Systems Science
Approach to Future Earth

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Shall I Compare Thee To A Summer’s Day?

by William Shakespeare

Shall I compare thee to a summer’s day?
Thou art more lovely and more temperate.
Rough winds do shake the darling buds of May,
And summer’s lease hath all too short a date.
Sometime too hot the eye of heaven shines,
And often is his gold complexion dimm’d;
And every fair from fair sometime declines,
By chance or nature’s changing course untrimm’d;
But thy eternal summer shall not fade
Nor lose possession of that fair thou ow’st;
Nor shall Death brag thou wander’st in his shade,
When in eternal lines to time thou grow’st:
So long as men can breathe or eyes can see,
So long lives this, and this gives life to thee.
<table>
<thead>
<tr>
<th>Goal #</th>
<th>Description</th>
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<tbody>
<tr>
<td>Goal 1</td>
<td>End poverty in all its forms everywhere</td>
<td>Goal 10</td>
<td>Reduce inequality within and among countries</td>
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<td>Goal 2</td>
<td>End hunger, achieve food security and improved nutrition and promote sustainable agriculture</td>
<td>Goal 11</td>
<td>Make cities and human settlements inclusive, safe, resilient and sustainable</td>
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<td>Goal 3</td>
<td>Ensure healthy lives and promote well-being for all at all ages</td>
<td>Goal 12</td>
<td>Ensure sustainable consumption and production patterns</td>
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<td>Goal 4</td>
<td>Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all</td>
<td>Goal 13</td>
<td>Take urgent action to combat climate change and its impacts</td>
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<td>Goal 5</td>
<td>Achieve gender equality and empower all women and girls</td>
<td>Goal 14</td>
<td>Conserve and sustainably use the oceans, seas and marine resources for sustainable development</td>
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<td>Goal 6</td>
<td>Ensure availability and sustainable management of water and sanitation for all</td>
<td>Goal 15</td>
<td>Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss</td>
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<tr>
<td>Goal 7</td>
<td>Ensure access to affordable, reliable, sustainable and modern energy for all</td>
<td>Goal 16</td>
<td>Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels</td>
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<td>Goal 8</td>
<td>Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all</td>
<td>Goal 17</td>
<td>Strengthen the means of implementation and revitalize the global partnership for sustainable development</td>
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<td>Goal 9</td>
<td>Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation</td>
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IIASA IS COLLABORATING WITH FUTURE EARTH TO PROVIDE SYSTEMS SCIENCE TO SUPPORT GLOBAL, REGIONAL AND NATIONAL TRANSITIONS TO SUSTAINABILITY

June 2015

Future Earth Scientific and Engagement Committees meeting & International Symposium & Public Lecture: “Science-Policy in a Global Context”
THE EARLY 1970s

Sources: nuclearweaponarchive.org, The Guardian
International, independent, interdisciplinary

Research on major global problems

Solution oriented, integrated systems analysis
IIASA TRULY INTERNATIONAL

- 1,445 visitors & collaborators in 2014
- Plus ~25% of IIASA alumni (3,505 people worldwide) remain actively involved in IIASA research
- Plus ~600 partner institutions
- In sum, ~2500 researchers from some 65 countries involved in IIASA’s research network (external faculty)
- And it is not just research networks: IIASA researchers took part in 112 advisory boards and steering committees in 2014
INTERDISCIPLINARY

- Natural Scientists & Engineers: 35%
- Social Scientists: 28%
- Mathematicians and others: 37%
IIASA AS THE EXPERT ADVISOR

IIASA researchers take part in 100 + advisory boards and steering committees, including:

– Leadership Council of the Sustainable Development Solutions Network (SDSN) – input to define Sustainable Development Goals (SDGs)
– UN Secretary General Technical Group on Sustainable Energy for All
– Advisory Council of the German Government on Global Change (WBGU)
– Arctic Council
– UN Food and Agriculture Organization Land and Water Division
EXAMPLES OF EARLY RESEARCH

GLOBAL CHALLENGES INEXTRICABLY LINKED

Energy & Climate Change

Food & Water

Poverty & Equity
IIASA’S
SYSTEMS
SCIENCE
APPROACH
RESEARCHING GLOBAL CHALLENGES

- Integrated
- Interdisciplinary
- International
- Independent
- Solution-oriented
- Long term
- Trade offs

} = Systems Analysis
Benefits of Systems Approach: Bridging across research and policy making silo’s (Example 1)

- 2006-12: Global Energy Assessment involving 500 experts around the world
- 2009 to date: GEA provides critical input to Un Secretary-General’s Sustainable Energy For All Initiative including defining the aspirational yet feasible objectives:
  1. Ensure universal access to modern energy services
  2. Double the global rate of improvements in energy efficiency
  3. Double the share of renewable energy in the global energy mix
Global Primary Energy

