Mitigation and Adaptation Studies

Class 4: The Syndrome of Modern Global Change: Diagnosis, Prognosis, Therapy

Contents:  
- Baseline  
- Syndrome  
- Diagnosis (continued from class 3)  
- Prognosis  
- Therapy  

Also: Systems - Introduction
Diagnosis

Role of Economy

An Inquiry into the Nature and Causes of the Wealth of Nations

ADAM SMITH

Published in 1776
Economy: the “invisible hand”

Assumption:
Agents independently seeking their own gain will produce the overall best result for society.
The current mainstream model of the global economy is based on a number of assumptions about the way the world works, what the economy is, and what the economy is for. These assumptions arose in an earlier period, when the world was relatively empty of humans and their artifacts. Built capital was the limiting factor, while natural capital was abundant. It made sense not to worry too much about environmental “externalities,” since they could be assumed to be relatively small and ultimately solvable. It also made sense to focus on the growth of the market economy, as measured by gross domestic product (GDP), as a primary means to improve human welfare. And it made sense to think of the economy as only marketed goods and services and to think of the goal as increasing the amount of these that were produced and consumed.

The current mainstream model of the global economy is based on a number of assumptions about the way the world works, what the economy is, and what the economy is for. These assumptions arose in an earlier period, when the world was relatively empty of humans and their artifacts. Built capital was the limiting factor, while natural capital was abundant. It made sense not to worry too much about environmental “externalities,” since they could be assumed to be relatively small and ultimately solvable. It also made sense to focus on the growth of the market economy, as measured by gross domestic product (GDP), as a primary means to improve human welfare. And it made sense to think of the economy as only marketed goods and services and to think of the goal as increasing the amount of these that were produced and consumed.


Published in 1776
The current mainstream model of the global economy is based on a number of assumptions about the way the world works, what the economy is, and what the economy is for. These assumptions arose in an earlier period, when the world was relatively empty of humans and their artifacts. Built capital was the limiting factor, while natural capital was abundant. It made sense not to worry too much about environmental “externalities,” since they could be assumed to be relatively small and ultimately solvable. It also made sense to focus on the growth of the market economy, as measured by gross domestic product (GDP), as a primary means to improve human welfare. And it made sense to think of the economy as only marketed goods and services and to think of the goal as increasing the amount of these that were produced and consumed.

For almost a century, the consumption of products has been the dominant paradigm and mindset.

John Maynard Keynes ("The General Theory of Employment, Interest and Money", 1936): "I should support at the same time all sorts of policies for increasing the propensity to consume. For it is unlikely that full employment can be maintained, whatever we may do about investment, with the existing propensity to consume."

Victor Lebow (1955): "Our enormously productive economy … demands that we make consumption our way of life, that we convert the buying and use of goods into rituals, that we seek our spiritual satisfaction, our ego satisfaction, in consumption … we need things consumed, burned up, replaced and discarded at an ever-accelerating rate."
In 1970, Milton Friedman argued that businesses’ sole purpose is to generate profit for shareholders.

This led to globalization …
## Diagnosis

### Role of Economy

![Diagram showing the safe and just space for humanity with focus on social foundation, food, water, income, health, education, and gender equality.]

<table>
<thead>
<tr>
<th>Social Foundation</th>
<th>Illustrative Indicators of Global Deprivation</th>
<th>Share of Population</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food security</td>
<td>Population undernourished</td>
<td>13</td>
<td>2010-12</td>
</tr>
<tr>
<td>Income</td>
<td>Population living below $1.25 (purchasing power parity) per day</td>
<td>21</td>
<td>2005</td>
</tr>
</tbody>
</table>
| Water and sanitation | Population without access to an improved drinking water source  
                          | Population without access to improved sanitation                                                       | 13                  | 2008        |
| Health care       | Population without regular access to essential medicines                                                     | 30                  | 2004        |
| Education         | Children not enrolled in primary school  
                          | Illiteracy among 15-24 year olds                                                                           | 10                  | 2009        |
|                   |                                                                | 11                  | 2009        |
| Energy            | Population lacking access to electricity  
                          | Population lacking access to clean cooking facilities                                                     | 19                  | 2009        |
|                   |                                                                | 39                  | 2009        |
| Gender equality   | Employment gap between women and men in waged work (excluding agriculture)                                  | 34                  | 2009        |
|                   | Representation gap between women and men in national parliaments                                            | 77                  | 2011        |
| Social equity     | Population living in countries with significant income inequality                                           | 33                  | 1995–2009   |
| Voice             | Population living in countries perceived (in surveys) not to permit political participation or freedom of expression | To be determined    |             |
| Jobs              | Labor force not employed in decent work                                                                       | To be determined    |             |
| Resilience        | Population facing multiple dimensions of poverty                                                              | To be determined    |             |

