Climate Change: India’s Perspectives

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22 October 2005
IRADe: Profile

- Activities
  - Research projects
  - Training and capacity building
  - Policy advocacy
  - Networking and dissemination

- Energy Policy Analysis
  - Stanford University, UNDP, Energia, MNES, Petrofed

- Environment and climate change
  - UNEP, MOEF, Reliance Industries
Outline of Presentation

- India’s Emissions
- Impact of Climate Change
- Model and Scenarios
- Policies
- Suggestions for International Negotiations
What does it mean in per capita terms?

Compared to an average Indian citizen, an average U.S. citizen consumes:

*Equiv. population of USA

<table>
<thead>
<tr>
<th>Multiplication Factor</th>
<th>Commodity</th>
<th>Consumption (U.S.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Cereal</td>
<td>1470</td>
</tr>
<tr>
<td>4</td>
<td>Milk</td>
<td>980</td>
</tr>
<tr>
<td>52</td>
<td>Meat</td>
<td>12740</td>
</tr>
<tr>
<td>6</td>
<td>Fertilizers</td>
<td>1470</td>
</tr>
<tr>
<td>7</td>
<td>Cement</td>
<td>1715</td>
</tr>
<tr>
<td>6.4</td>
<td>Cotton &amp; wood fabrics</td>
<td>1568</td>
</tr>
<tr>
<td></td>
<td>Copper</td>
<td>60025</td>
</tr>
<tr>
<td></td>
<td>Iron and Steel</td>
<td>5390</td>
</tr>
<tr>
<td></td>
<td>Aluminum</td>
<td>20825</td>
</tr>
<tr>
<td></td>
<td>Organic Chemicals</td>
<td>13230</td>
</tr>
<tr>
<td></td>
<td>Inorganic Chemicals</td>
<td>6860</td>
</tr>
</tbody>
</table>
What does it mean in per capita terms?

Compared to an average Indian citizen, an average U.S. citizen consumes.

*Equiv. population of USA

<table>
<thead>
<tr>
<th>Times</th>
<th>Commodity</th>
<th>Per cap. cons. of USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>320</td>
<td>Cars</td>
<td>78400</td>
</tr>
<tr>
<td>102</td>
<td>Commercial Vehicles</td>
<td>24990</td>
</tr>
<tr>
<td>14</td>
<td>Solid Fuels</td>
<td>3430</td>
</tr>
<tr>
<td>61</td>
<td>Liquid Fuels</td>
<td>14945</td>
</tr>
<tr>
<td>227</td>
<td>Gas</td>
<td>55615</td>
</tr>
<tr>
<td>46</td>
<td>Electricity</td>
<td>11270</td>
</tr>
<tr>
<td>35</td>
<td>Total Energy</td>
<td>8575</td>
</tr>
<tr>
<td>27</td>
<td>Total Carbon dioxide</td>
<td>6615</td>
</tr>
</tbody>
</table>

* Equivalent USA population =

\[
\text{population} \times \frac{\text{Per cap. cons. of USA}}{\text{Per cap. cons. of India}}
\]
Why should India be Concerned about Climate Change?

Risk of Sea Level Rise

- Total area of 5763 km² along the Coastal States of India - 0.41% could be inundated and almost 7.1 million - 4.6% of coastal population could be affected for one meter sea level rise *(TERI, 1996)*

- Intrusion of sea-water in the ground water.

- Temperature can reduce agricultural and fishing incomes.

- One-meter sea level rise it would displace 7 million persons in India *(ADB, 1995)*.
Risk of Extreme Events

- In the cyclone in Andhra Pradesh in India in 1996, more than 1,000 people died and there was huge property loss.

