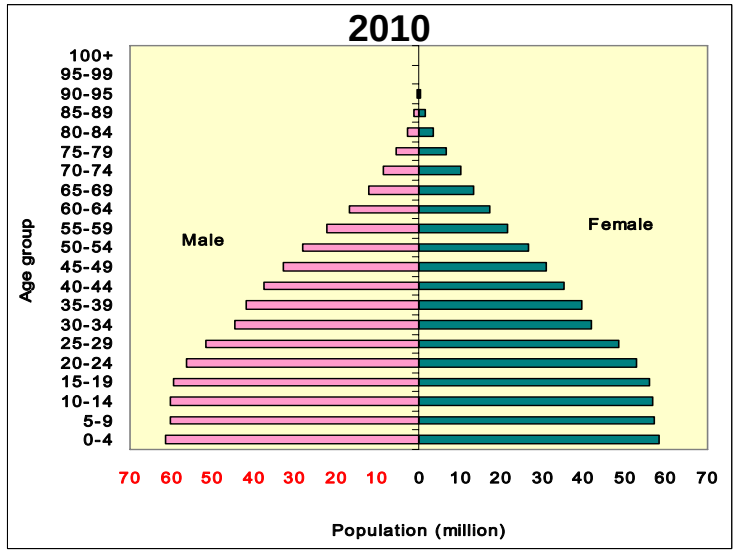
Some Examples:

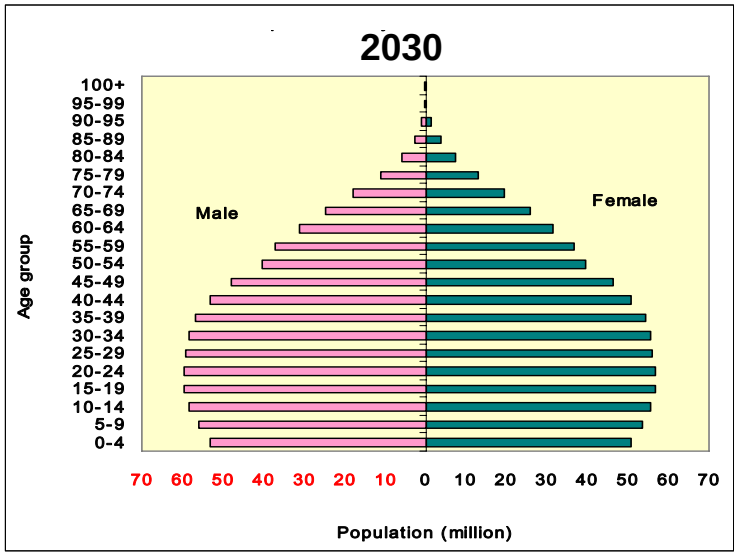
Demographic Transitions in India:

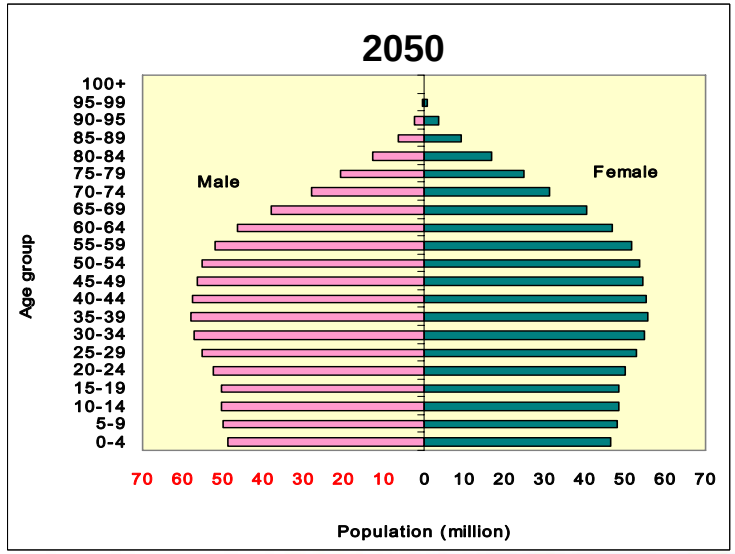
Labor Supply and Human Capital

Demographic Transitions in India: Age/Gender Profile

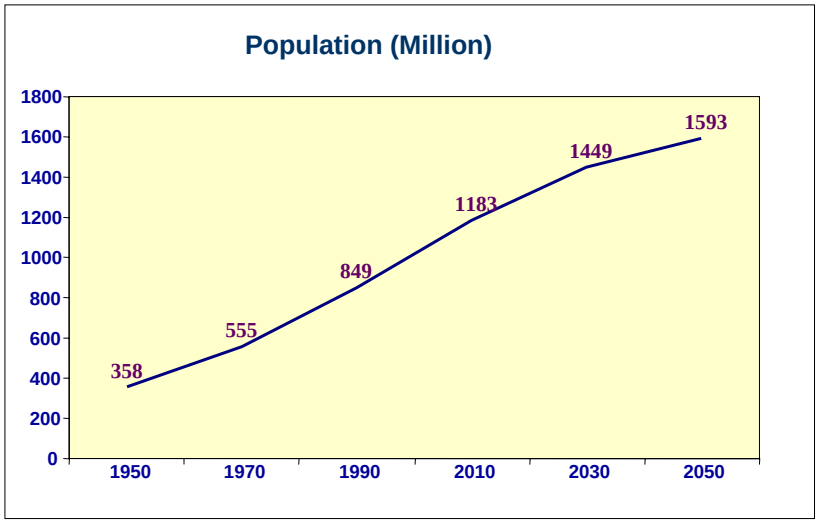


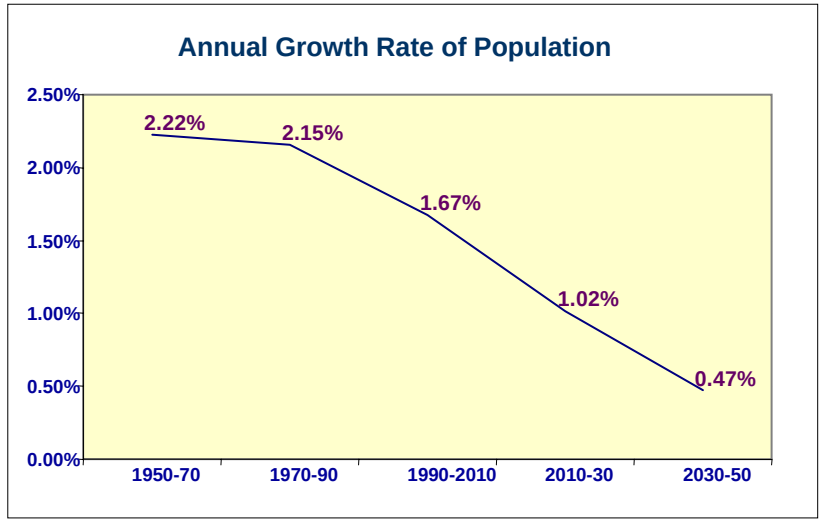


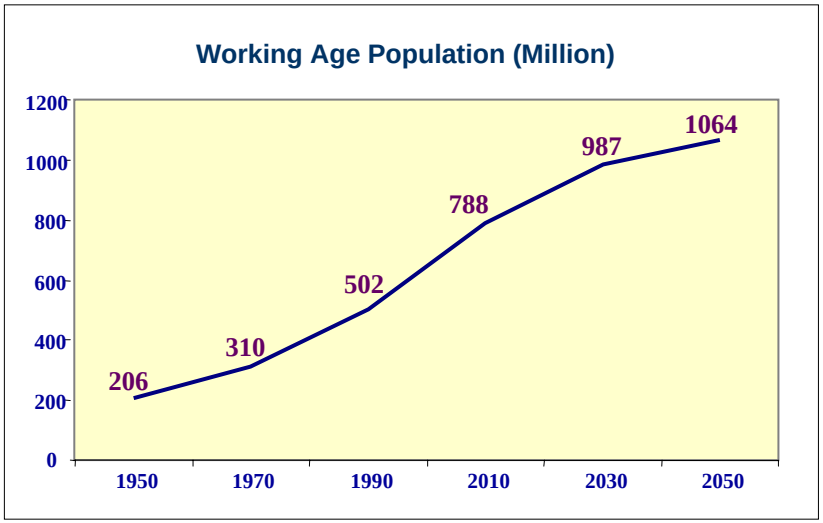


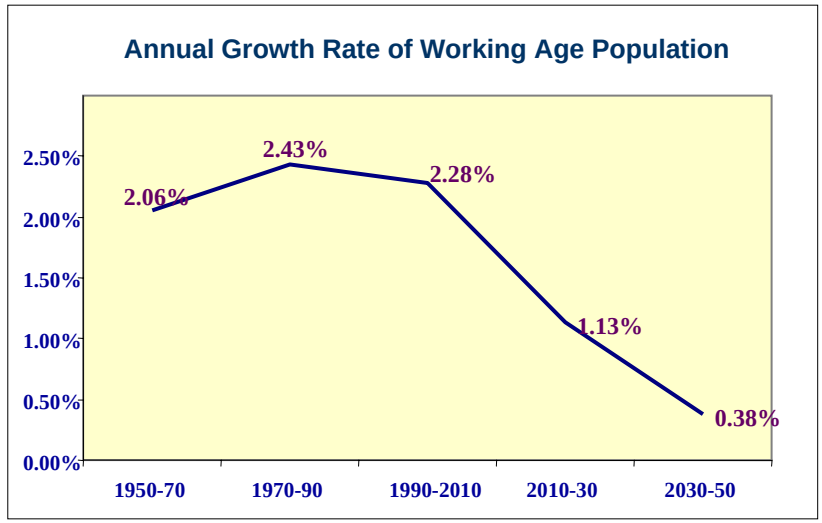


Population and Working Age Population









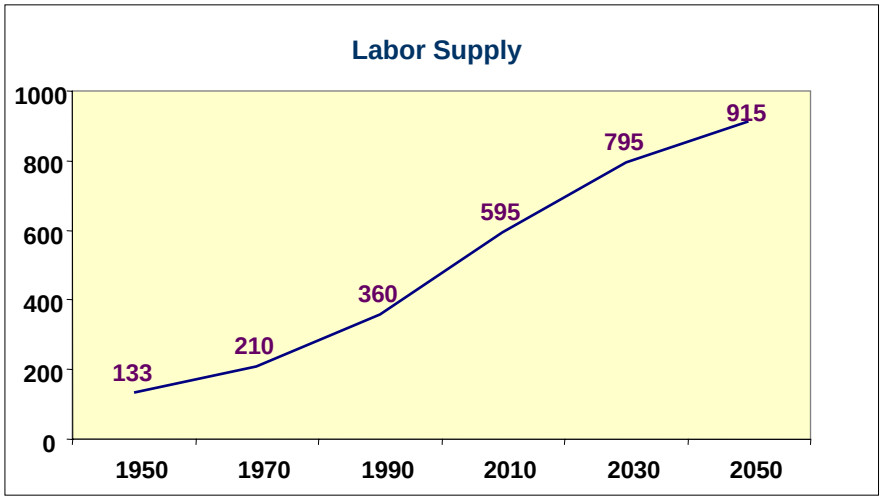
Working Age Population and Labor Supply (Million)

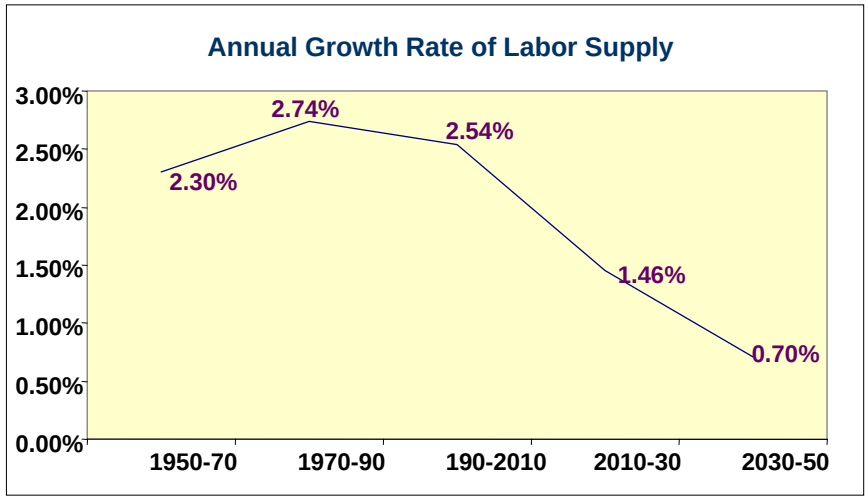
Rural/Urban Population (Million)