Source: Raworth; Rockström et al.
Women carry out 70% of the global work hours but they only earn 10% of the global salary.
Diagnosis

Role of Economy

Illustrative Indicators of Global Deprivation

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Share of Population</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undernourished</td>
<td>13</td>
<td>2010–12</td>
</tr>
<tr>
<td>Living below $1.25 (purchasing power parity) per day</td>
<td>21</td>
<td>2005</td>
</tr>
<tr>
<td>Without access to an improved drinking water source</td>
<td>13</td>
<td>2008</td>
</tr>
<tr>
<td>Without access to improved sanitation</td>
<td>39</td>
<td>2008</td>
</tr>
<tr>
<td>Without regular access to essential medicines</td>
<td>30</td>
<td>2004</td>
</tr>
<tr>
<td>Not enrolled in primary school</td>
<td>10</td>
<td>2009</td>
</tr>
<tr>
<td>Unemployment among 15–24 year olds</td>
<td>11</td>
<td>2009</td>
</tr>
<tr>
<td>Population lacking access to electricity</td>
<td>19</td>
<td>2009</td>
</tr>
<tr>
<td>Population lacking access to clean cooking facilities</td>
<td>39</td>
<td>2009</td>
</tr>
<tr>
<td>Employment gap between women and men in waged work</td>
<td>34</td>
<td>2009</td>
</tr>
<tr>
<td>Representation gap between women and men in national parliaments</td>
<td>77</td>
<td>2011</td>
</tr>
<tr>
<td>Population living in countries with significant income inequality</td>
<td>33</td>
<td>1995–2009</td>
</tr>
<tr>
<td>Population living in countries perceived (in surveys) not to permit political participation or freedom of expression</td>
<td>To be determined</td>
<td></td>
</tr>
<tr>
<td>Labor force not employed in decent work</td>
<td>To be determined</td>
<td></td>
</tr>
<tr>
<td>Population facing multiple dimensions of poverty</td>
<td>To be determined</td>
<td></td>
</tr>
</tbody>
</table>

Source: See endnote 8.
Diagnosis

Role of Economy
What, then, is the biggest source of stress on planetary boundaries today? It is the excessive consumption levels of roughly the wealthiest 10 percent of people in the world and the resource-intensive production patterns of companies producing the goods and services that they buy. The richest 10 percent of people in the world hold 57 percent of global income, and just 11 percent of the global population generates about half of global CO2 emissions. And one third of the world's reactive nitrogen use is used to produce meat for people in the European Union, just 7 percent of the world's population.
What, then, is the biggest source of stress on planetary boundaries today? It is the excessive consumption levels of roughly the wealthiest 10 percent of people in the world and the resource-intensive production patterns of companies producing the goods and services that they buy. The richest 10 percent of people in the world hold 57 percent of global income. Just 11 percent of the global population generates about half of global CO2 emissions. And one third of the world’s “sustainable budget” for reactive nitrogen use is used to produce meat for people in the European Union, just 7 percent of the world’s population.

Raworth, 2013
What, then, is the biggest source of stress on planetary boundaries today? It is the excessive consumption levels of roughly the wealthiest 10 percent of people in the world and the resource-intensive production patterns of companies producing the goods and services that they buy. The richest 10 percent of people in the world hold 57 percent of global income. Just 11 percent of the global population generates about half of global CO2 emissions. And one third of the world’s “sustainable budget” for reactive nitrogen use is used to produce meat for people in the European Union, just 7 percent of the world’s population.

Raworth, 2013

<table>
<thead>
<tr>
<th>Year</th>
<th>Top 1%</th>
<th>Top 5%</th>
<th>Top 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>49.6%</td>
<td>77.2%</td>
<td>89.4%</td>
</tr>
<tr>
<td>2009</td>
<td>45.4%</td>
<td>73.7%</td>
<td>86.5%</td>
</tr>
<tr>
<td>2016</td>
<td>50.8%</td>
<td>77.7%</td>
<td>89.1%</td>
</tr>
</tbody>
</table>
What, then, is the biggest source of stress on planetary boundaries today? It is the excessive consumption levels of roughly the wealthiest 10 percent of people in the world and the resource-intensive production patterns of companies producing the goods and services that they buy. The richest 10 percent of people in the world hold 57 percent of global income. Just 11 percent of the global population generates about half of global CO2 emissions. And one third of the world’s “sustainable budget” for reactive nitrogen use is used to produce meat for people in the European Union, just 7 percent of the world’s population.