- Frequent storms in Orissa
Impact of Climate Change

Rice Yield
\( \Delta T \ 2.5^\circ C \text{ to } 4.9 \ ^\circ C \)
-15% to -42%

Wheat Yield
-25% to -55%
(Without carbon fertilization effect)

With fertilization smaller but similar impact

With adaptation
\( \Delta T + 2^\circ C + 7\% \)  Precipitation  GDP\( _{\text{Agri}} \) ↓ 7%
\( \Delta T + 3.5^\circ C + 15\% \)  Precipitation  GDP\( _{\text{ag}} \) ↓ 25%

⇒ Poverty ↑ ⇒ Hunger ↑
Economic Models: The India Model

- Multi-sectoral, inter-temporal optimising model
- Endogenous income distribution
- Focus on Welfare effects (incidence of absolute poverty)
- Consumption is sensitive to relative prices.
- Dynamically optimal.
Model Structure I

- Model maximises the present discounted value of utility corresponding to the per capita consumption.
- Time horizon: 35 years
- Eight commodities or Goods: Agriculture, Coal, oil, Electricity, Industry, Transport, Services, Gas.
- Alternative methods of producing the same good are permitted.
- Model constrained to ensure consistency.
Model Structure II

- Exports, Imports, Savings bounded above to rule out unrealistic results.
- Endogenous income distribution with a constant lorenz ratio and exogenous population growth.
- Stationary state at the end of the period under consideration.
- Optimal solution found simultaneously for all time-periods (not the usual year by year optimality).
- **Solver:** GAMS
Model Structure III

- **Emission Inventory**: Both production and consumption activities pollute. Emission coefficient is derived for each activity and for each fuel and pollutant. Stock accounting also included.

- **Carbon reduction options**: Activity level reduction, Change in composition of production (more polluting goods imported), Technical options to mitigate pollution without loss of output. Input reduction, Fuel switching.
Scenarios Analysed

- Business-as-usual (BAU)
- 10% (cumulative) Carbon emission reductions: C10
- 20% (cumulative) Carbon emission reductions
- Oil price shock (of 300%) [foreign investment of up to 3% of GDP]
- Oil price shock (of 300%) – with lower foreign investments (limited to 2% of GDP)
- COR (Capital output Ratio) falling (indicating technical progress)
Results I

- Average GDP growth rate (BAU): 5.03%
- A 10% reduction in Carbon emission: not much of an impact in the medium run (15th year, C10 of table 1)
- GDP and consumption levels fall (marginally) in the long run (34th year)
- A 20% reduction has significant adverse effects on both GDP and PC (per capita) consumption (GDP falls by 2.87% in the 34th year).
- Model postpones losses to the end of the period due to: discounting of future consumption.
- There is a shift away from coal based-activities (especially in the long-run)
Results II

- Oil price shocks tend to have long-term impacts (contrary to conventional belief that these merely cause temporary deviations from equilibrium) and cause losses of large magnitudes.

- Impact of oil price shocks similar to those of carbon emission constraints (except for the implications for carbon emissions which, in this case, tend to rise)

**Parameter Sensitivity of the Model**

- Important parameters of the model:
  - Savings rate (endogenous but bounded), COR (exogenous), Oil price (exogenous), discount rate (exogenous).
Conclusions

- The Model’s results indicate that India stands to lose significantly on committing to reduce emissions.
- Magnitude of these losses are uncertain and difficult to estimate, given the specificity of various models and their consequent incomparability.
- Estimates of magnitudes (or even directions) of the effects of carbon emission restrictions on the economy depend crucially on the underlying structure of the model and models developed for a particular structure (or a purpose) are unlikely to be directly useful for other circumstances or purposes.
Conclusions (continued)

- Binding commitments to emission reduction must be on a *quid pro quo* basis, in return for equally binding compensation flows that should mute the costs of cleaner development, especially its impact on poverty.
India’s Efforts to Reduce GHG emissions

- Emphasis on energy conservation
- Promotion of renewable energy
- Abatement of air pollution
- Afforestation and wasteland development
- Economic reforms and subsidy removal
- Fuel substitution policies
Motivation for Energy Conservation

- Energy Scarcity or unavailability
- Lack of capital for new plants
- Scarcity of non-renewable fossil fuel resources
- Concern for air pollution
- Increasing oil imports
Institutional Setup

- **Petroleum Conservation Research Centre (PCRA)**
  - To reduce oil imports
  - Oil exploration, production and refining
- **Energy management Centre (EMC)**
  - Training, research and implementation
- **Ministry of Non-Conventional Energy Sources (MNES)**
  - Energy conservation
- **Power Finance Corporation (PFC)**
  - Improve supply-side efficiencies
Promotion of Renewable Energy: Major Activities

- Cogeneration
- Conservation
- Geothermal energy improved stoves etc.