	Rural	Urban	Total	% Rural	% Urban
1950	296	62	358	82.75%	17.25%
1970	445	110	555	80.25%	19.75%
1990	633	217	849	74.47%	25.53%
2010	825	358	1183	69.74%	30.26%
2030	850	599	1449	58.63%	41.37%
2050	717	876	1593	45.00%	55.00%

Gender-wise Working Age Population (Million)

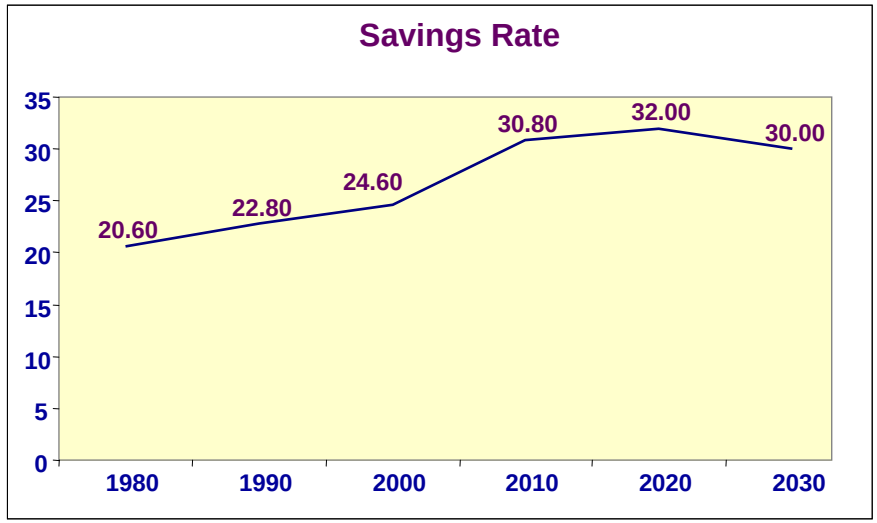
	Female	Male	Total	% of Population
1950	98.78	107.66	206.44	57.73%
1970	150.08	160.19	310.27	55.91%
1990	241.89	260.10	501.99	59.10%
2010	383.44	404.28	787.72	66.57%
2030	483.97	502.91	986.88	68.10%
2050	523.42	540.96	1064.38	66.83%





Human Capital, Productivity and Growth

- Human Capital
  - Government Expenditure in Education
  - Private Expenditure in Education
  - Urban / Rural & Gender-wise Education Expenditure
  - (Net) Migration by Labor Classes (intra & inter county)
- R&D
  - Government/ Private Expenditure
  - Knowledge Flows
- Technology
  - Backbones (infrastructures)
  - Learning, transfers, deployment
- Saving/ Investments
  - Social Security
  - Lifestyles, Behaviors
- Governance
  - Institutions
  - Laws
  - Policies



How demographic and some other development policies alter drivers for Sustainability Scenarios?

- Policies for public private partnership → higher (public and private) investments in education → Increases supply of education services
- Incentives for education for women and socially and economically backward sections enhances demand for education
- Women's education reduces fertility rates & this together with family planning campaigns lead to lower population (than in reference & some others cases)
- The increases in labor participation rates and enhanced skill profiles maintains labor supply and higher productivity in next few decades
- Rural development policies (including education, employment, infrastructure push and reduced risk for investments) break through the rural/ urban dualism

(Likewise for other drivers, the sustainability scenario story differ)

Some key areas where sustainability scenario differ

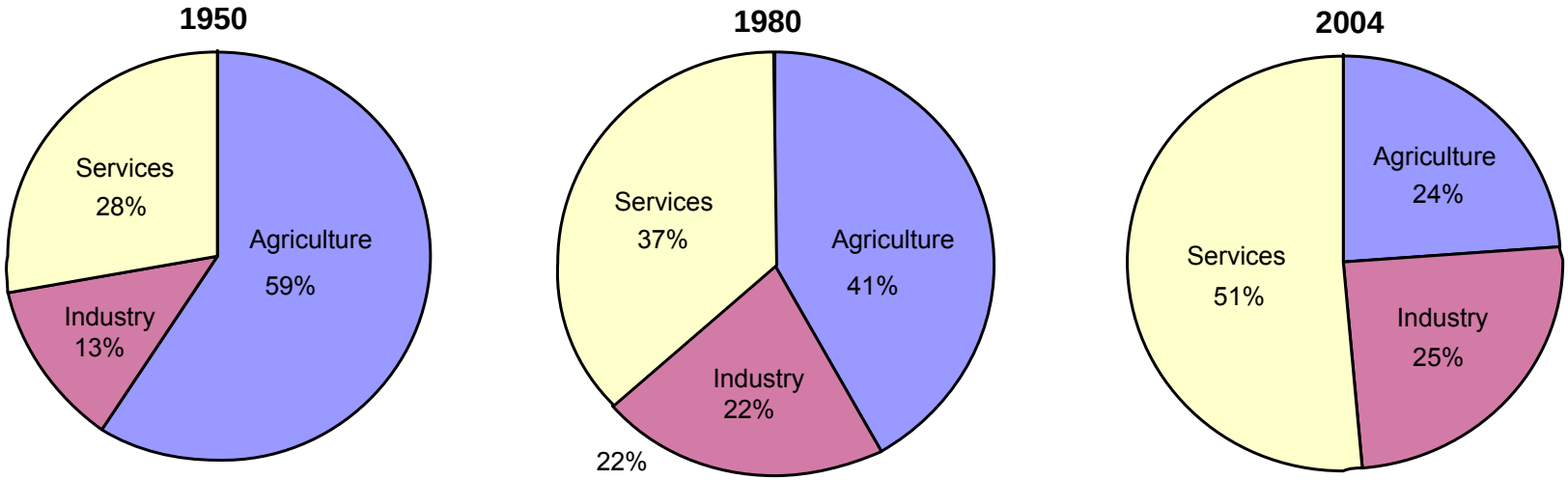
- Demographics
  - Lower Population Growth (e.g. investment in women's education)
  - Higher investment in social infrastructures (e.g. health, education)
- Conservation
  - Efficient technology, Substitutions, Recycling, Pricing, Dematerialization
- City Planning
  - Architecture/ Building Codes; Land use policies; Public Transport
- Infrastructure choices
- Multiple output measures
- Selective technology push
- Incentives for environmental industry
- Influencing consumer preferences/ behavior

(While the specifics of future policies in these areas could be debated, we do describe the qualitative story and quantification of key parameters transparently)

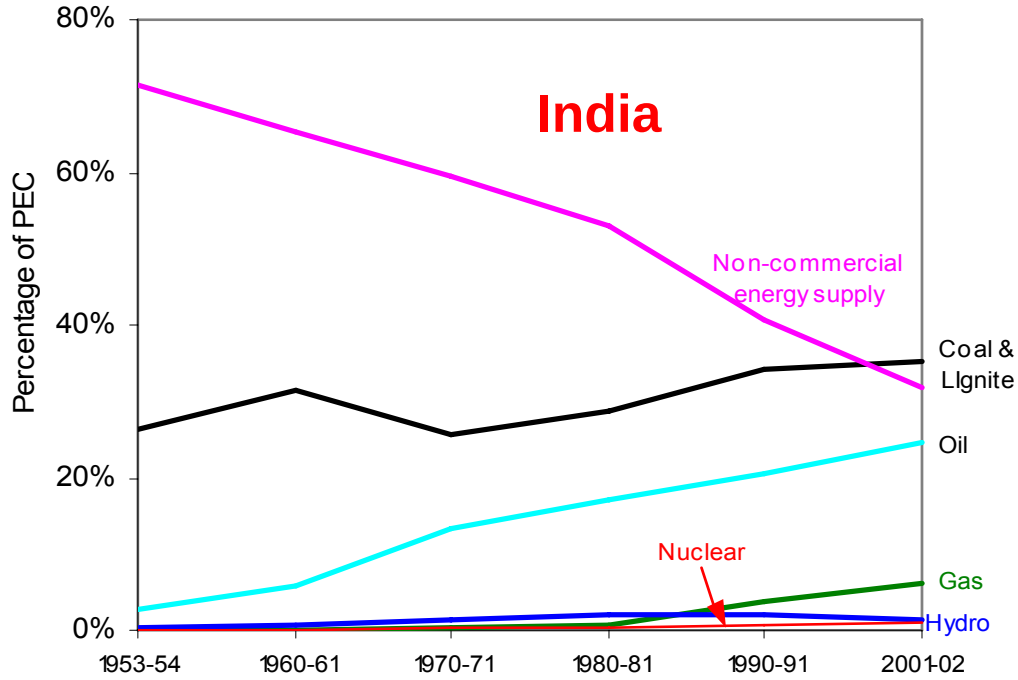
Other Key Transitions:

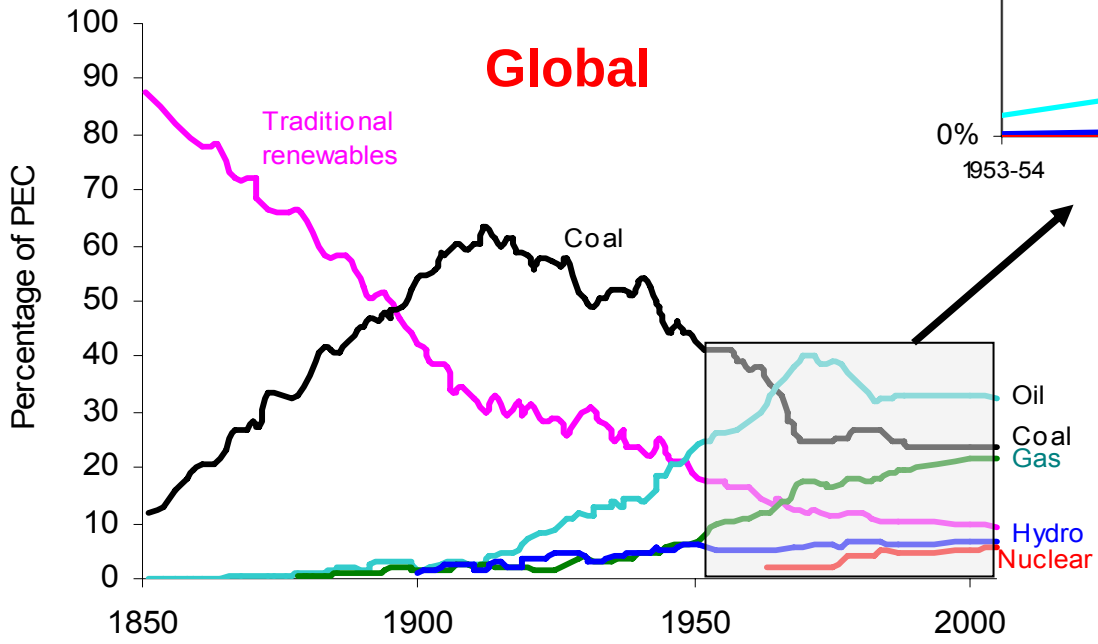
GDP structure, Energy resources, Sector demands, Consumption, Savings and Investment behavior