Raworth, 2013

Wealth Distribution:

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2009</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top 1%</td>
<td>2000: 49.6%</td>
<td>2009: 45.4%</td>
<td>2016: 50.8%</td>
</tr>
<tr>
<td>Top 5%</td>
<td>2000: 77.2%</td>
<td>2009: 73.7%</td>
<td>2016: 77.7%</td>
</tr>
<tr>
<td>Top 10%</td>
<td>2000: 89.4%</td>
<td>2009: 86.5%</td>
<td>2016: 89.1%</td>
</tr>
</tbody>
</table>

Role of Economy

Diagnosis

Share of membership in world's richest 1%, top 10 countries

<table>
<thead>
<tr>
<th>Country</th>
<th>2016</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>37.8%</td>
<td>32.9%</td>
</tr>
<tr>
<td>Japan</td>
<td>9.6</td>
<td>12</td>
</tr>
<tr>
<td>UK</td>
<td>7.3</td>
<td>7.6</td>
</tr>
<tr>
<td>France</td>
<td>5.3</td>
<td>9.1</td>
</tr>
<tr>
<td>Germany</td>
<td>5.1</td>
<td>5.1</td>
</tr>
<tr>
<td>China</td>
<td>4.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Italy</td>
<td>3.6</td>
<td>6.3</td>
</tr>
<tr>
<td>Canada</td>
<td>3.6</td>
<td>4</td>
</tr>
<tr>
<td>Australia</td>
<td>3.5</td>
<td>3</td>
</tr>
<tr>
<td>Switzerland</td>
<td>2.3</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: Raworth, Rockström et al.
Currently:
An Economy that meets the needs of the present while **destroying** the Earth's life-support system, on which the welfare of current and future generations depends.
Sustainable Development is a development that meets the needs of the present while safeguarding Earth’s life-support system, on which the welfare of current and future generations depends.

“Sustainable Development is a development that meets the needs of the present while safeguarding Earth’s life-support system, on which the welfare of current and future generations depends.”

Griggs et al., 2013
Key Points

Baseline
During the Holocene, climate and sea level were exceptionally stable.
The Holocene was a “safe operating space for humanity.”

Syndrome
During the last few hundred years, humanity has introduced rapid and large changes.
The system is outside the “normal range” and in the dynamic transition into the Post-Holocene; we have increasing disequilibrium.

Diagnosis
A consumption-based economy combined with easy access to energy caused humans to accelerate flows in the Earth’s life-support system and sustain rapid population growth.
Modern humans are the “Anthropogenic Cataclysmic Virus” (ACV) in the Earth’s life-support system.
Mitigation and Adaptation Studies

Class 4: The Syndrome of Modern Global Change: Diagnosis, Prognosis, Therapy

Contents:

- Baseline
- Syndrome
- Diagnosis (continued from class 3)
- Prognosis
- Therapy

Also: Systems - Introduction
Prognosis
Exploring Possible Futures
Exploring Possible Futures

- climate change:
  - extreme weather
  - global atmospheric warming
  - ocean warming
  - ocean acidification
  - sea level rise
- global disasters
Exploring Possible Futures

- climate change:
  - extreme weather
  - global atmospheric warming
  - ocean warming
  - ocean acidification
  - sea level rise
- global disasters

- population growth
- economic growth
- land use, food and water security
- social and technological risks inc. wars)
- extinction
- governance
- pandemics
Exploring Possible Futures

- climate change:
  - extreme weather
  - global atmospheric warming
  - ocean warming
  - ocean acidification
  - sea level rise
- global disasters
- population growth
- economic growth
- land use, food and water security
- social and technological risks (inc. wars)
- extinction
- governance
- pandemics

Methodology

- modeling and simulations
  - participatory modeling (development of options)
  - scenario-based modeling and simulations: model validation, ensembles, selection of scenarios, not predictions
- risk assessments:
  - risk perception and biases, comprehensiveness
  - based on past system behavior
Exploring Possible Futures

- climate change:
  - extreme weather
  - global atmospheric warming
  - ocean warming
  - ocean acidification
  - sea level rise
  - global disasters

- population growth
- economic growth
- land use, food and water security
- social and technological risks inc. wars)
- extinction
- governance
- pandemics

Methodology
- modeling and simulations
  - participatory modeling *(development of options)*
  - scenario-based modeling and simulations: *model validation, ensembles, selection of scenarios, not predictions*
- risk assessments:
  - risk perception and biases, comprehensiveness
  - based on past system behavior
Prognosis

Guide to the Millennium Assessment Reports

Full Reports

The Working Group assessment reports are between 500-1800 pages in length, with a volume of summaries of about 120 printed pages.

- Current States & Trends
- Scenarios
- Policy Responses
- Multiscale Assessments

Synthesis Reports

The first set of assessment reports consists of an overall synthesis and 5 others that interpret the MA findings for specific audiences.

- Overall synthesis
- Biodiversity
- Desertification
- Business & Industry
- Wetlands and Water
- Health

About the Millennium Assessment

The Millennium Ecosystem Assessment assessed the consequences of ecosystem change for human well-being. From 2001 to 2005, the MA involved the work of more than 1,360 experts worldwide. Their findings provide a state-of-the-art scientific appraisal of the condition and trends in the world's ecosystems and the services they provide, as well as the scientific basis for action to conserve and use them sustainably.

