Mitigation and Adaptation Studies

Class 18: Knowing the Hazards: Climate Hazards, Public Health, Food-Water-Energy Nexus
Class 19: Foresight

Contents:
- Preliminaries
- Climate Change and Sea Level Hazards
  - Observing the Planet
  - Detecting Changes
  - Assessing Knowledge
  - Understanding the Processes and Causes
  - Having Foresight
- Public Health
- Food-Water-Energy Nexus
Climate Change and Sea Level Hazards

Questions:
- How well do we know the past and current changes?
- How well do we understand the processes and causes?
- How are the hazards potentially going to impact human and non-human systems?
- To what extent can we predict or anticipate future changes?
- Do we have foresight in terms of what might happen?

Changes in means:
- air temperature
- precipitation
- wind field/circulation
- evapotranspiration
- humidity
- soil moisture
- permafrost
- sea and lake levels
- inundation
- river runoff
- desertification
- ice and snow cover

Changes in extremes:
- Storms (hurricanes, typhoons, tornados, thunderstorms)
- Floods
- Droughts
- Heat Waves
- Ice storms and snow fall

Changes in dynamics and chemistry:
- ocean circulation
- atmospheric circulation
- ocean temperature
- ocean acidification
- soil, air and water chemistry

Changes in biosphere:
- ecosystem health and services
- migration
- invasive species
- extinction
Climate Change and Sea Level Hazards

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Understanding the Processes
What causes the sea level to change?

- Terrestrial water storage, extraction of groundwater, building of reservoirs, changes in runoff, and seepage into aquifers
- Subsidence in river delta region, land movements, and tectonic displacements
- Surface and deep ocean circulation changes, storm surges
- As the ocean warms, the water expands
- Exchange of the water stored on land by glaciers and ice sheets with ocean water

SYR - FIGURE 3-4
Local Sea Level: *vertical distance between sea surface and land surface*

Local Sea Level (LSL) changes = Sea Surface Height (SSH) changes - Land surface height (LSH) changes.

$$LSL(x,t) = SSH(x,t) - LSH(x,t)$$
Understanding the Processes

\[ LSL = \text{short-period part} + \text{long-period part} \]

Separation at a period of about 2 months:

**High-frequency part** of LSL equation:

\[ h_{hf}(t) = w(t) + h_{tidal}(t) + h_{atmos}(t) + h_{seiches}(t) + h_{tsunami}(t). \]

Important for projection of maximum flood levels

Short-period variations are the result of local to regional processes

**Low-Frequency part** of the LSL equation:

\[
\delta h_{lf}(\vec{x}, t) = N(\vec{x}, t) + S(\vec{x}, t) + C(\vec{x}, t) + F(\vec{X}, t) + A(\vec{x}, t) + \]
\[
I(\vec{x}, t) + G(\vec{x}, t) + T(\vec{x}, t) + P(\vec{x})(t - t_0) + \]
\[
V_0(\vec{x})(t - t_0) + \delta V(\vec{x}, t) + \Omega(\vec{x}, t) \]

\( N \): nodal tide
\( S \): steric changes
\( C \): changes in ocean currents
\( A \): changes in atmospheric circulation
\( F \): freshening
\( I \): changes in the mass of the large ice sheets
\( G \): changes in continental glaciers
\( T \): changes in terrestrial hydrosphere
\( P \): postglacial rebound
\( V_0 \): secular vertical land motion
\( \delta V \): non-linear vertical land motion
\( B \): changes in shape and extent of ocean basins.