Changing Composition of India's GDP by Sector

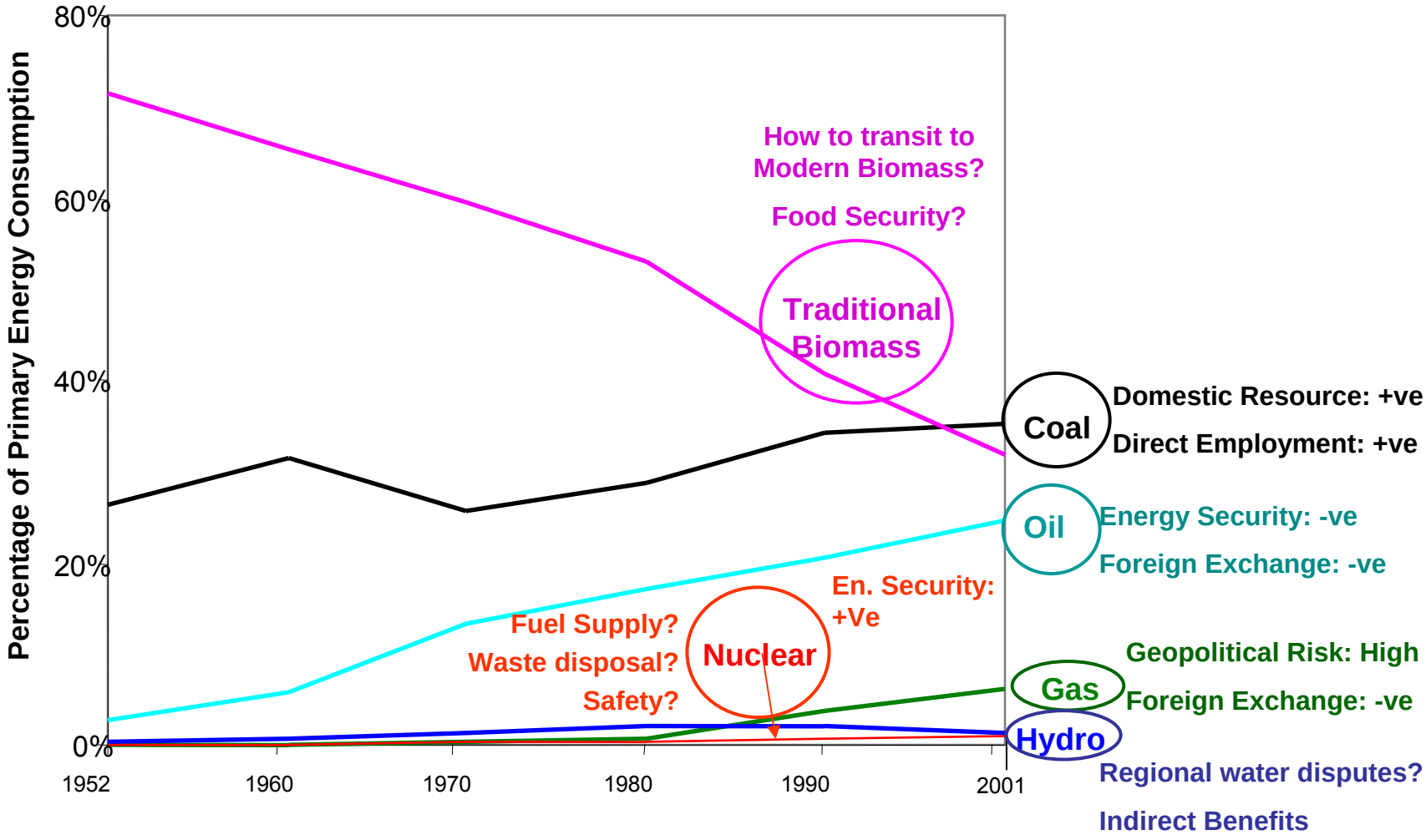


Energy Transitions: Global & India

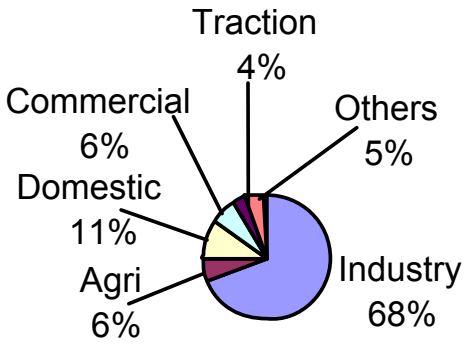




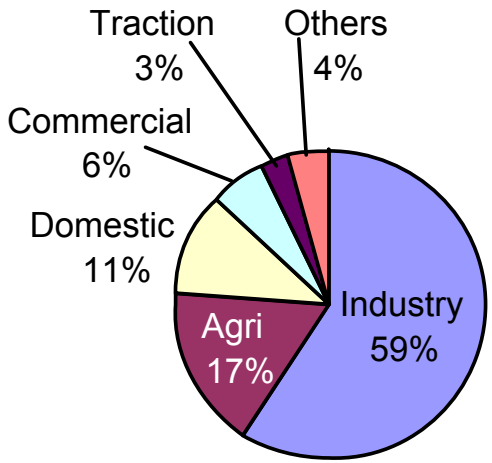
Energy Transitions: How they matte to Low Carbon Future?