Useful Links

- IslandPress
- Order printed reports from Island Press
- GreenFacts.org
- Popularization synthesis report
- USGS
- MA Data Portal

Also on This Site

- Directory of Authors
- Slide Presentations
- Graphic Resources
- Donors & In-Kind Contributors

Scenarios Assessment

The Scenarios Working Group considered the possible evolution of ecosystem services during the twenty-first century by developing four global scenarios exploring plausible future changes in drivers, ecosystems, ecosystem services, and human well-being.

Three of four detailed scenarios examined by the Scenarios Working Group suggest that significant changes in policies, institutions, and practices can mitigate some but not all of the negative consequences of growing pressures on ecosystems, but the changes required are substantial and are not currently underway.

Assessment report chapters

- Contents, Foreword, Preface [pdf, 1640 KB]
- 01. MA Conceptual Framework [pdf, 294 KB]
- 02. Global Scenarios in Historical Perspective [pdf, 291 KB]
- 03. Ecology in Global Scenarios [pdf, 255 KB]
- 04. State of Art in Describing Future Changes in Ecosystem Services [pdf, 425 KB]
- 05. Rationale and Logic of the Scenarios [pdf, 480 KB]
- 06. Methodology for Developing the MA Scenarios [pdf, 1619 KB]
- 07. Drivers of Change in Ecosystem Conditions and Services [pdf, 1402 KB]
- 08. Scenarios [pdf, 1972 KB]
- 09. Ecosystem Services across Scenarios [pdf, 4073 KB]
- 10. Biodiversity Across Scenarios [pdf, 1036 KB]
- 11. Human Well-being Across Scenarios [pdf, 266 KB]
- 12. Trade-offs Among Ecosystem Services [pdf, 307 KB]
- Appendices [pdf, 4852 KB]

Scenarios Working Group

Prognosis
Prognosis
Prognosis

CLIMATE CHANGE 2013
The Physical Science Basis
Summary for Policymakers

IPCC
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

WG I
WORKING GROUP I CONTRIBUTION TO THE FIFTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE
Prognosis
**Prognosis**

**Trajectories of the Earth System in the Anthropocene**

Will Steffen, Johan Rockström, Katherine Richardson, Timothy M. Lenton, Carl Folke, Diana Liverman, Colin P. Summerhayes, Anthony D. Barnosky, Sarah E. Cornell, Michel Crucifix, Jonathan F. Donges, Ingo Fetzer, Steven J. Lade, Marten Scheffer, Ricarda Winkelmann, and Hans Joachim Schellnhuber

PNAS published ahead of print August 6, 2018 [https://doi.org/10.1073/pnas.1810141115](https://doi.org/10.1073/pnas.1810141115)
Prognosis

Trajectories of the Earth System in the Anthropocene

Will Steffen, Johan Rockström, Katherine Richardson, Timothy M. Lenton, Carl Folke, Diana Liverman, Colin P. Summerhayes, Anthony D. Barnosky, Sarah E. Cornell, Michel Crucifix, Jonathan F. Donges, Ingo Fettner, Steven J. Lade, Marten Schlesser, Ricarda Winkelmann, and Hans Joachim Schellnhuber

PNAS published ahead of print August 6, 2019 | https://doi.org/10.1073/pnas.1910141115
Prognosis

Trajectories of the Earth System in the Anthropocene

Will Steffen, Johan Rockström, Katherine Richardson, Timothy M. Lenton, Carl Folke, Diana Liverman, Colin R. Summerhayes, Anthony D. Barnosky, Sarah E. Cornell, Michel Crucifix, Jonathan F. Donges, Ingo Fettke, Steven J. Lade, Martin Schellnhuber, Ricarda Winkelmann, and Hans Joachim Schellnhuber

PNAS published ahead of print August 6, 2010 https://doi.org/10.1073/pnas.1015411115
Prognosis
Prognosis

Extinction of mammals and birds

Extinction of insects

Loss of soil

Trajectories of the Earth System in the Anthropocene

Steffen, Johan Rockström, Katherine Richardson, Timothy M. Lenton, Carl Folke, Diana Liverman, Colin B. Lemmetyinen, Anthony D. Barnosky, Sarah E. Cornell, Michel Crucifix, Jonathan F. Donges, Ingo Fischer, Steven J. Lade, Marijn Schelvis, Ricarda Winkelmann, and Hans Joachim Schellnhuber

PNAS published ahead of print August 6, 2018 https://doi.org/10.1073/pnas.1808111115
Exploring Possible Futures