Comments on the relation between mass changes (exchange and redistribution) and LSL

Important for projections of LSL

Long-period variations are the result of local to global processes
Understanding the Processes

Sea level equation (Farrell & Clark, 1976)

\[
\xi(\vartheta, \lambda, t) = c(t) + O(\vartheta, \lambda, t) \int_{-\infty}^{t} \int_{0}^{\pi} \int_{0}^{2\pi} G(\vartheta, \lambda, \vartheta', \lambda', t - t') \\
\frac{d}{dt'} \left\{ O(\vartheta', \lambda', t') \rho_W \xi(\vartheta', \lambda', t') + [1 - O(\vartheta', \lambda', t')] \rho_L \eta(\vartheta', \lambda', t') \right\} \sin \vartheta' d\lambda' d\vartheta' dt'.
\]

\(\xi\): local sea level change (distance to the deformable solid Earth surface),

\(G\): Green's function for sea level,

\(O\): ocean function,

\(\eta\): cumulated water/ice load change due to mass added or removed from land,

\(\rho_W\) and \(\rho_L\): densities of the ocean water and the load (water or ice), respectively,

\(c(t)\): quantity to ensure mass conservation.
Understanding the Processes

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All mass movements:
- change the geoid
- displace the ocean bottom vertically
- redistribute the water masses in the ocean

Load on land areas

Load on ocean areas
Understanding the Processes

Fingerprints of the large ice sheets

Plag and Juettner, 2001
Understanding the Processes

postglacial sea levels

steric changes

Greenland

Antarctica

Plag, 2006
Understanding the Processes

- Postglacial sea levels
- Steric changes
- Tide gauges

Greenland

Antarctica
Understanding the Processes

**postglacial sea levels**

**steric changes**

**tide gauges**

**Greenland**

**Antarctica**

**reconstructed LSL**

Greenland Ice sheet contribution: 0.3 - 0.5 mm/yr

Antarctica Ice sheet contribution: 0.1 - 0.3 mm/yr

Example global average: 1.14 mm/yr at tide gauges
0.90 mm/yr global average
Climate Change and Sea Level Hazards

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Causes
Understanding the Causes
The Intergovernmental Panel on Climate Change (IPCC) is the leading international body for the assessment of climate change. It was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) to provide an authoritative international assessment of the scientific aspects of climate change, based on the most recent scientific, technical and socio-economic information published worldwide. The IPCC's periodic assessments of the causes, impacts and possible response strategies to climate change are the most comprehensive and up-to-date reports available on the subject, and form the standard reference for all concerned with climate change in academia, government and industry worldwide. This Synthesis Report is the fourth element of the IPCC Fifth Assessment Report, Climate Change 2013/2014. More than 800 international experts assessed climate change in this Fifth Assessment Report. The three Working Group contributions are available from the Cambridge University Press:

Climate Change 2013 – The Physical Science Basis
Contribution of Working Group I to the Fifth Assessment Report of the IPCC

Climate Change 2014 – Impacts, Adaptation, and Vulnerability
Contribution of Working Group II to the Fifth Assessment Report of the IPCC

Climate Change 2014 – Mitigation of Climate Change
Contribution of Working Group III to the Fifth Assessment Report of the IPCC

This Summary for Policymakers is based on the assessments carried out by the three Working Groups of the IPCC and written by a dedicated Core Writing Team of authors. It provides an integrated assessment of climate change and addresses the following topics:

• Observed changes and their causes
• Future climate changes, risks and impacts
• Future pathways for adaptation, mitigation and sustainable development
• Adaptation and mitigation
Understanding the Causes

C. Drivers of Climate Change

Natural and anthropogenic substances and processes that alter the Earth’s energy budget are drivers of climate change. Radiative forcing (RF) quantifies the change in energy fluxes caused by changes to the drivers for 2011 relative to 1750, unless otherwise indicated. Positive RF leads to surface warming, negative RF leads to surface cooling. RF is estimated based on its site and remote observations, properties of greenhouse gases and aerosols, and calculations using numerical models representing observed processes. Some emitted compounds affect the atmospheric concentration of other substances. The RF can be reported based on the concentration changes of each substance. Altogether, the emission-based RF of a component can be reported, which provides a more direct link to human activities. It includes contributions from all substances affected by that emission. The total anthropogenic RF of the two approaches are identical when considering all drivers. Though both approaches are used in this Summary for Policymakers, emission-based RFs are emphasized.

