Introduction to Integrated Environment Assessment Models

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Presentation Agenda

- Why Integrated Environment Assessment?
- What is Integrated Environment Assessment?
  Example: Integrated Assessment of Climate Change
- What are Integrated Assessment Models and Component Models?
  Example: Integrated Assessment Models for Climate Change Policy Analysis
- What kind of results and insights do Integrated Assessment provide?
  Example: Results and Insights from Integrated Assessment of Climate Change
- Why and what kind of capacity building for Integrated Assessment in developing countries?
Why Integrated Environment Assessment?
Multiple Interfaces of Environment Assessment

Policymaking Process

Integrated Assessment

Models and Frameworks

Knowledge disciplines

- Meteorology
- Geophysics
- Biology
- Geochemistry
- Atmospheric Chemistry
- Economics
- Policy sciences
- Climatology
- Hydraulics

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What to Integrate?

- Diverse Scientific Disciplines
- Diverse socio-economic scenarios
- Macro and micro-economies
- Local and regional boundaries
- Short and long time horizons
- Local and global environmental concerns
- Rural and urban perspectives
- Regional emissions and impact assessment
- Probability and Decision under uncertainty
- Technology
Why Integrated Assessment?

• To assemble, summarise, organise, interpret and reconcile pieces of existing knowledge

• To add value through integration (but not to add knowledge)

• To develop full range of policy outcomes

• To enhance Communication between scientific disciplines and policy formulation
Why Integrated Assessment Models?

• Framework for conducting research ensuring consistency pointing to areas where more information is required
• IAMs are good ‘forecasting’ and ‘heuristic’ tools
• Communications tools between different sciences and between science and policy
• Insights from investigations in the domains of the sub-components
What is Integrated Environment Assessment?

Example
Integrated Assessment of Climate Change
Climate Issues

Understanding “Climate” versus “Climate Change”
Integrated Climate Change Dimensions

- Atmospheric Composition
- Climate & Sea Level
- Human Activities
- Ecosystems
Integrated Framework for Climate Change

Climate Change
- Temperature rise
- Sea-level rise
- Precipitation change
- Droughts and floods

Impacts on human and natural systems
- Food and water resources
- Ecosystem and biodiversity
- Human settlements
- Human health

Emissions and concentrations
- Greenhouse gases
- Aerosols

Socio-economic development paths
- Economic growth
- Technology
- Population
- Governance

Adaptation

Mitigation
What are Integrated Assessment Models?

Example

Integrated Assessment Models for Climate Change Policy Analysis
AIM Model System

AIM/Energy/Technology/Country
A bottom-up technology selection model of energy use and emissions at country and local level

AIM/Ecosystem/Water/Impact
A set of ecosystem models, including a vegetation dynamics model, a water resource model, an agricultural productivity model and a health impact model

AIM/Bottom-up
A bottom-up technology & land use model for Asia-Pacific region

AIM/Top-down
A general-equilibrium-type world economic model

AIM/Material
An environment-economy integrated model with material balance and recycling process modules

AIM/Trend
A reduced-form model to project future socio-economic trends and environmental change for all 42 countries

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Strategic Database

Innovational Work System

Outputs

AI M-Trend

AI M-Top-down

AI M-Energy

AI M-Material

AI M-Ecosystem

Common Database

Policy making

Monitoring & Processing Data from IEM

Statistics

Outputs

Outputs

Outputs

Outputs

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MiniCAM
An Integrated Modelling Framework

- Atmospheric Composition: MAGICC
- Climate & Sea Level: SCENGEN
- Human Activities: ERB-AGLU
- Ecosystems: AGLU & MERGE
What are Component Models?
GDP and CO2 Emissions: AIM/Trend Model

A set of ecosystem models, including a technology selection model, a water resource model, an agricultural productivity model and a health impact model. Future environmental trend will be estimated for all 42 countries. The model includes material balance and recycling process modules, and it is projected to account for future socio-economic trends.

Environmental Industry (waste management, recycle) and Green Purchasing will be considered. Technology assessment and needs will be evaluated for the Asia-Pacific region to project future socio-economic trends.

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>GDP Growth</th>
<th>CO2 per capita [t-C/cap/yr]</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU+EUROPE+FORMER USSR</td>
<td>1990</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>NORTH AMERICA</td>
<td>2000</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>ASIA PACIFIC</td>
<td>2010</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>LATIN AMERICA</td>
<td>2020</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>AFRICA+MIDDLE EAST</td>
<td>2030</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>SGP</td>
<td>2040</td>
<td>40</td>
<td>10</td>
</tr>
</tbody>
</table>

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SO$_2$ Emission
AIM/Emission Model

2000

2030

Million Tons

Million Tons

< 0.01

< 0.01

0.01 - 0.017

0.017 - 0.026

0.026 - 0.035

0.035 - 0.044

0.044 - 0.053

0.053 - 0.060

> 0.060

< 0.01

0.01 - 0.017

0.017 - 0.026

0.026 - 0.035

0.035 - 0.044

0.044 - 0.053

0.053 - 0.060

> 0.060

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### Water Consumption: AIM/Ecosystem Model