Prognosis

- climate change:
  - extreme weather
  - global atmospheric warming
  - ocean warming
  - ocean acidification
  - sea level rise
- global disasters

- population growth
- economic growth
- land use, food and water security
- social and technological risks inc. wars)
- extinction
- governance
- pandemics

Methodology

- modeling and simulations
  - participatory modeling (development of options)
  - scenario-based modeling and simulations: model validation, ensembles, selection of scenarios, not predictions
- risk assessments:
  - risk perception and biases, comprehensiveness
  - based on past system behavior
Exploring Possible Futures

Prognosis

- climate change:
  - extreme weather
  - global atmospheric warming
  - ocean warming
  - ocean acidification
  - sea level rise
  - global disasters

- population growth
- economic growth
- land use, food and water security
- social and technological risks inc. wars)
- extinction
- governance
- pandemics

Methodology

- modeling and simulations
  - participatory modeling (development of options)
  - scenario-based modeling and simulations: model validation, ensembles, selection of scenarios, not predictions

- risk assessments:
  - risk perception and biases, comprehensiveness
  - based on past system behavior
Prognosis

Assessing the risk …
Assessing the risk ...
The Global Risks
Report 2019
14th Edition

In partnership with Marsh & McLennan Companies and Zurich Insurance Group
### Top 5 Global Risks in Terms of Likelihood

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset price collapse</td>
<td>Asset price collapse</td>
<td>Severe income disparity</td>
<td>Severe income disparity</td>
<td>Income disparity</td>
<td>Intensified conflict with regional consequences</td>
<td>Large-scale involuntary migration</td>
<td>Extreme weather events</td>
<td>Extreme weather events</td>
<td>Extreme weather events</td>
<td></td>
</tr>
<tr>
<td>1st</td>
<td>1st</td>
<td>1st</td>
<td>1st</td>
<td>1st</td>
<td>1st</td>
<td>1st</td>
<td>1st</td>
<td>1st</td>
<td>1st</td>
<td>1st</td>
</tr>
<tr>
<td>Siling Chinese economy (&lt;9%)</td>
<td>Siling Chinese economy (&lt;9%)</td>
<td>Financial crises</td>
<td>Chronic fiscal imbalances</td>
<td>Chronic fiscal imbalances</td>
<td>Extreme weather events</td>
<td>Extreme weather events</td>
<td>Extreme weather events</td>
<td>Extreme weather events</td>
<td>Extreme weather events</td>
<td></td>
</tr>
<tr>
<td>2nd</td>
<td>2nd</td>
<td>2nd</td>
<td>2nd</td>
<td>2nd</td>
<td>2nd</td>
<td>2nd</td>
<td>2nd</td>
<td>2nd</td>
<td>2nd</td>
<td>2nd</td>
</tr>
<tr>
<td>Chronic disease</td>
<td>Chronic disease</td>
<td>Complementary</td>
<td>Rising greenhouse gas emissions</td>
<td>Rising greenhouse gas emissions</td>
<td>Unemployment and underemployment</td>
<td>Failure of national governance</td>
<td>Failure of climate-change mitigation and adaptation</td>
<td>Major natural disasters</td>
<td>Cyber-attacks</td>
<td>Natural disasters</td>
</tr>
<tr>
<td>3rd</td>
<td>3rd</td>
<td>3rd</td>
<td>3rd</td>
<td>3rd</td>
<td>3rd</td>
<td>3rd</td>
<td>3rd</td>
<td>3rd</td>
<td>3rd</td>
<td>3rd</td>
</tr>
<tr>
<td>Global governance gaps</td>
<td>Global governance gaps</td>
<td>Biodiversity loss</td>
<td>Cyber-attacks</td>
<td>Water supply crises</td>
<td>Climate change</td>
<td>State collapse or regional conflict</td>
<td>Intensified conflict with regional consequences</td>
<td>Large-scale terrorist attacks</td>
<td>Data fraud or theft</td>
<td></td>
</tr>
<tr>
<td>Retrenchment from globalization</td>
<td>Retrenchment from globalization</td>
<td>Climate change</td>
<td>Water supply crises</td>
<td>Water supply crises</td>
<td>Climate change</td>
<td>Rapid and massive spread of infectious diseases</td>
<td>Weapons of mass destruction</td>
<td>Extreme weather events</td>
<td>Extreme weather events</td>
<td></td>
</tr>
<tr>
<td>5th</td>
<td>5th</td>
<td>5th</td>
<td>5th</td>
<td>5th</td>
<td>5th</td>
<td>5th</td>
<td>5th</td>
<td>5th</td>
<td>5th</td>
<td>5th</td>
</tr>
<tr>
<td>Oil and gas price spikes</td>
<td>Oil and gas price spikes</td>
<td>Food shortage crisis</td>
<td>Chronic fiscal imbalances</td>
<td>Water crises</td>
<td>Weapons of mass destruction</td>
<td>Water crises</td>
<td>Water crises</td>
<td>Extreme weather events</td>
<td>Extreme weather events</td>
<td></td>
</tr>
</tbody>
</table>