Total radiative forcing is positive, and has led to an uptake of energy by the climate system. The largest contribution to total radiative forcing is caused by the increase in the atmospheric concentration of CO₂ since 1750 (see Figure SPM.1). (1.2, 3.7, 8.1, 8.5)

- The total anthropogenic RF for 2011 relative to 1750 is 2.29 (1.13 to 3.33) W m⁻² (see Figure SPM.3), and it has increased more rapidly since 1970 than during prior decades. The total anthropogenic RF best estimate for 2011 is 4.9% higher than that reported in AR4 for the year 2007. This is caused by a combination of continued growth in most greenhouse gas concentrations and improved estimates of RF by aerosols indicating a weaker net cooling effect (negative RF). (8.5)

- The RF from emissions of well-mixed greenhouse gases (CO₂, CH₄, N₂O, and Halocarbons) for 2011 relative to 1750 is 2.06 (2.22 to 3.78) W m⁻² (see Figure SPM.3). The RF from changes in concentrations in these gases is 2.83 (2.26 to 3.48) W m⁻². (8.3)

- Emissions of CO₂ alone have caused an RF of 1.68 (1.33 to 2.03) W m⁻² (see Figure SPM.5). Including emissions of other carbon-containing gases, which also contributed to the increase in CO₂ concentrations, the RF of CO₂ is 1.82 (1.46 to 2.18) W m⁻². (8.1, 8.5)

- Emissions of CH₄ alone have caused an RF of 0.57 (0.44 to 0.70) W m⁻² (see Figure SPM.5). This is much larger than the concentration-based estimate of 0.48 (0.38 to 0.68) W m⁻² (unchanged from AR4). This difference in estimates is caused by concentration changes in ocean and stratospheric water vapor due to CH₄ emissions and other emissions indirectly affecting CH₄. (8.3, 8.5)

- Emissions of stratospheric ozone-depleting halocarbons have caused a net positive RF of 0.18 (0.01 to 0.35) W m⁻² (see Figure SPM.5). Their own positive RF has outweighed the negative RF from the ozone depletion that they have induced. The positive RF from all halocarbons is similar to the value in AR4, with a reduced RF from CFCs but increases from many of their substitutes. (8.3, 8.5)

- Emissions of short-lived gases contribute to the total anthropogenic RF. Emissions of carbon monoxide (CO) are variably certain to have induced a positive RF, while emissions of nitrogen oxides (NOₓ) are likely to have induced a net negative RF (see Figure SPM.5). (8.3, 8.5)
Understanding the Causes
Understanding the Causes

Globally averaged greenhouse gas concentrations

- Ice cores
- Atmospheric measurements

Global anthropogenic CO₂ emissions

Quantitative information of CH₄ and N₂O emission time series from 1850 to 1970 is limited

Year

(ГtCO₂/yr)
Understanding the Causes

Greenhouse gas emissions by economic sectors

- **Electricity and heat production**: 25%
- **AFOLU**: 24%
- **Buildings**: 6.4%
- **Transport**: 14%
- **Industry**: 21%
- **Other energy**: 9.6%
- **Energy**
  - Direct GHG emissions
  - Indirect CO₂ emissions
  - Total: 49 Gt CO₂-eq (2010)
  - Energy: 1.4%
  - Industry: 11%
  - Transport: 0.3%
  - Buildings: 12%
  - AFOLU: 0.87%
Understanding the Causes

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Class 18: Knowing the Hazards: Climate Hazards, Public Health, Food-Water-Energy Nexus
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Mitigation and Adaptation Studies

Questions and Conclusions:
- How well do we understand past and current changes:
  - We have comprehensive observations that document the variability of the system
  - Detecting changes in dynamics and system state is nevertheless difficult due to large variability
  - Knowledge about changes in variables and underlying processes is evolving rapidly
- How well do we understand the processes?
- How well can we anticipate future changes
- Do we have sufficient foresight in terms of what might happen?