**1995 Baseline**

**2030 Market Force**

**2032 Policy Reform**

#### Change of water consumption from 1995 to 2032 (Domestic + Agriculture + Industry)

<table>
<thead>
<tr>
<th>Year</th>
<th>1990</th>
<th>2000</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF</td>
<td>100</td>
<td>200</td>
<td>300</td>
<td>400</td>
<td>500</td>
<td>600</td>
</tr>
<tr>
<td>PR</td>
<td>150</td>
<td>300</td>
<td>450</td>
<td>600</td>
<td>750</td>
<td>900</td>
</tr>
</tbody>
</table>

**Notes:**
- CF: Current Forecasts
- PR: Policy Reform Forecasts

**Water Consumption**

*Graph showing water consumption trend from 1995 to 2032 with different scenarios.*

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**Tables:**

<table>
<thead>
<tr>
<th>Year</th>
<th>Consumption (m³/ha/year)</th>
<th>Domestic</th>
<th>Agriculture</th>
<th>Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>100</td>
<td>50</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>2032</td>
<td>700</td>
<td>400</td>
<td>200</td>
<td>100</td>
</tr>
</tbody>
</table>

**Graph:**

- *X-axis:* Year (1995-2040)
- *Y-axis:* Water Consumption (m³/ha/year)

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**Maps:**

- **1995 Baseline**
- **2030 Market Force**
- **2032 Policy Reform**
AIM/Top-down & AIM/Bottom-up Model

26 region – 36 sector Computable General Equilibrium Model (AIM/Top-down)

Country level

Bottom-up technology & land use Model (AIM/Bottom-up)

World level

Bottom-up technology & land use Model (AIM/Bottom-up)

Bottom-up technology & land use Model (AIM/Bottom-up)

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Insights from
Integrated Climate Change Assessment
Emissions and Concentrations
Energy and Carbon Emissions for India: AIMENDUSE Model

Energy Consumption

Carbon Emissions

Year

Carbon (MT)

Exa Joules

1995 2005 2015 2025 2035

Coal

Oil

Gas

Hydro

Nuclear

Renewables

Biomass

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GHG versus Local Emissions in India

Carbon Emissions

<table>
<thead>
<tr>
<th>Year</th>
<th>Carbon (MT)</th>
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</thead>
<tbody>
<tr>
<td>1995</td>
<td>200</td>
</tr>
<tr>
<td>2005</td>
<td>400</td>
</tr>
<tr>
<td>2015</td>
<td>600</td>
</tr>
<tr>
<td>2025</td>
<td>800</td>
</tr>
<tr>
<td>2035</td>
<td></td>
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</table>

SO₂ Emissions

<table>
<thead>
<tr>
<th>Year</th>
<th>Million Tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>4</td>
</tr>
<tr>
<td>2005</td>
<td>5</td>
</tr>
<tr>
<td>2015</td>
<td>6</td>
</tr>
<tr>
<td>2025</td>
<td>7</td>
</tr>
<tr>
<td>2035</td>
<td>6</td>
</tr>
</tbody>
</table>
Global Carbon Mitigation Scenarios
(2000 - 2100)

- Base Case
- 750ppmv
- 650ppmv
- 550ppmv
Technology, Energy & Climate: MINICAM

- Soil carbon sequestration
- Sequestration from fossil power generation
- Sequestration from synfuels production
- Sequestration from H2 production
- End-use technology improvements
- Nuclear
- Solar
- Biomass
- 550 ppmv emissions

550 ppmv
Indian Energy System Transformation
Under 550 ppmv Stabilization

Base Case Energy System

Energy Changes: 550 ppmv Case

- Carbon Capture
- Energy Efficiency
- Wind
- Solar
- Biomass
- Hydro
- Nuclear
- Gas
- Oil
- India 550 ppmv emission

550 ppmv
Technological Change in India to Stabilize CO₂ at 550 ppmv

Non-Fossil Energy Contribution to GHG Mitigation

- Carbon Capture
- Energy Efficiency
- Wind
- Solar
- Biomass
- Hydro
- Nuclear
- Gas
- Oil
- India 550 ppmv emission

550 PPMV

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Regional Energy Market Development
Impact of Regional Energy Market Developments in South-Asia

Emissions Reduction (2015)

Year

Reduction (%)

0.0
1.5
3.0
4.5
6.0
7.5
9.0
10.5

Carbon
SOX

Grid Integration
Grid Integration + Regional Co-operation
Why and What kind of Capacity Building for Integrated Environment Assessment in Developing Countries?
Integrated Environment Assessment: Developing Country Problems

- Assessment and modeling capabilities
- Inadequate database
- Structural changes in the economy
- Myriad and conflicting developmental concerns
- Weak regional and international linkages
- Lack of sustained funding
Limitations of Present Approaches

- Limited capability to characterize and parameterize long term interactions between the economy, society, and environment
- Assumptions derived from developed world perspective
- Inability to characterize discontinuities and extreme events
- Weak behavioral interfaces
- Distance between analysts and policy makers
Capacity Building Needs for Developing Countries

- Inventorize existing best competence, data and experiences
- Networking and cooperation with regional and global teams
- Promote integrated assessment modeling under developing country expert leadership in cooperation with global experts
- Sustained funding
- Institutionalize integrated assessment activities