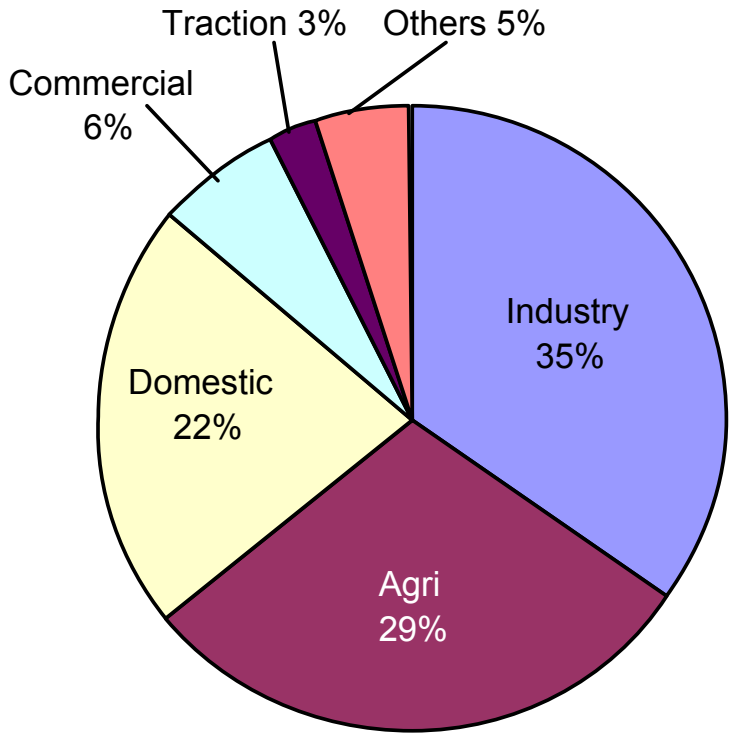
Shifting Sector Demand for Electricity



1960
12 TWH

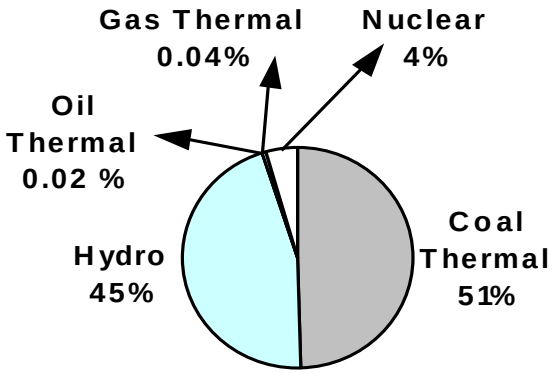


1980
78 TWH

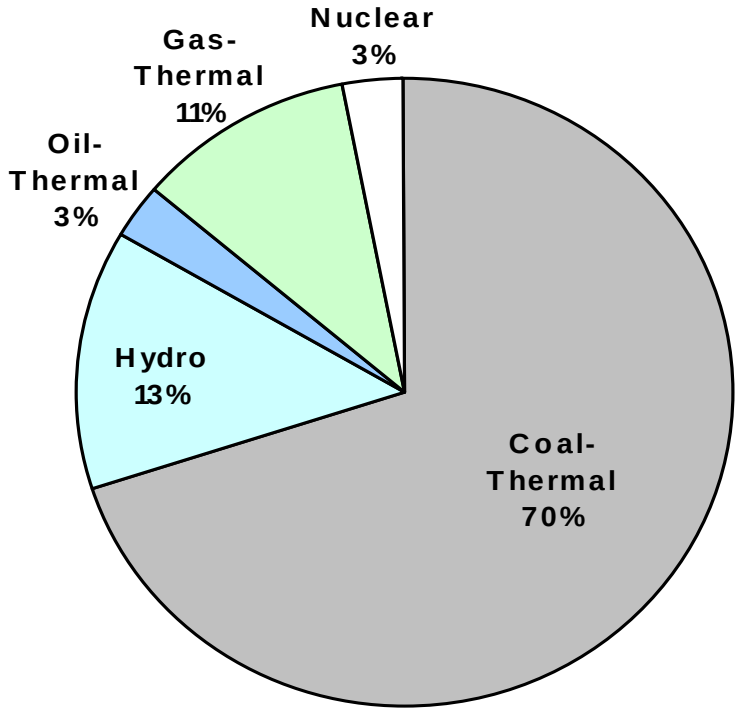


2000
313 TWH

Changing Mix of Electricity Generation

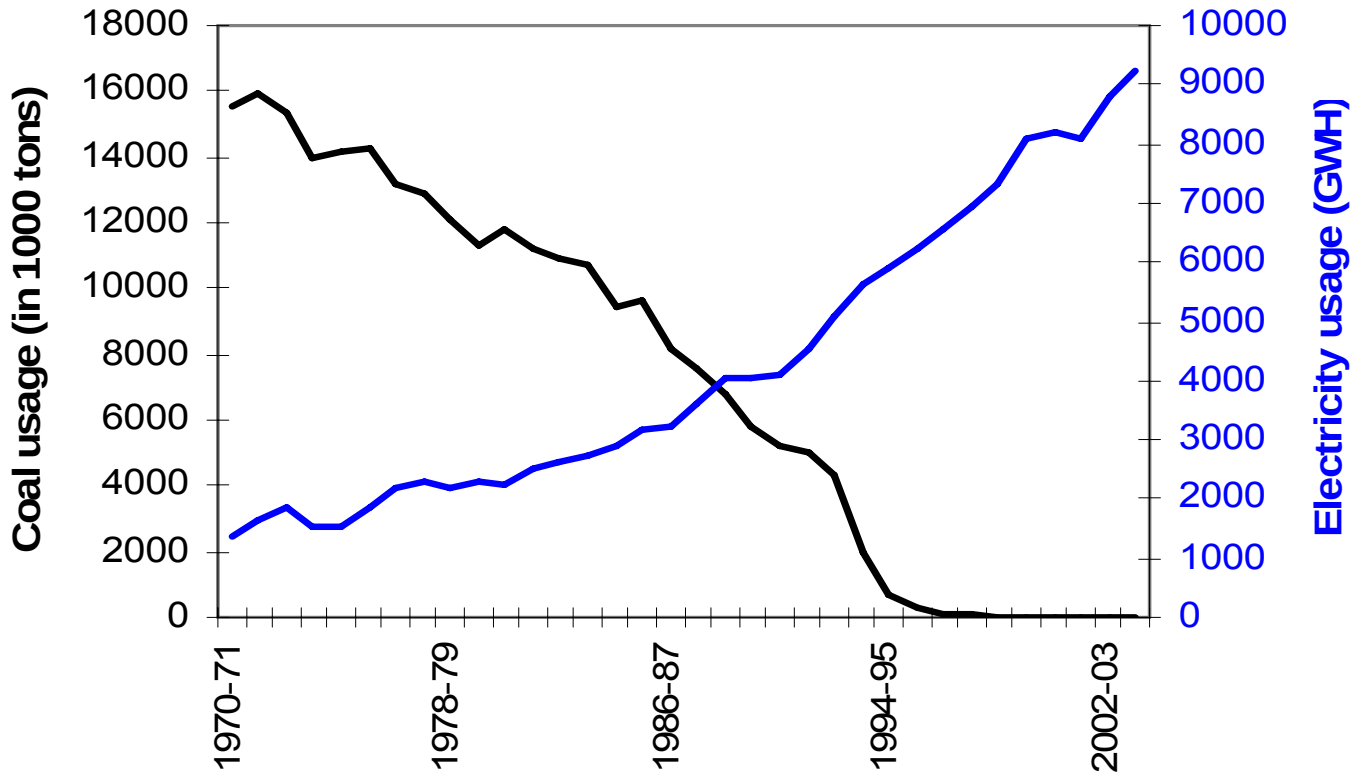


1971
61 TWH



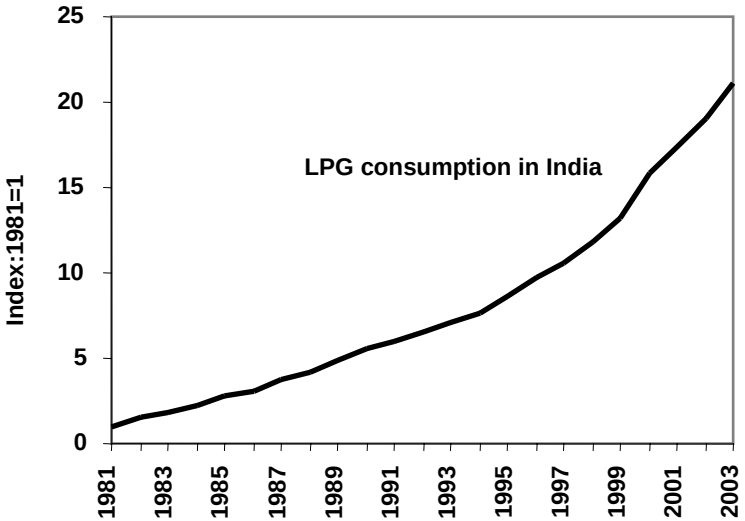
2001
558 TWH

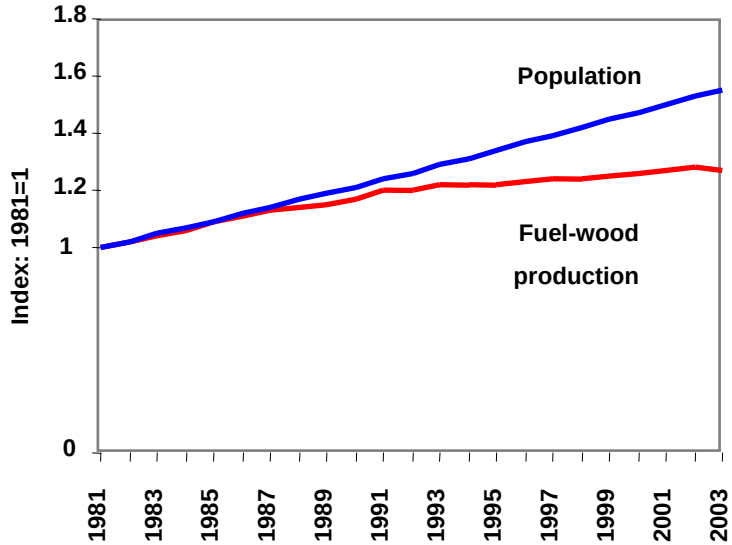
Shifting End-use Energy Mix: Coal & electricity use by Railways

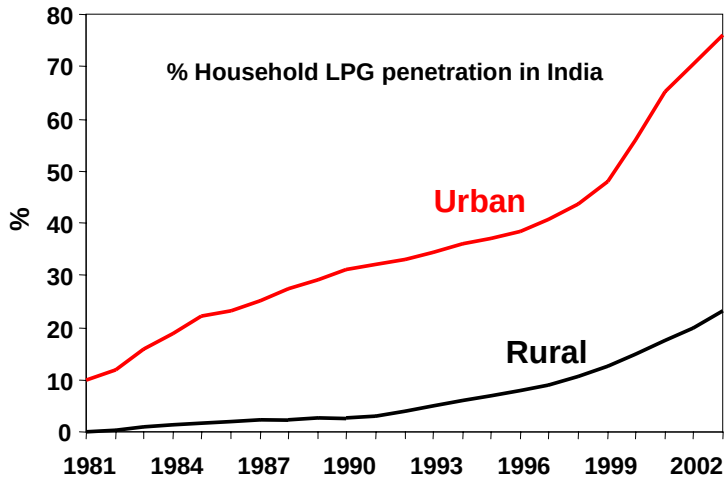


Data Source: CSO, GoI and Indian Railways annual reports

Transition in Household Energy in India: Fuel-wood to LPG



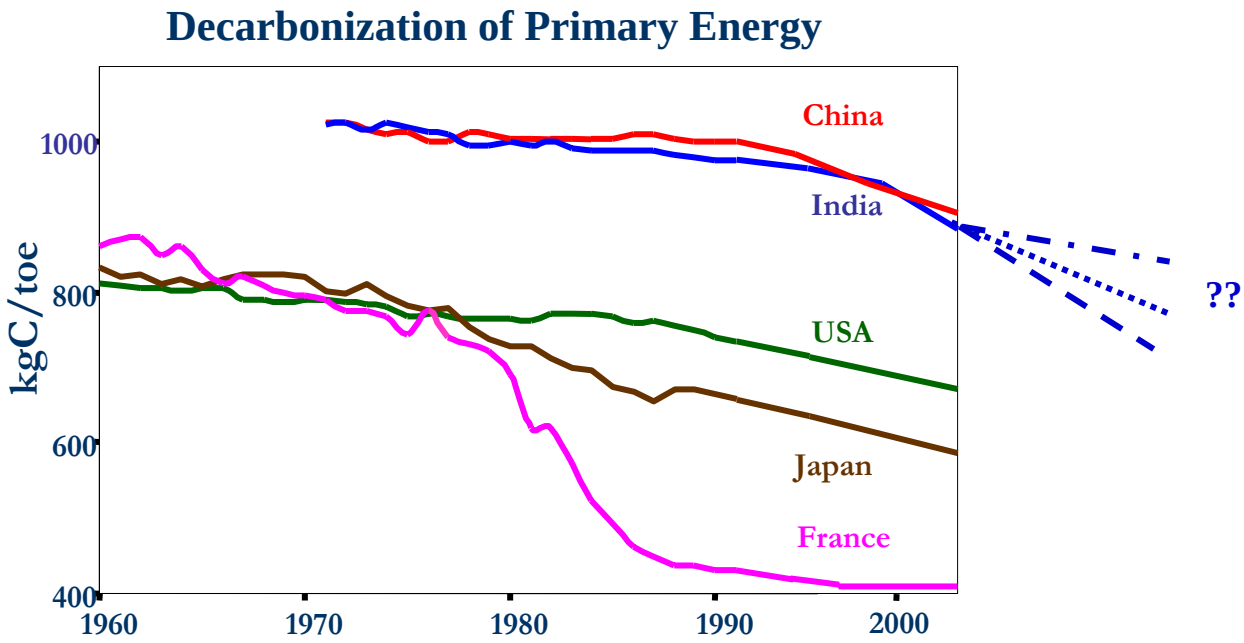




Data Sources - Census 2001, NSS 1994, 2000

Path Dependence: Lock-ins vs. Innovations

- Elasticity of long-term paths to short-term influences
- Lock-ins from current technology supply
- Development policies and path dependence

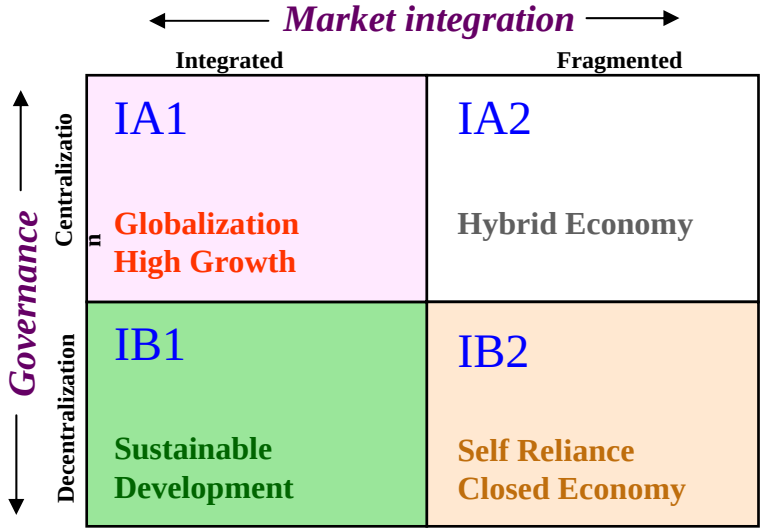


Adapted from Nakicenovic et. al.

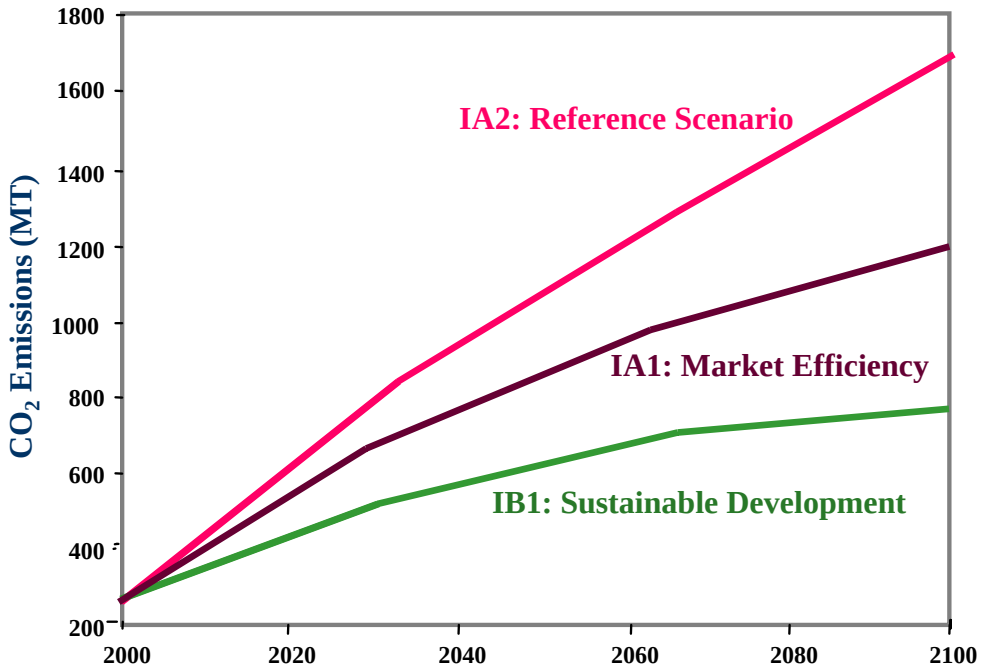
Modeling Development Paths

Indian Carbon Emissions Scenarios

Scenario Framework



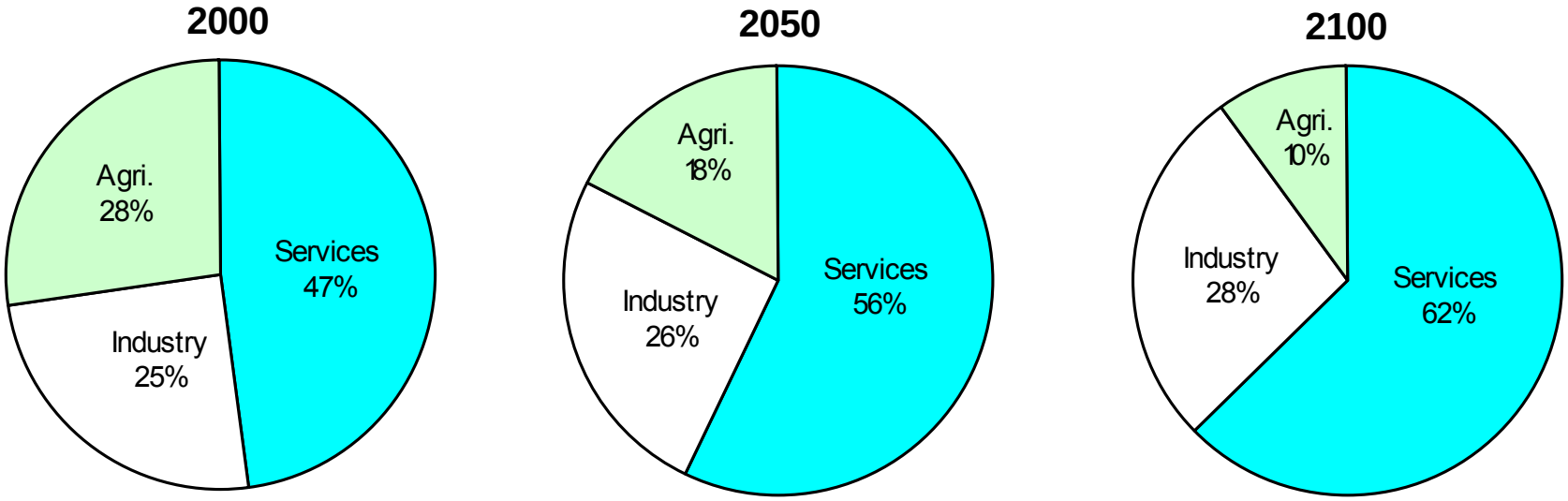
Carbon Emissions



India's Total Carbon Emission in 21st Century
(Billion Ton CO_2)