Class 18: Knowing the Hazards: Climate Hazards, Public Health, Food-Water-Energy Nexus
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Mitigation and Adaptation Studies

Class 19: Developing Foresight

Contents
- The Role of Paradigms
- Uncertainty or Probability?
- Foresight and Foreseeability
- Foresight, Foreseeability, and Decision Making
The Role of Paradigms
The Role of Paradigms

Oxford English Dictionary: a paradigm is "a typical example or pattern of something; a pattern or model"

Kuhn (1962). The Structure of Scientific Revolutions:
- Sciences go through alternating periods of normal science (existing model of reality dominates a period of puzzle-solving), and revolution (the model of reality itself undergoes sudden drastic change).
- Paradigms have two different aspects in periods of normal science and scientific revolution
- Normal science: paradigm refers to a set of exemplary experiments that are likely to be copied or emulated. Underpinning this set are shared preconceptions, made prior to – and conditioning – the collection of evidence. These preconceptions embody quasi-metaphysical hidden assumptions and elements, although the interpretations of the paradigm may vary among individual scientists. Conviction that the current paradigm is reality tends to disqualify evidence that might undermine the paradigm itself. This leads to unreconciled anomalies.
- Scientific Revolution: The unreconciled anomalies eventual lead to a revolutionary overthrow of the incumbent paradigm, and its replacement by a new one: paradigm shift. Comparable to the perceptual change that occurs when the interpretation of an ambiguous image shifts from one state to another.
The Role of Paradigms
Knowing the “paradigms”, “immutable truths”
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James Balog, 2013:

- “Slavery is necessary”
- “Child work is acceptable”
- “Women should not vote”
Knowing the “paradigms”, “immutable truths”

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Recent “immutable truths”:
• The oceans are invincible …
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Living Blue Planet Report 2015

DATE: September 15, 2015

THIS PUBLICATION RELATES TO:
- Ocean Habitat
- Overfishing
- Oil and Gas Development
- Oceans

WWF’s Living Blue Planet Report takes a deep look at the health of our oceans and the impact of human activity on marine life. Data on marine ecosystems and human impacts upon them is limited, reflecting the lack of attention the ocean has received to date. Nevertheless, the trends shown here present a compelling case for action to restore our ocean to health.

Knowing the “paradigms”, “immutable truths”

James Balog, 2013:
• “Slavery is necessary”
• “Child work is acceptable”
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Recent “immutable truths”:
• The oceans are invincible …
• Growth is necessary for economic prosperity

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Mitigation and Adaptation Studies

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Uncertainty or Probability?
“**A good understanding of the climate system** is essential to allow society to prepare for the future. Increasing populations, diminishing resources, changing weather patterns and extreme events in combination with water scarcity and changing crop yields will all put pressure on communities. The only sure thing is that the climate and weather in the coming years will continue to have a **degree of uncertainty and surprise us.**”

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Aleatoric uncertainties: statistical uncertainties
Epistemic uncertainties: systemic uncertainties, including knowledge gaps
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Aleatoric uncertainties: statistical uncertainties
Epistemic uncertainties: systemic uncertainties, including knowledge gaps

Complex systems:
Aiming at understanding (foreseeing) what the system might do, instead of trying to predict (with uncertainty) what it will do …
Uncertainty or Probability?
Decision Making:

Half full or half empty?
Decision Making:

Half full or half empty?

Focus on what we don’t know, uncertainty

What we don’t know

Our knowledge

Uncertainty or Probability?
Decision Making:

<table>
<thead>
<tr>
<th>Half full or half empty?</th>
<th>Glass of knowledge</th>
</tr>
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What we don’t know

Focus on what we don’t know, uncertainty

Our knowledge
Decision Making:

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Uncertainty or Probability?

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What we don’t know
Uncertainty or Probability?