### Top 5 Global Risks in Terms of Impact

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset price collapse</td>
<td>Asset price collapse</td>
<td>Financial crises</td>
<td>Major systemic financial failure</td>
<td>Major systemic financial failure</td>
<td>Financial crises</td>
<td>Water crises</td>
<td>Failure of climate-change mitigation and adaptation</td>
<td>Weapons of mass destruction</td>
<td>Weapons of mass destruction</td>
<td>Weapons of mass destruction</td>
</tr>
<tr>
<td>1st</td>
<td>1st</td>
<td>1st</td>
<td>1st</td>
<td>1st</td>
<td>1st</td>
<td>1st</td>
<td>1st</td>
<td>1st</td>
<td>1st</td>
<td>1st</td>
</tr>
<tr>
<td>Retrenchment from globalization (developed)</td>
<td>Retrenchment from globalization (developed)</td>
<td>Climate change</td>
<td>Water supply crises</td>
<td>Water supply crises</td>
<td>Climate change</td>
<td>Rapid and massive spread of infectious diseases</td>
<td>Weapons of mass destruction</td>
<td>Extreme weather events</td>
<td>Extreme weather events</td>
<td></td>
</tr>
<tr>
<td>2nd</td>
<td>2nd</td>
<td>2nd</td>
<td>2nd</td>
<td>2nd</td>
<td>2nd</td>
<td>2nd</td>
<td>2nd</td>
<td>2nd</td>
<td>2nd</td>
<td>2nd</td>
</tr>
<tr>
<td>Oil and gas price spikes</td>
<td>Oil and gas price spikes</td>
<td>Geopolitical conflict</td>
<td>Food shortage crisis</td>
<td>Chronic fiscal imbalances</td>
<td>Water crises</td>
<td>Weapons of mass destruction</td>
<td>Water crises</td>
<td>Water crises</td>
<td>Natural disasters</td>
<td>Extreme weather events</td>
</tr>
<tr>
<td>3rd</td>
<td>3rd</td>
<td>3rd</td>
<td>3rd</td>
<td>3rd</td>
<td>3rd</td>
<td>3rd</td>
<td>3rd</td>
<td>3rd</td>
<td>3rd</td>
<td>3rd</td>
</tr>
<tr>
<td>Chronic disease</td>
<td>Chronic disease</td>
<td>Asset price collapse</td>
<td>Chronic fiscal imbalances</td>
<td>Chronic fiscal imbalances</td>
<td>Unemployment and underemployment</td>
<td>Intensified conflict with regional consequences</td>
<td>Large-scale involuntary migration</td>
<td>Major natural disasters</td>
<td>Failure of climate-change mitigation and adaptation</td>
<td></td>
</tr>
<tr>
<td>Financial crises</td>
<td>Financial crises</td>
<td>Extreme energy price volatility</td>
<td>Extreme volatility in energy and agriculture prices</td>
<td>Failure of climate-change mitigation and adaptation</td>
<td>Critical infrastructure breakdown</td>
<td>Failure of climate-change mitigation and adaptation</td>
<td>Severe energy price shock</td>
<td>Failure of climate-change mitigation and adaptation</td>
<td>Natural disasters</td>
<td></td>
</tr>
<tr>
<td>5th</td>
<td>5th</td>
<td>5th</td>
<td>5th</td>
<td>5th</td>
<td>5th</td>
<td>5th</td>
<td>5th</td>
<td>5th</td>
<td>5th</td>
<td>5th</td>
</tr>
</tbody>
</table>

Note: Global risks may not be strictly comparable across years, as definitions and the set of global risks have evolved with new issues emerging on the 10-year horizon. For example, cyber-attacks, income disparity and unemployment entered the set of global risks in 2012. Some global risks were reclassified: water crises and rising income disparity were re-categorized first as societal risks and then as a trend in the 2015 and 2016 Global Risks Reports, respectively.
The Global Risks Report 2019
14th Edition

In partnership with Marsh & McLennan Companies and Zurich Insurance Group
Prognosis
The Global Risks
Report 2019
14th Edition

In partnership with Marsh & McLennan Companies and Zurich Insurance Group
Prognosis


Note: Survey respondents were asked to select up to six pairs of global risks they believe to be most interconnected. See Appendix B for more details. To ensure legibility, the names of the global risks are abbreviation. See Appendix A for the full name and description.
Assessing the risk...

Homo sapiens have a huge amount of data and knowledge.

GLOBAL WARMING OF 1.5 °C

an IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.