Reference (IA2) Scenario	: 363
Market Efficiency (IA1) Scenario	: 286 (79% of IA2)
Sustainable Development (IB1) Scenario	: 198 (55% of IA2)

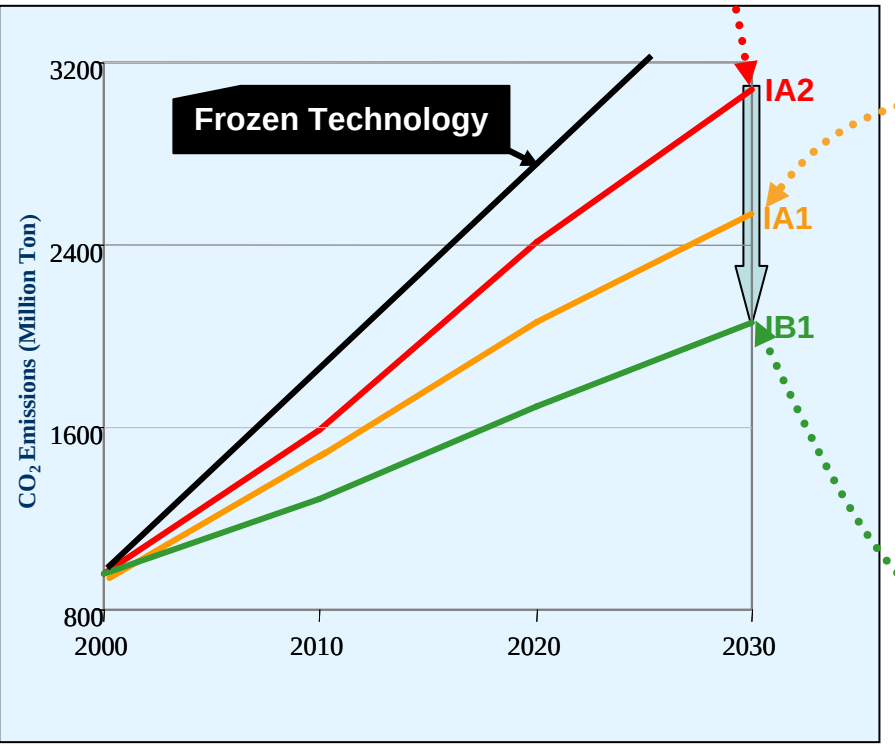
Sector shares in GDP (Reference Scenario)



Sources: Planning Commission, expert discussion and

Technologies in Scenarios: Short-term (2030)

Conventional Technology Path: Includes significant endogenous technological change



Globalization/Market Efficiency Scenario

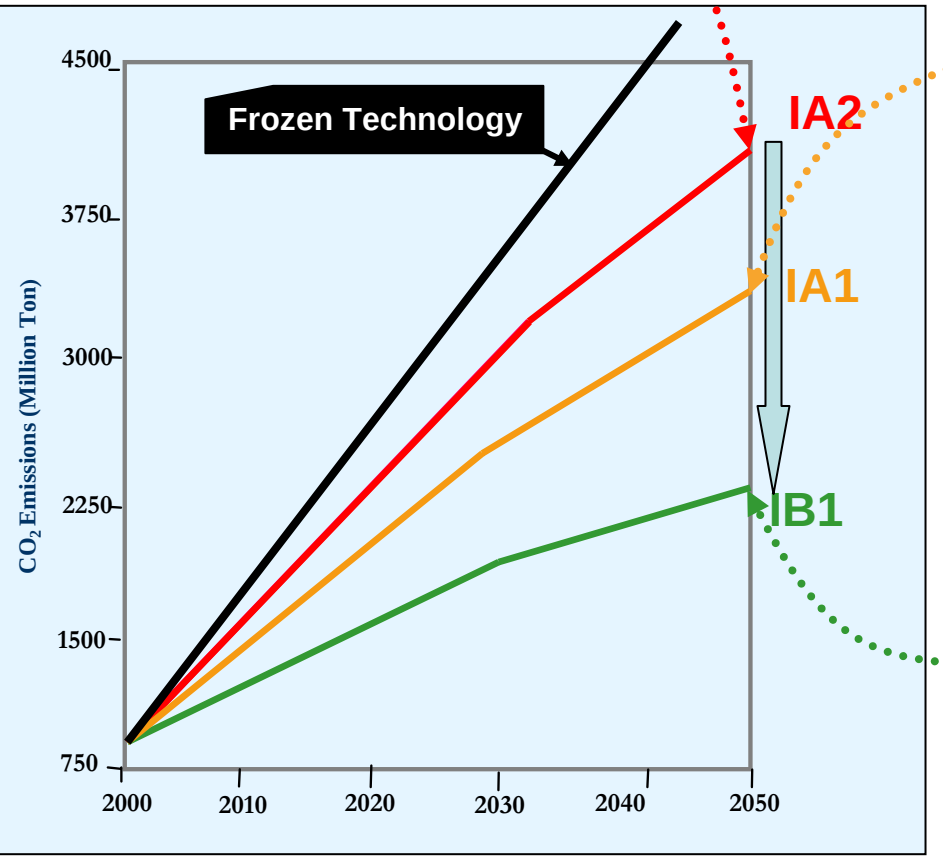
- Infrastructures, Efficient energy markets
- Gasoline hybrid car, Fuel cell vehicles
- Ultra-critical boilers, IGCC, CCGT
- Building and Appliance standards
- Nuclear Fission, Information highways

Sustainable Development Scenario

- Energy efficiency, Environment markets
- Bikeways, Advanced car sharing system
- Renewable energy, Recycling and reuse
- Virtual communication system
- Urban planning, Public transport

Technologies in Low Carbon Scenarios: Medium-Term (2050)

Conventional Technology Path: Includes significant endogenous technological change



Globalization/Market Efficiency Scenario

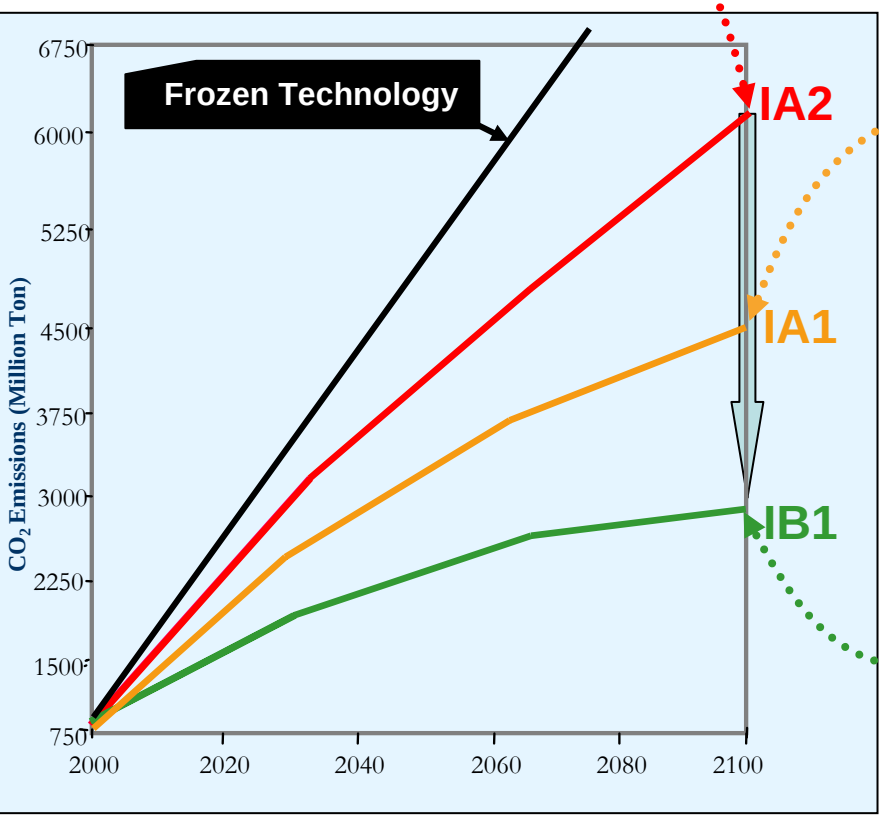
- Synfuels, Next-Gen Nuclear (Thorium)
- Fuel cell vehicles, Pipeline networks
- Energy efficient appliances/ infrastructure
- Coal liquid, IGCC, Hydrogen from gas
- Advanced materials, Nanotechnology

Sustainable Development Scenario

- Push for renewable energy & recycling
- Advanced car pooling, Shared assets
- High speed trains, Swap of transport by IT
- Dematerialization, Community institutions
- Sustainable habitats, Reforestation

Technologies in Scenarios: Long-term (2100)

Conventional Technology Paths: Includes significant endogenous technological change



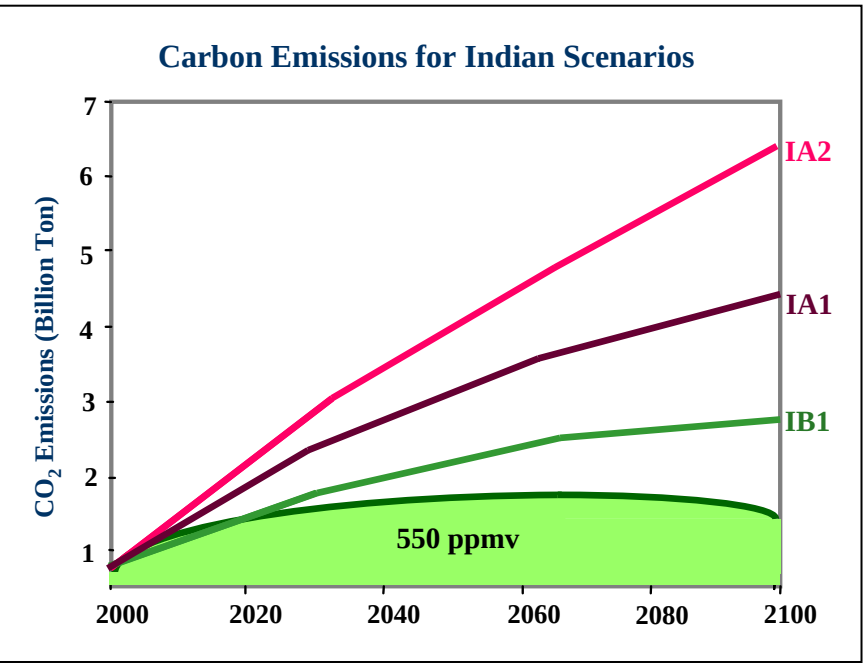
Globalization/Market Efficiency Scenario