Decision Making:

Half full or half empty?  Glass of knowledge  What we don’t know

Focus on what we don’t know, uncertainty

Our knowledge

Using what we know to develop foresight
WORKING WITH A CHANGING CLIMATE, NOT AGAINST IT
PROJECT REPORT

Hydro-Meteorological Disaster Risk Reduction:
A Survey of Lessons Learned for Resilient Adaptation
to a Changing Climate

Is Resilience the key?

http://icw.com/articles/2013/07/08/
ergetech-operational-resilience.aspx

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Liz Wiig, Bevan Driver, Mark Ferrara
Working with a Changing Climate, not against it

PROJECT REPORT

Hydro-Meteorological Disaster Risk Reduction: A Survey of Lessons Learned for Resilient Adaptation to a Changing Climate

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Actions based on one's perceptions of reality have real consequences.
WORKING WITH A CHANGING CLIMATE, NOT AGAINST IT

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Is Resilience the key?

SOURCE: www.forbes.com

Self-Perception and Perception of the World

Actions based on one's perceptions of reality have real consequences.
Before delving into the existential vs sub-existential and sexy vs unsexy dichotomies, it is useful to consider three cognitive weaknesses that hinder recognition, engagement and rational responses to GCRs: probabilistic thinking, caring about people we cannot see and valuing the future.

First, and stating the obvious, GCRs are risks. Engaging with risks of any kind requires probabilistic thinking, at which human beings in general are notoriously poor (Dawes, 2001; Tversky & Kahneman, 1974). We tend to inappropriately focus on specific rather than general information, neglecting base rates (Tversky and Kahneman, 1982; Welsh and Navarro, 2012). We are prone to overestimating the probability of positive events and underestimating the likelihood of negative ones (Sharot, 2011), in particular when predicting what will happen to ourselves (Weinstein and Klein, 1995; Weinstein, 1980, 1989) or those we care about (Kappes et al., 2018). We tend to be particularly optimistic in predicting outcomes that will not be known for some time (Armor & Taylor, 2002, pp. 339-340), and our optimistic beliefs tend to persevere even in the face of contrary evidence (Garrett and Sharot, 2017). Faced with information about a risk, we tend to assume that it will not actually materialise, or that its consequences will not really be catastrophic.
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Peter Bishop, 2017, Fast Future Publishing
Foresight and Foreseeability
Foreseeability

n. reasonable anticipation of the possible results of an action, such as what may happen if one is negligent or consequential damages resulting from breach of a contract.

The facility to perceive, know in advance, or reasonably anticipate that damage or injury will probably ensue from acts or omissions.

In the law of **Negligence**, the foreseeability aspect of proximate cause—the event which is the primary cause of the injury—is established by proof that the actor, as a person of ordinary intelligence and circumspection, should reasonably have foreseen that his or her negligent act would imperil others, whether by the event that transpired or some similar occurrence, and regardless of what the actor surmised would happen in regard to the actual event or the manner of causation of injuries.

*West's Encyclopedia of American Law, edition 2. Copyright 2008 The Gale Group, Inc. All rights reserved.*
Foresight and Foreseeability
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In his law dictionary, Gifis (1991, 195–196) writes that “Foreseeability encompasses not only that which the defendant foresaw, but that which the defendant ought to have foreseen.”
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Foresight and Foreseeability

ABo UtLessons LeAned

Why:
Philosopher Santana was noted as having said, “Those who do not learn from history are doomed to repeat it.” There are now variations on this theme, uttered by famous as well as the not so famous individuals, but the core message remains: people must know history in order to learn from it. People around the globe, through trial and error, have forever been learning tactical and strategic responses to their local and regional hydro-meteorological hazards and disasters. Much of what they have learned in their local environments could be of value to others facing similar hazards and disasters far away.
"Lessons learned" instead of "Lessons noted"

Foresight and Foreseeability

ABOUT LESSONS LEARNED

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Comparison of world population projections
Projections from 2015 onwards depict different fertility variants

Source: UN Population Division (2017 revision), HYDE
CC BY

https://ourworldindata.org/future-population-growth
Foresight and Foreseeability

Population Growth

"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.