- Other renewables
- Nuclear
- Gas
- Oil
- Coal
- Biomass

Graph showing the global primary energy trends from 1850 to 2000, with different technologies and energy sources represented.
Global Primary Energy
no CCS, no Nuclear

- Energy savings (efficiency, conservation, and behavior) ~40% improvement by 2030
- ~55% renewables by 2030
- Nuclear phase-out (policy)
- Oil phase-out (necessary)

Source: Riahi et al, 2012
Energy savings (efficiency, conservation, and behavior)
~40% improvement by 2030
~30% renewables by 2030

Limited Intermittent REN

Oil phase-out (necessary)

Limited Bioenergy
Bio-CCS – “negative CO₂

Source: Riahi et al, 2012
Global Primary Energy

Sub-Saharan Africa

~50% renewables by 2030

Source: Riahi et al, 2012
Global Primary Energy

China

~50% efficiency and decline of coal by 2030

Source: Riahi et al, 2012
Global Primary Energy
Europe

~30% renewables by 2030

Source: Riahi et al, 2012
Final Energy Transformations

- **Fossils (Gas, Oil & Coal)**
- **Other Low Carbon (Nuclear, Fossil-CCS)**
- **Renewables (Wind, Solar, Geothermal, Bioenergy)**

Chart showing the percentage of energy from different sources from 2005 to 2050.
Multiple Benefits of Integrated Policies

Total Global Policy Costs (2010-2030)

- Only Energy Security
- Only Air Pollution and Health
- Only Climate Change

Added costs of ES and PH are comparatively low when CC is taken as an entry point.

Source: McCollum, Krey, Riahi, 2012
Benefits of Systems Approach: Bridging across research and policy making silo’s (Example 2)

• 2011: IIASA model GAINS identifies 16 measures to curb the release of either black carbon or methane (pollutants that harm human or plant health while simultaneously exacerbating climate change).

• Feb 2012: US State Secretary Hillary Clinton launched the Climate and Clean Air Coalition to Reduce Short Lived Climate Pollutants

• Today, CCAC has 33 member countries, 39 International Organizations and IIASA’s Markus Amann on scientific committee

DOI: 10.1126/science.1210026
GAINS identified 16 key air quality measures that, together with CO$_2$ mitigation, increase chances to stay below the 2º target

Global temperature 1900–2070

Reference Scenario
IEA World Energy Outlook 2009

CO$_2$ Measures
IEA 450 ppm scenario 2009

Near-term Measures
IIASA set of 16 measures for CH$_4$ and black carbon

CO$_2$ + Near-term Measures

These 16 measures are
– win (for air quality),
– win (for near-term climate change)
– win (for economic development)

Source: Shindell et al., Science (2012), 335/6065:183–189

http://gains.iiasa.ac.at
IS THE FORMATION OF SECONDARY INORGANIC AEROSOLS IN THE JINGJINJI REGION NH₃-LIMITED?

A large fraction of PM2.5 in China consists of secondary inorganic aerosols, also during episodes.

Based on IIASA research:
2014: NH₃/nitrogen use efficiency adopted as the main direction of World Bank support for the JingJinJi Clean Air Action program of the Chinese government.

Air quality seen as entry point for good N management practices.
Jan 2014: European Commission announce 2030 climate and energy goals for a competitive, secure and low-carbon EU economy. These include:

- A reduction in greenhouse gas emissions by 40% below the 1990 level
- An EU-wide binding target for renewable energy of at least 27%

Goals were informed by an extensive impact assessment, for which IIASA researchers contributed data and model results to help policymakers understand future emissions, as well as the potential benefits and costs of various climate policies.

Source: EU Trends to 2050 Update
UN

80% probability that world population, now 7.2 billion, will increase to between 9.6 and 12.3 billion in 2100, with the median at 10.9 billion.

IIASA

Most likely scenario indicates that world population will increase to 9.2 billion by 2050, peak at 9.4 billion around 2070 and start a slow decline to 9.0 billion by the end of the century.
Almost universally, women with higher levels of education have fewer children. Better education is associated with lower mortality, better health, and different migration patterns. Hence, the global population outlook depends greatly on further progress in education, particularly of young women.
PROJECTING INDIA’S FUTURE POPULATION

India - Base Year 2010

1.22 Billion
Males

Females

Pop < 15 yrs  No Education  Incomp. Primary  Primary
Lower Secondary  Upper Secondary  Post Secondary
PROJECTING INDIA’S FUTURE POPULATION

India - Projections 2030 - SSP1

1.5 Billion
Males

Females

Population in Millions

Age (in Years)

0-4
5-9
10-14
15-19
20-24
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65-69
70-74
75-79
80-84
85-89
90-94
95-99
100+