India yet to show progress in the area of reducing cost
Fuel Substitution: From Biomass to Fuels

- Substitution of non-commercial energy by commercial energy
  - Increasing overall efficiency
- Shift from ‘old biomass’ to fossil fuels
- ‘Old biomass’
  - Carbon neutral but may result in deforestation
- ‘New biomass’
  - Biogasification, improved stoves, efficient kilns and biofuels
Coal Substitution

- Increased use of oil and gas due to liberalization
- Coal use in railways phased out
- Efficiency likely to increase with private sector entry
Trend in Supply of Primary Commercial Energy (MTOE)

Trend in supply of primary commercial energy (mtoe)

<table>
<thead>
<tr>
<th>Time period</th>
<th>MTOE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1953-54</td>
<td>50</td>
</tr>
<tr>
<td>1960-61</td>
<td>100</td>
</tr>
<tr>
<td>1970-71</td>
<td>150</td>
</tr>
<tr>
<td>1980-81</td>
<td>200</td>
</tr>
<tr>
<td>1990-91</td>
<td>250</td>
</tr>
<tr>
<td>2001-02</td>
<td>300</td>
</tr>
<tr>
<td>2003-04</td>
<td>350</td>
</tr>
</tbody>
</table>

- **coal & lignite**
- **crude oil**
- **natural gas**
- **hydro power**
- **nuclear power**
- **wind power**
- **total**
Change in Share of Different Fuels in Primary Commercial Energy Supply (%)

Change in share of different fuels in primary commercial energy supply (%)

Percent share

- coal & lignite
- crude oil
- natural gas
- hydro power
- nuclear power
- wind power

Time period
- 1953-54
- 1960-61
- 1970-71
- 1980-81
- 1990-91
- 2001-02
- 2003-04

Integrated Research and Action for Development
The Dark Side: Compulsory Energy Savings

- Lack of electrical appliances
- Lack of water pipes: trips to water resources on foot
- Lack of fuel: dependence on biomass
- Lack of fans and heating: reduced productivity
- Lack of infrastructure: energy savings at the cost of human welfare
Resource Conservation and Recycling

- Driven by poverty and lower income
  - Some items used for generations (e.g. clothing, furniture)
  - Recycling of paper, bottles, textiles common
  - Vehicles and machinery not thrown away
Per Capita Emission Principle

- Recognized in the UN FCCC
  - Netherlands vs. India
- Within EU: Portugal and Germany
- South Korea, Saudi Arabia, and Argentina have higher emissions than Brazil, China, and India
- Incentive to stay below the global average
## Carbon Dioxide Emissions and Shares

<table>
<thead>
<tr>
<th>Countries</th>
<th>Total CO2 Emissions (Billion Tonnes)</th>
<th>Share of CO2 Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annex - I</td>
<td>10.67</td>
<td>11.85</td>
</tr>
<tr>
<td>Brazil</td>
<td>0.21</td>
<td>0.31</td>
</tr>
<tr>
<td>China</td>
<td>2.52</td>
<td>3.51</td>
</tr>
<tr>
<td>India</td>
<td>0.73</td>
<td>1.22</td>
</tr>
<tr>
<td>BCI</td>
<td>3.46</td>
<td>5.04</td>
</tr>
<tr>
<td>Remaining</td>
<td>5.13</td>
<td>7.25</td>
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<tr>
<td>Total</td>
<td>19.27</td>
<td>24.14</td>
</tr>
<tr>
<td>Global</td>
<td>22.85</td>
<td>25.58</td>
</tr>
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</table>
Measures Taken