Mammal diversity will take millions of years to recover from the current biodiversity crisis

Matt Davis, Søren Faurby, and Jens-Christian Svenning
PNAS published ahead of print October 15, 2018 https://doi.org/10.1073/pnas.1804056115

Climate-driven declines in arthropod abundance restructure a rainforest food web

Bradford C. Lister and Andres Garcia
PNAS published ahead of print October 15, 2018 https://doi.org/10.1073/pnas.1722477115
Exploring Possible Futures

- climate change:
  - extreme weather
  - global atmospheric warming
  - ocean warming
  - ocean acidification
  - sea level rise
- global disasters

- population growth
- economic growth
- land use, food and water security
- social and technological risks inc. wars)
- extinction
- governance
- pandemics

Methodology

- modeling and simulations
  - participatory modeling (*development of options*)
  - scenario-based modeling and simulations: *model validation, ensembles, selection of scenarios, not predictions*
- risk assessments:
  - risk perception and biases, comprehensiveness
  - based on past system behavior
Exploring Possible Futures

Prognosis

- climate change:
  - extreme weather
  - global atmospheric warming
  - ocean warming
  - ocean acidification
  - sea level rise
- global disasters

- population growth
- economic growth
- land use, food and water security
- social and technological risks inc. wars)
- extinction
- governance
- pandemics

Methodology

- modeling and simulations
  - participatory modeling (*development of options*)
  - scenario-based modeling and simulations: *model validation, ensembles, selection of scenarios, not predictions*
- risk assessments:
  - risk perception and biases, comprehensiveness
  - based on past system behavior
Prognosis
Our Commitment: The “~400 ppm CO₂ World”: 
Our Commitment: The “~400 ppm CO$_2$ World”:

Example: Mid-Pliocene, 3.3 to 3.0 Million Years ago
Temperature: ~1 - 2 °C higher
Sea level:
- global average on the order of 10 m higher than today
- regionally 5 to 40 m higher;
- most likely, much stronger storms due to larger temperature difference between tropics and polar regions
Example: Mid-Pliocene, 3.3 to 3.0 Million Years ago

Temperature: ~1 - 2 °C higher

Sea level:
- global average on the order of 10 m higher
- regionally 5 to 40 m higher
- most likely, much stronger storms due to larger temperature difference between regions

Hansen et al., 2016: “… Evidence … that 2°C global warming is highly dangerous.”

Prognosis
Prognosis

Exploring possible futures and developing foresight:
Broad range of futures

“Current State”

“Normal Range”
(800,000 years)
Prognosis

Exploring possible futures and developing foresight:
Broad range of futures

“Prognosis”

“Current State”

“Normal Range”
(800,000 years)
Prognosis

Exploring possible futures and developing foresight: How to present the futures?
Prognosis

Exploring possible futures and developing foresight: How to present the futures?
Prognosis

Exploring possible futures and developing foresight: How to present the futures?
Prognosis
"Yet in all societies, even those that are most vicious, the tendency to a virtuous attachment is so strong that there is a constant effort towards an increase of population” Malthus, 1798.
"That the increase of population is necessarily limited by the means of subsistence, That population does invariably increase when the means of subsistence increase, and, That the superior power of population is repressed, and the actual population kept equal to the means of subsistence, by misery and vice.”

Malthus, 1798.

"Yet in all societies, even those that are most vicious, the tendency to a virtuous attachment is so strong that there is a constant effort towards an increase of population” Malthus, 1798.
"Yet in all societies, even those that are most vicious, the tendency to a virtuous attachment is so strong that there is a constant effort towards an increase of population” *Malthus, 1798.*

“That the increase of population is necessarily limited by the means of subsistence, That population does invariably increase when the means of subsistence increase, and, That the superior power of population is repressed, and the actual population kept equal to the means of subsistence, *by misery and vice.*”

*Malthus, 1798.*

Lovelock: Carrying Capacity will be down to 1 Billion in 2050
Key Points

Baseline
During the Holocene, climate and sea level were exceptionally stable
The Holocene was a “safe operating space for humanity”

Syndrome
During the last few hundred years, humanity has introduced rapid and large changes
The system is outside the “normal range” and in the dynamic transition into the Post-Holocene; we have increasing disequilibrium

Diagnosis
A consumption-based economy combined with easy access to energy caused humans to accelerate flows in the Earth’s life-support system and sustain rapid population growth.
Modern humans are the “Anthropogenic Cataclysmic Virus” (ACV) in the Earth’s life-support system

Prognosis
We are heading rapidly into a very different system state (tipping points; Post-Holocene)
Our knowledge is changing rapidly; there is room for surprises; Foresight is needed
Mitigation and Adaptation Studies

Class 4: The Syndrome of Modern Global Change: Diagnosis, Prognosis, Therapy

Contents:
- Baseline
- Syndrome
- Diagnosis (continued from class 3)
- Prognosis
- Therapy

Also: Systems - Introduction
Therapy

Earth’s Life-Support System

FLOWS

SOCIETY
Therapy

Earth’s Life-Support System

FLOWS

SOCIETY
Therapy

For Homo sapiens, flows are regulated by
- ethics,
- social norms,
- economic rules
- Purpose of economy is to increase human wealth;
- Earth and its natural wealth is basically infinite.