Pop < 15 yrs
No Education
Incomp. Primary
Primary
Lower Secondary
Upper Secondary
Post Secondary
PROJECTING INDIA’S FUTURE POPULATION

India - Base Year 2010

1.22 Billion
Males

Females

Population in Millions

Pop < 15 yrs
No Education
Incomp. Primary
Primary
Lower Secondary
Upper Secondary
Post Secondary
PROJECTING INDIA’S FUTURE POPULATION

India - Projections 2030 - SSP3

1.6 Billion
Males

Females

Population in Millions

Age (in Years)

0-4
5-9
10-14
15-19
20-24
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65-69
70-74
75-79
80-84
85-89
90-94
95-99
100+

Pop < 15 yrs
No Education
Incomp. Primary
Primary
Lower Secondary
Upper Secondary
Post Secondary
IMPACT OF EDUCATION ON POPULATION

India - Projections 2060 - SSP1

- Population in Millions
  - Age (in Years)
  - Males: 1.5 Billion
  - Females

India - Projections 2060 - SSP3

- Population in Millions
  - Age (in Years)
  - Males: 2.1 Billion
  - Females

Legend:
- Pop < 15 yrs
- No Education
- Incomp. Primary
- Primary
- Lower Secondary
- Upper Secondary
- Post Secondary
Systems Science and Effective Science to Policy Interface

What is needed in order to get out of our “silos”? and To fully benefit from Systems Approaches?
ACADEMIC TRAINING AND CAPACITY BUILDING

New paradigms
New curricula
New funding architecture
Revised academic carrier incentives
Political, Societal and Economic Governance

Trans-sectoral (nexus) policies
Trans-sectoral budgeting & investments
Long term policies & investments
Re-definition of governmental subsidies
Revival of trans-boundary regional cooperation

POSITIVE PARADIGMS
NEW PARTNERSHIPS
### Y2015: Transformational Change – Main Events

<table>
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<tr>
<th>Event</th>
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The World in 2050 (TWI2050)
Integrating knowledge on SDSN pathways to global sustainable development

Inaugural Meeting @ IIASA
10-12 March 2015
The World in 2050

- Global development within a safe and just operating space and planetary boundaries
- “Safe Space” of interaction among SDGs: integrated models to sustainability narratives
- Transformational pathways based on existing literature e.g. SSPs, GEA, SDSN’s DDPP
- Co-benefits of transformation toward the “safe space” and how to achieve sustainable futures
The World in 2050 “Consortium”

- AIMES
- Future Earth
- Centre for Integrated Studies on Climate Change and the Environment
- Earth League, whole Earth system modelling initiative
- Earth Institute, Columbia University
- Global Ocean Ecosystem Dynamics (GLOBEC)
- Indian Institute International Futures
- Indian Institute of Technology (IIT)
- International Energy Agency (IEA)
- International Food Policy Research Institute (IFPRI)
- International Monetary Fund (IMF)
- International Institute for Applied System Analysis (IIASA)
- Joint Global Change Research Institute at Pacific Northwest National Laboratory (PNNL JGCRI)
- National Center for Atmospheric Research (NCAR)
- National Institute for Environmental Studies (NIES)
- UN Population Division
- UNEP- World Conservation Monitoring Centre (UNEP-WCMC)
- World Bank
- Organisation for Economic Co-operation and Development (OECD)
- Potsdam Institute for Climate Impact Change (PIK)
- PBL - Netherlands Environmental Assessment Agency
- Stanford University
- Stockholm Resilience Centre
- The City University of New York (CUNY)
- Tsinghua University
Thank you and hope to welcome you soon at IIASA!
IIASA IN 2014

Getting to Eureka

How an interdisciplinary research environment leads to unexpected discoveries

IPCC Expert Meeting: Climate research community looks into future scenarios

In May, climate experts gathered at IIASA at an Expert Meeting of the Intergovernmental Panel on Climate Change (IPCC) to discuss and further develop new socioeconomic scenarios as shared tools for climate research.

The new scenarios are planned to allow a more integrated assessment of mitigation, adaptation, and climate change impacts across the entirety of IPCC work in the future. IIASA has been instrumental in the development of new scenarios for the IPCC including the Shared Socioeconomic Pathways (SSPs) and the Representative Concentration Pathways (RCPs) used in the Fifth Assessment Report. Read More...

New research analyzes policies needed to limit climate change to a more stringent 1.5°C limit by 2100. More...

A new study shows that geography is a key factor determining how big the impacts of bioterrorism on climate. More...

IIASA NEWS

Featured Video

Klaus A. Schmidt, Scientific-Policy in a Shared World

IIIASA IN BRIEF

IIASA IN DEEP

EVENTS

pub.iiasa.ac.at/ar14/

www.iiasa.ac.at/su14