- Synfuels, Gas hydrates, Nuclear Fusion
- Fuel cell vehicles, High air transport share
- IT controlled buildings/appliances
- Advanced global shipping networks
- Global R&D, Intensive agriculture

Sustainable Development Scenario

- Integrated resources/technology planning
- Decentralized & renewable technologies
- Lifestyle changes, Eco-friendly choices
- Sustainable agriculture/forestry/land-use
- Multi-purpose water systems
- Sustainable habitats, Service Pools

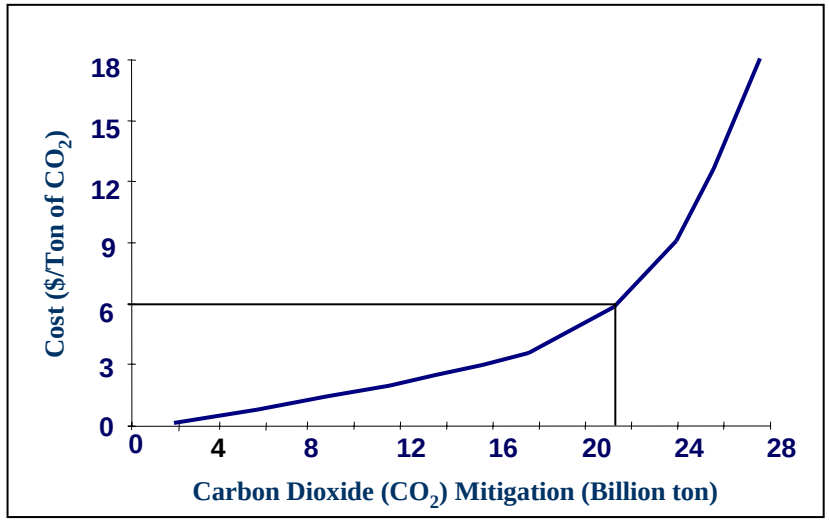
Carbon Emissions and Mitigation



India's Total Carbon Emission in 21st Century
(Billion Ton CO_2)

Reference (IA2) Scenario	: 363
Market Efficiency (IA1) Scenario	: 286 (79% of IA2)
Sustainable Development (IB1) Scenario	: 198 (55% of IA2)
550 PPMV Cost-effective Regime	**: 140 (39% IA2)**

Carbon Mitigation Supply-Curve for India (2005-2035)
(Reference (IA2) Scenario)



Aligning Development and Climate actions for co-benefits

- Climate change is a derivative problem of development
- Strategies for dealing with sustainable development and climate change have many common elements, and aligning these would deliver multiple dividends / co-benefits
- Combination of strategic actions for top-down push of major programs and economic signals to motivate numerous bottom-up actions
- Correcting coordination failures, motivating co-benefit actions (including correct sequencing of policies), aligning long-term and short-term signals and top-down and bottom-up actions

Illustrations from India

- **Aligning Future Sustainability (e.g. MDG) and Climate Goals**
- **Co-Benefits from Joint Market for CO2 and SO2 Mitigation**
- **Co-benefits of Cooperation for Energy-Water Markets in South-Asia**
- **Co-benefits of Sustainable Development and Mitigation of Climate Change Risks to Long-life Assets like Infrastructures**

Mainstreaming Climate Change in National Development

Climate policies and actions to be driven by:

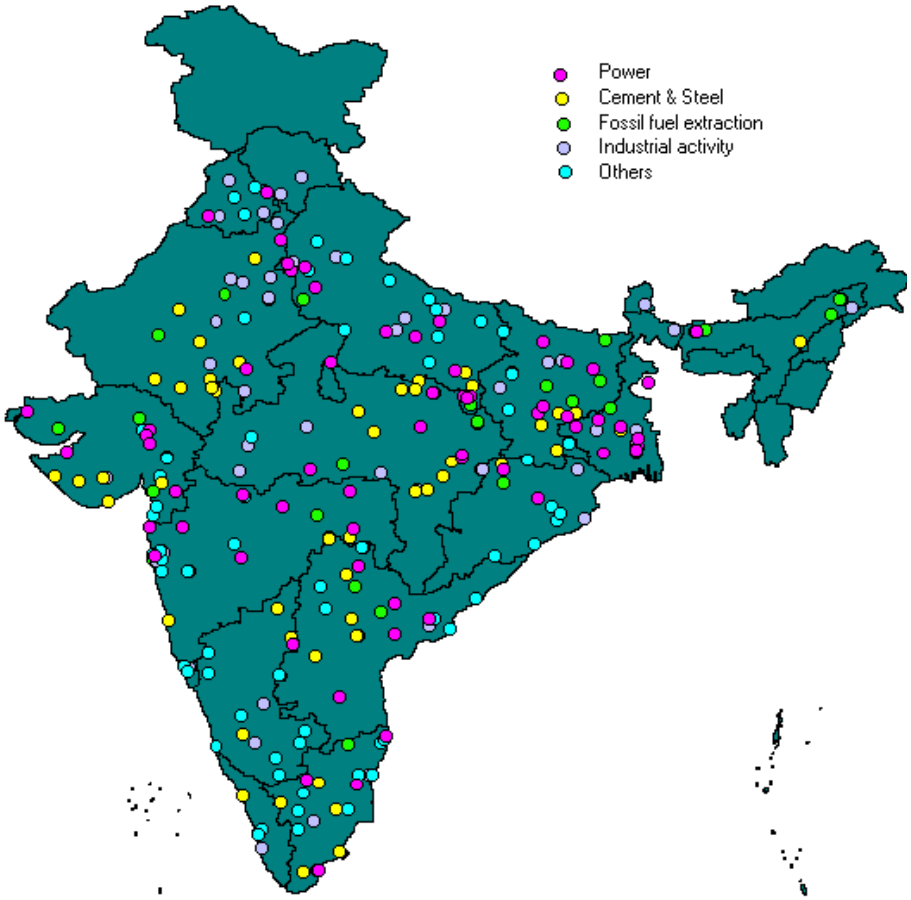
- *National development targets*
- *Agreed goals under extant international agreements*

MDG, India's National Targets and Climate Change

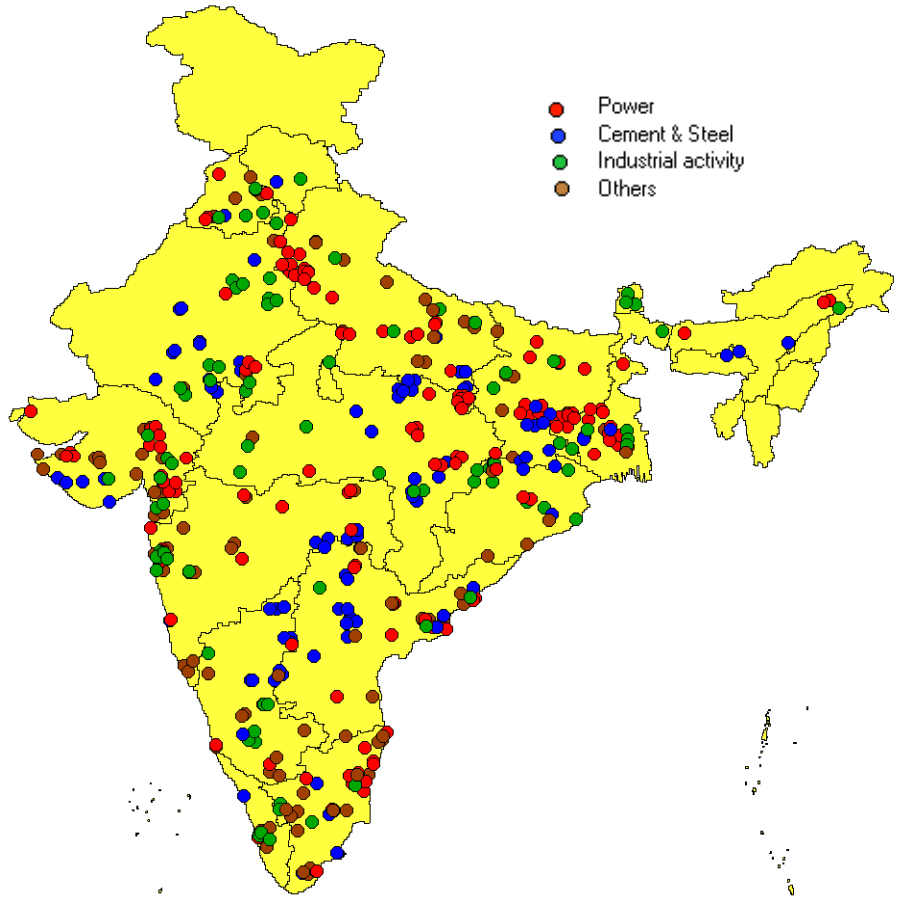
MDG and global targets	India's National plan targets	Interface with Climate Change
Goal 1: Eradicate extreme poverty and hunger Targets: Halve, between 1990 and 2015, the proportion of people with income below $1 a day and those who suffer from hunger	• Double the per capita income by 2012 • Reduce poverty ratio by 15% by 2012 • Contain population growth to 16.2% between 2001-2011	• Income effect would enhance choices for cleaner fuels and adaptive capacity • Reduce GHG Emissions due to lower population
Goal 7: Ensure environmental sustainability Targets: Integrate SD principles in country policies/ programs to reverse loss of environmental resources Target: Halve by 2015 the proportion of people without sustainable access to safe drinking water	• Increase in forest cover to 25% by 2007 and 33% by 2012 (from 23% in 2001) • Sustained access to potable drinking water to all villages by 2007 • Electrify 80,000 additional villages by 2012 via decentralized sources • Cleaning of all major polluted rivers by 2007 and other notified stretches by 2012	• Enhanced sink capacity, reduced GHG and local emissions; lower fossil imports; reduced pressure on land, resources and ecosystems • Higher adaptive capacity to from enhanced supply of water, health & education in rural areas