- Motivation for implementation of energy efficient options
- Afforestation and Wasteland Development
- Programmes of afforestation supported by government
- Rate of deforestation has decreased in the 1990’s
## CO2 Emissions - Per Capita and Growth

<table>
<thead>
<tr>
<th>Countries</th>
<th>Per Capita CO2 Emissions (Tonnes)</th>
<th>Growth (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1991</td>
<td>2002</td>
</tr>
<tr>
<td>Annex - I</td>
<td>11.95</td>
<td>12.40</td>
</tr>
<tr>
<td>Brazil</td>
<td>1.47</td>
<td>1.80</td>
</tr>
<tr>
<td>China</td>
<td>2.16</td>
<td>2.71</td>
</tr>
<tr>
<td>India</td>
<td>0.84</td>
<td>1.17</td>
</tr>
<tr>
<td>BCI</td>
<td>1.59</td>
<td>2.01</td>
</tr>
<tr>
<td>Remaining</td>
<td>2.55</td>
<td>2.77</td>
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<tr>
<td>Total</td>
<td>3.59</td>
<td>3.88</td>
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<tr>
<td>Global</td>
<td>4.25</td>
<td>4.11</td>
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</table>
## Population

<table>
<thead>
<tr>
<th>Countries</th>
<th>Population (Billion)</th>
<th>Population Share</th>
<th>Population Growth (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annex-I</td>
<td>0.89</td>
<td>0.96</td>
<td>16.63</td>
</tr>
<tr>
<td>Brazil</td>
<td>0.15</td>
<td>0.17</td>
<td>2.72</td>
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<tr>
<td>China</td>
<td>1.17</td>
<td>1.29</td>
<td>21.69</td>
</tr>
<tr>
<td>India</td>
<td>0.86</td>
<td>1.04</td>
<td>16.07</td>
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<tr>
<td>BCI</td>
<td>2.17</td>
<td>2.51</td>
<td>40.48</td>
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<tr>
<td>Remaining</td>
<td>2.01</td>
<td>2.62</td>
<td>37.48</td>
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<tr>
<td>Total</td>
<td>5.08</td>
<td>6.08</td>
<td>94.59</td>
</tr>
<tr>
<td>Global</td>
<td>5.37</td>
<td>6.23</td>
<td>100.00</td>
</tr>
</tbody>
</table>
## CO₂ Emission and Developing Countries

<table>
<thead>
<tr>
<th>Countries</th>
<th>Per Capita Emissions (Tonnes)</th>
<th>Total Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGA (50)</td>
<td>6.46</td>
<td>8.30</td>
</tr>
<tr>
<td>BGA (110)</td>
<td>1.08</td>
<td>1.23</td>
</tr>
<tr>
<td>AGA+BGA</td>
<td>2.02</td>
<td>2.23</td>
</tr>
<tr>
<td>Brazil</td>
<td>1.47</td>
<td>1.80</td>
</tr>
<tr>
<td>China</td>
<td>2.16</td>
<td>2.71</td>
</tr>
<tr>
<td>India</td>
<td>0.84</td>
<td>1.17</td>
</tr>
<tr>
<td>BCI</td>
<td>1.59</td>
<td>2.01</td>
</tr>
</tbody>
</table>
## Lead by Annex I Countries

<table>
<thead>
<tr>
<th>Time Period</th>
<th>dC/dt: Growth of Emissions</th>
<th>d²C/dt²: Rate of Change of Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Annex I</td>
<td>Non-Annex I</td>
</tr>
<tr>
<td>1980-2000</td>
<td>&gt; 0</td>
<td>&gt;&gt; 0</td>
</tr>
<tr>
<td>2000-2020</td>
<td>≤ 0</td>
<td>&gt; 0</td>
</tr>
<tr>
<td>2020-2050</td>
<td>&lt; 0</td>
<td>≤ 0</td>
</tr>
<tr>
<td>2050-2100</td>
<td>&lt;&lt; 0</td>
<td>&lt; 0</td>
</tr>
</tbody>
</table>
Thank You