Smith (1776)
Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

WCED (1987)

- Purpose of economy is to increase human wealth;
- Earth and its natural wealth is basically infinite.

Smith (1776)

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs”.

WCED (1987)
Sustainable Development is a development that meets the needs of the present while safeguarding Earth’s life support systems, on which the welfare of current and future generations depends.

Griggs et al. (2013)

Purpose of economy is to increase human wealth; Earth and its natural wealth is basically infinite.

Smith (1776)

“Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs”.

WCED (1987)

“Sustainable Development is a development that meets the needs of the present while safeguarding Earth’s life support systems, on which the welfare of current and future generations depends.”

Griggs et al. (2013)
Sustainable Development is a development that meets the needs of the present while safeguarding Earth’s life support systems, on which the welfare of current and future generations depends.

- Purpose of economy is to increase human wealth;
- Earth and its natural wealth is basically infinite.

*Smith (1776)*

'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs”.

*WCED (1987)*

“Sustainable Development is a development that meets the needs of the present while safeguarding Earth’s life support systems, on which the welfare of current and future generations depends.”

*Griggs et al. (2013)*
During the Holocene, climate and sea level were exceptionally stable. The Holocene was a “safe operating space for humanity.”

**Key Points**

**Baseline**
During the last few hundred years, humanity has introduced rapid and large changes. The system is outside the “normal range” and in the dynamic transition into the Post-Holocene; we have increasing disequilibrium.

**Syndrome**
A consumption-based economy combined with easy access to energy caused humans to accelerate flows in the Earth’s life-support system and sustain rapid population growth. Modern humans are the “Anthropogenic Cataclysmic Virus” (ACV) in the Earth’s life-support system.

**Diagnosis**
We are heading rapidly into a very different system state (tipping points; Post-Holocene). Our knowledge is changing rapidly; there is room for surprises; Foresight is needed.

**Prognosis**
Change in the purpose of economy from growing human wealth (growth addiction) to meeting our needs while safeguarding the life-support system.
Mitigation and Adaptation Studies

Class 4: The Syndrome of Modern Global Change: Diagnosis (continued), Prognosis, Therapy

Also: Systems - Introduction
Systems
Systems

• are networks of interdependent components and processes, with *materials* and *energy* flowing from one component of the system to another.
  – *Together have properties beyond those of individual parts*

• Central concept in environmental science.

• **Examples**: ecosystems, climates systems, geologic systems, economic systems
Components of a System

- **State Variables** store resources such as matter or energy or have the pathways through which these resources move from one state variable to another.
System Characteristics

• A System can be closed or open.
  – **Open** – exchanges matter and energy with surroundings
  – **Closed** - self contained, exchanges no matter or energy with the outside

• **Throughput** – the energy and matter that flow into, through, and out of a system
Systems involve feedback loops

- **Negative feedback loop** = system changes and moves in one direction; that movement acts as an output, and as an input back into the system; the input then moves the system in the other direction
- Input and output *neutralize* one another
  - Stabilizes the system
  - Example: body temperature
- **Most** systems in nature
Systems involve feedback loops

- **Negative feedback loop** = system changes and moves in one direction; that movement acts as an output, and as an input back into the system; the input then moves the system in the other direction
- Input and output **neutralize** one another
  - Stabilizes the system
  - Example: body temperature
- **Most** systems in nature
Systems involve feedback loops

- **Positive feedback loop** = system output causes the system to change in the *same way* and drives it *further* toward one extreme or another
  - Example: exponential population growth, spread of cancer, melting sea ice

- **Rare** in nature
  - *But is common in natural systems altered by humans*
Systems show several defining properties

- **Dynamic equilibrium** = when system processes move in opposing directions; balancing their effects
- **Homeostasis** = when a system maintains constant (stable) internal conditions
System Characteristics

Dynamic equilibrium
Emergent properties

- **Emergent properties** = system characteristics that are not evident in the components alone
  - The whole is more than the sum of the parts

*It is hard to fully understand systems; they connect to other systems and do not have sharp boundaries*
Stability of Systems

- **Disturbance** - periodic destructive events such as fire or flood that destabilize or change the system
- **Resilience** - ability of system to recover from disturbance
- **State Shift** - a severe disturbance in which the system does not return to normal but instead results in significant changes in some of its state variables
Stability of Systems

- **State Shift** – a severe disturbance in which the system does not return to normal but instead results in significant changes in some of its state variables.