LPS emitting SO_2 and CO_2

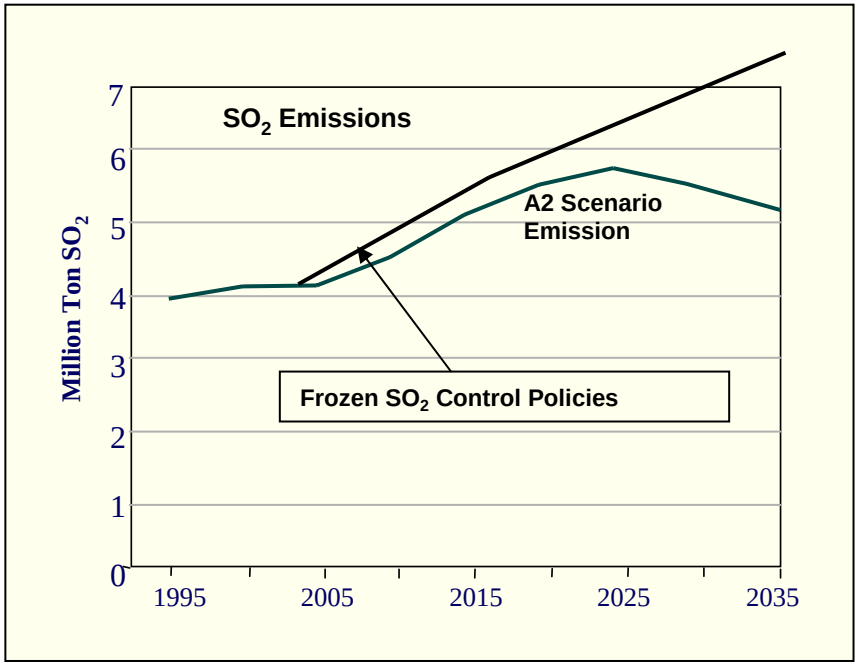
Year: 2000

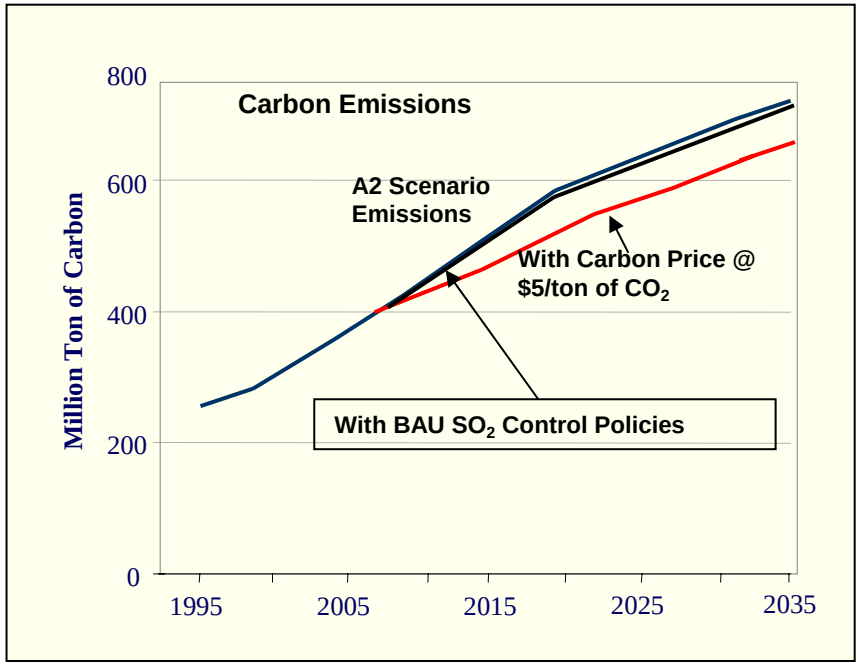


Year: 2030



Co-Benefits: Joint SO2 and CO2 Mitigation

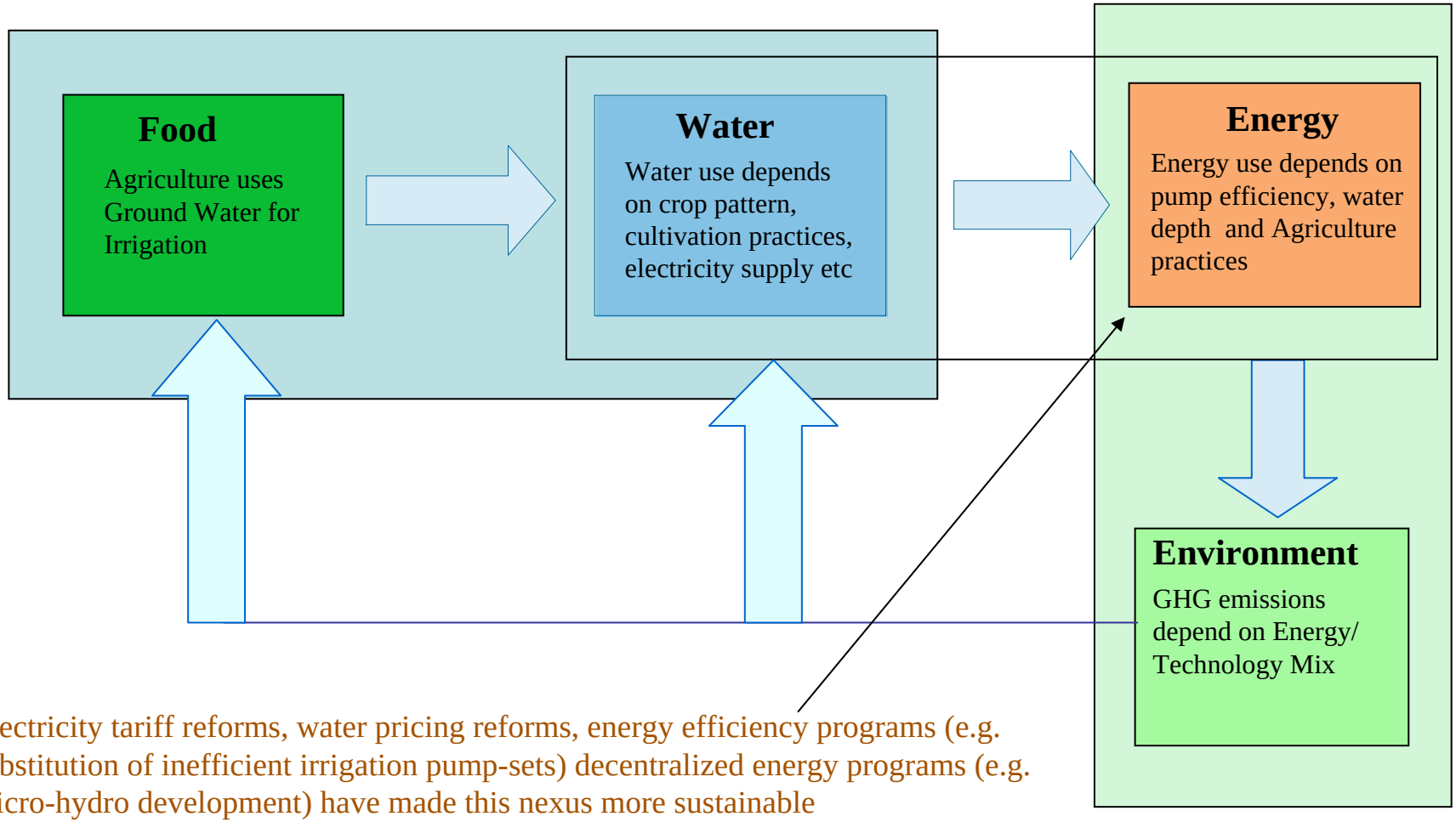




Joint Mitigation (Period 2005-2030)

Mitigation Regime	Co-benefits
SO_2 mitigation alone	Little carbon mitigation
Joint Mitigation: CO_2 mitigation @ $5/ton & same SO_2 target	Joint mitigation costs $400 Million less

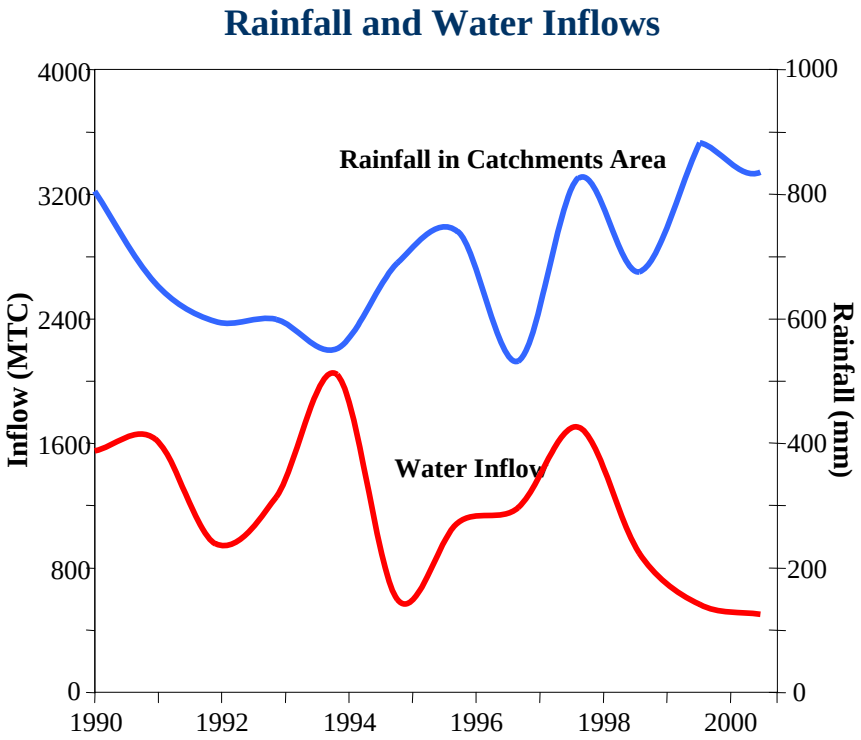
Food–Water–Energy–Environment Nexus

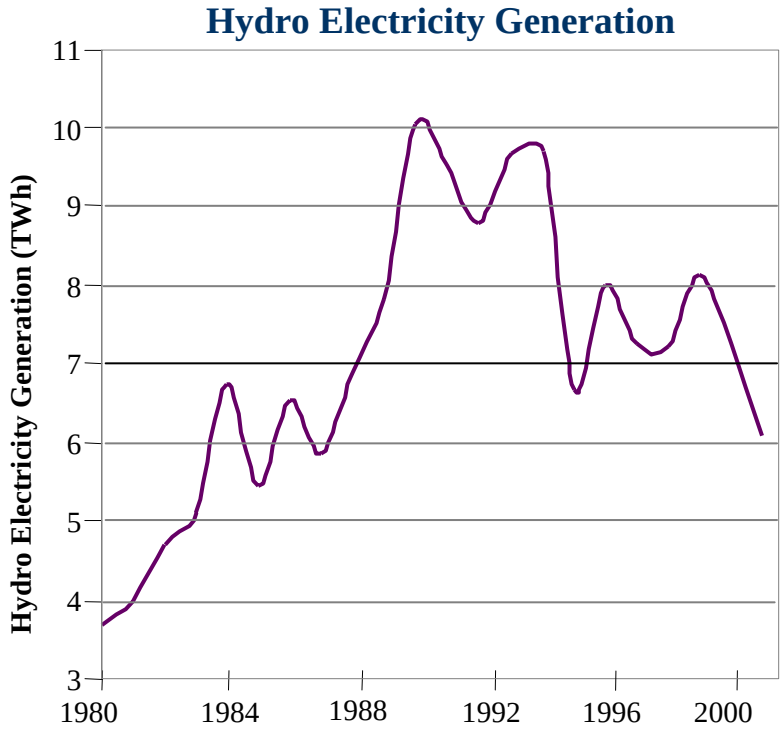


Electricity tariff reforms, water pricing reforms, energy efficiency programs (e.g. substitution of inefficient irrigation pump-sets) decentralized energy programs (e.g. micro-hydro development) have made this nexus more sustainable

Rainfall, Inflows and Hydro Electricity Generation

State of Andhra Pradesh

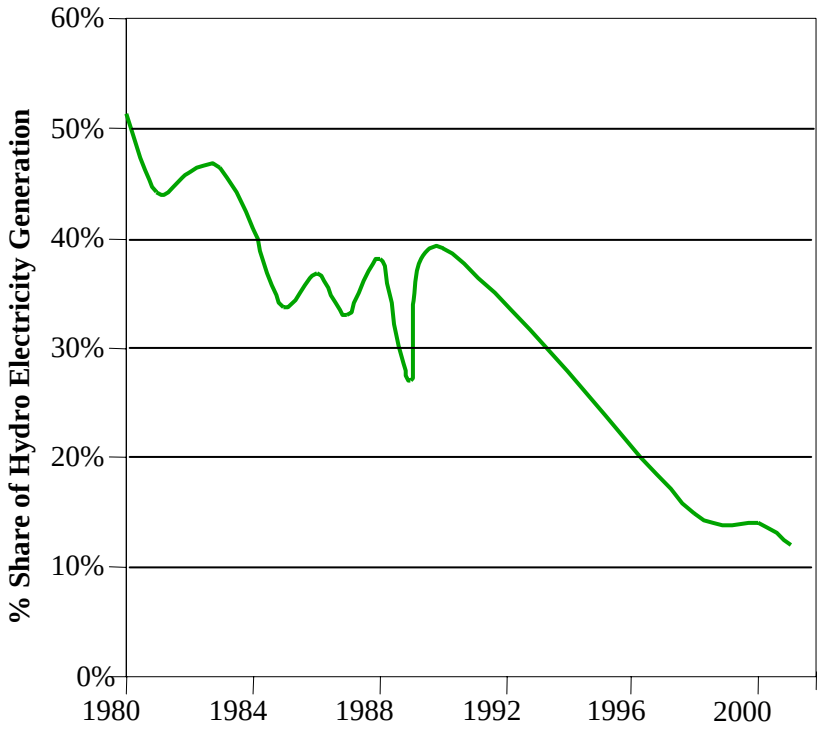




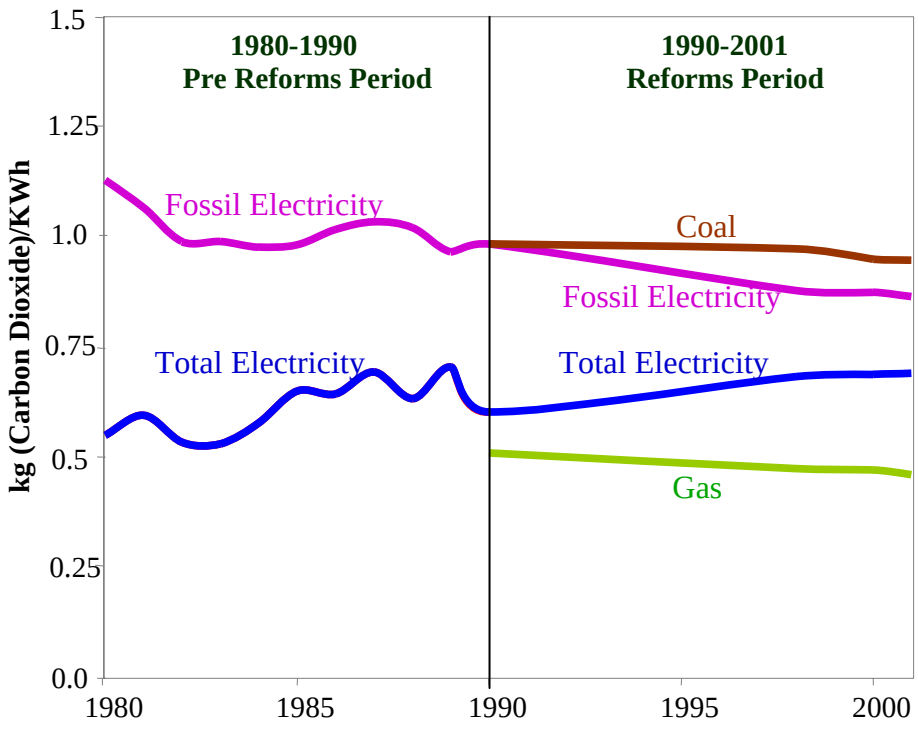
Rainfall, Inflows and Hydro Electricity Generation

State of Andhra Pradesh

Share of Hydro



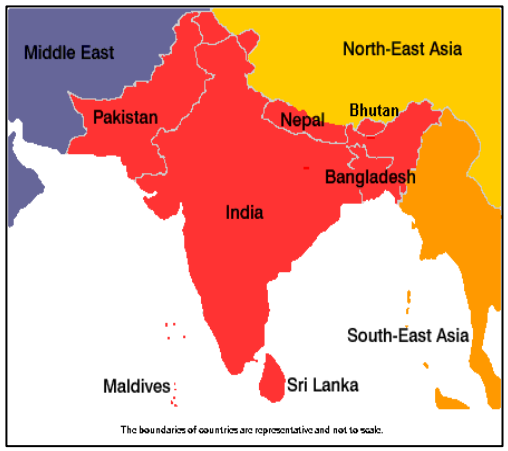
Carbon Emissions Baseline of Andhra Pradesh



Regional Cooperation: Energy and Water in South Asia

- Among the fastest growing regions
- Diverse geography, climate, energy resources, politico-economic systems
- High Fossil Dependence and Oil Imports
- Energy and Environment Security Concerns
- Shared Water

South-Asia Region

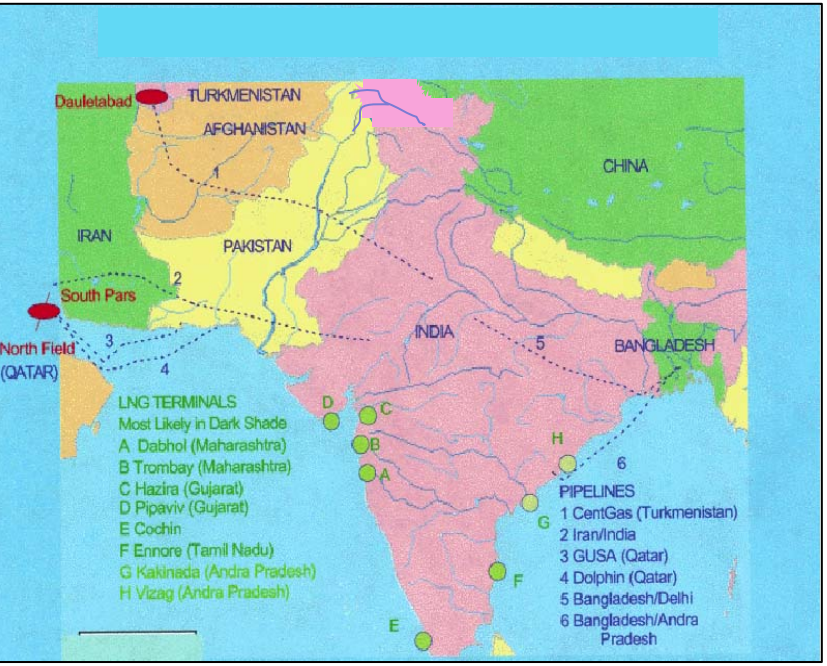


Diversity of Energy Use

Country	Dominant fuel in commercial energy consumption	Non commercial energy (as % of total energy consumption)
Bangladesh	Gas (65%)	47%
Bhutan	Imported oil & coal	95%
India	Coal (52%)	35%
Maldives	Imported oil	55%
Nepal	Oil (74%)	81%
Pakistan	Oil (55%)	33%
Sri Lanka	Oil (89%)	51%

Regional Cooperation: Energy and Water in South Asia

Integrated South-Asia Energy and Water Markets

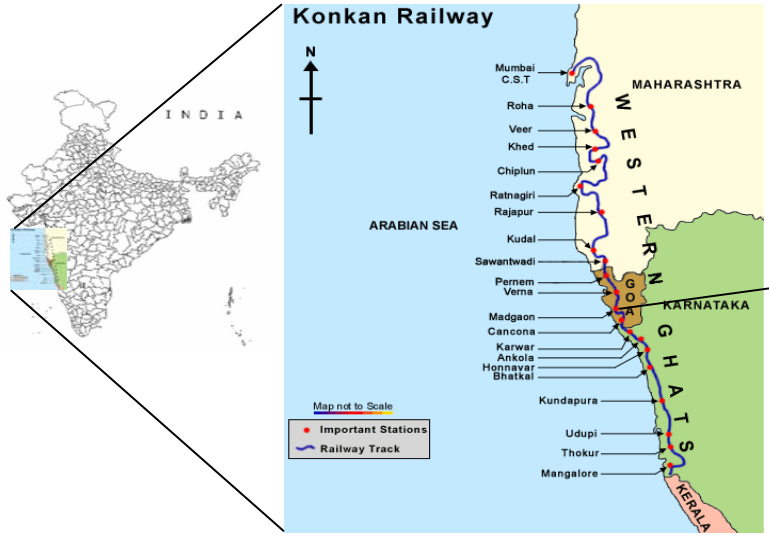


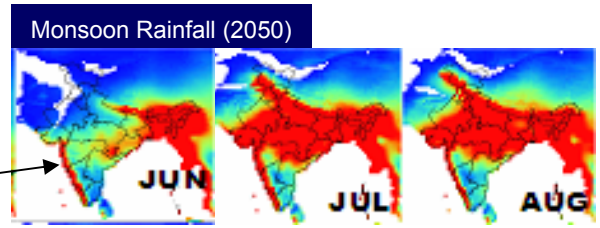
Benefit (Saving) Cumulative from 2010 to 2030		$ Billion	% GDP
Energy	60 Exa Joule	321	0.87
CO_2 Equiv.	5.1 Billion Ton	28	0.08
SO_2	50 Million Ton	10	0.03
	Total	359	0.98

Spillover Benefits:

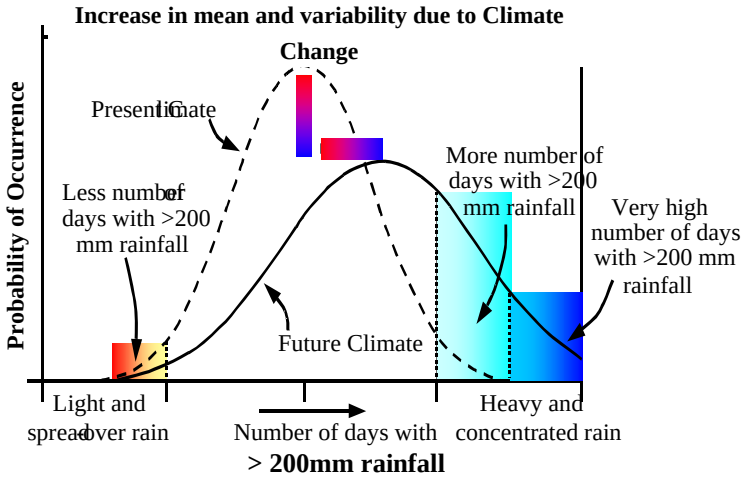
- 16 GW additional Hydropower
- Flood control
- Lower energy prices would enhance competitiveness of regional industries

Sustainable Development & Climate: Impacts on Infrastructure

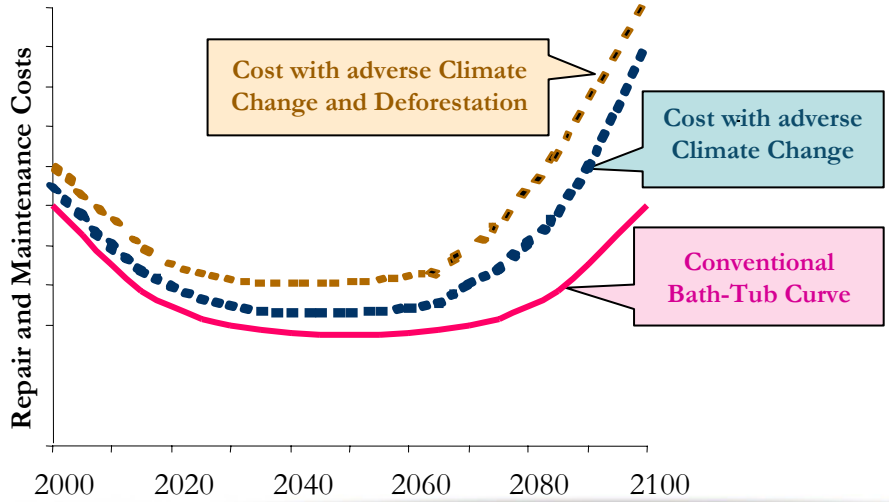




Increase in Climate Intensity and Variability



Maintenance Cost Curve



Conclusions: Regional Sustainability Scenarios

Realistic Modeling (Model Structure + Scenarios + Modeling)

- First best world versus **Real World modeling** (beyond Finding Potentials)
- Use **conceptual foundations** for model structure which accommodate or permit analysis of real world (i.e. How model structure can best represent real world dynamics?)
- Use insights to represent **drivers of drivers**
- "**Horses for courses**" approach to developing and using models
- **Transparency** of assumptions, information and analysis
- Explicit model and modeling architecture to claim **multiple dividends** in the "n" th best world
- **Results:** Much lower costs in transitions

Caution: Avoid Pitfalls of Disaggregated Scenarios

- **Consistency and compatibility** between regional and global scenarios
- **Additive** errors (e.g. energy market)
- Trade and shifting **comparative advantages**
- Possible abuse as **Benchmarks** for negotiation

Thank you