Carrying Capacity = function of: Arable Land, Nitrogen, Phosphorous, Climate, Water, Biodiversity, Land Use, Energy, Degradation, Technology, ...

\[ CC = f(A, N, P, C, W, B, L, E, D, T, ...) \]

\[ C = f(E, L, ...) \]

\[ W = f(C, L, E, D, ...) \]

"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

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Population Growth

Millions in South Sudan in Urgent Need of Food, U.N.

Why 20 Million People Are on Brink of Famine in a ‘World of Plenty’

Africa hit by worst famine crisis, 20 million people face death

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Population Growth Foresight and Foreseeability
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By JEFFREY GETTLEMAN  FEB 20, 2017

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

The world faces the largest humanitarian crisis since the United Nations was founded in 1945 with more than 20 million people in four African countries facing starvation and famine, the U.N. humanitarian chief warned.
Foresight and Foreseeability

Population Growth

1. MIGRANT POPULATION (STOCKS)

258 Million
INTERNATIONAL MIGRANTS were counted globally in 2017 - people residing in a country other than their country of birth. This represented 3.4% of the world's total population.

6. DISPLACEMENT

68.5 Million
INDIVIDUALS were forcibly displaced worldwide due to persecution, conflict, generalized violence, human rights violations, or other reasons by the end of 2017.

11. TRAFFICKING & MODERN SLAVERY

25 Million
VICTIMS OF FORCED LABOUR were estimated in 2016. Out of those, 5 million may have crossed an international border.

16. ENVIRONMENT

18.8 Million
PEOPLE in 135 countries were newly displaced by sudden-onset disasters within their own countries in 2017.
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Death toll of World War 2: 50 - 80 million
Foresight and Foreseeability

Land use changes
Foresight and Foreseeability

Land use changes

- Percentage of lightly affected ecosystems
- Percentage of Earth’s terrestrial ecosystems that show state shifts

Global ecological state:
- Present: ~650 million people, ~1 billion people, 1.65 billion, 2.52 billion, 7.00 billion, 8.20 billion, 9.00 billion

Future:
- Low: Critical transition as increased emergent global forcings reach threshold values that rapidly change all of Earth’s ecosystems
- High: 2025, 2045

Global forcing:
- Generally increases with human population size
Hazards and Disasters

Loss events worldwide 1980 – 2013

Number of events

- Geophysical events (Earthquake, tsunami, volcanic eruption)
- Meteorological events (Tropical storm, extratropical storm, convective storm, local storm)
- Hydrological events (Flood, mass movement)
- Climatological events (Extreme temperature, drought, forest fire)

© 2014 Münchener Rückversicherungs-Gesellschaft, Geo Risks Research – As at January 2014
Foresight and Foreseeability

Climate Change

“Normal Range”
(800,000 years)

“Current State”

“Prognosis”
Foresight and Foreseeability

Climate Change
Foresight and Foreseeability

Climate Change

What are the Impacts of Climate Change?
Foresight and Foreseeability

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Foresight and Foreseeability

Climate Change

What are the Impacts of Climate Change?

... and there is more:
- health
- supply chains
- mass extinction
- water security
- food security
- migration
- social unrest
...
How global warming is adding to the health risks of poor people

January 27, 2019 4.14am EST
Humanitarian response

Cyclone Idai crisis deepens as first cases of cholera confirmed in Mozambique

Five people test positive for waterborne disease in flooded port city of Beira amid warnings outbreak will spread

▲ Residents survey the devastation caused by Cyclone Idai in the Mozambican city of Beira, where fears of a cholera outbreak have been realised. Photograph: Karel Prinsloo/DEC
Foresight and Foreseeability
Food-Water-Energy Nexus

World Energy Perspectives | 2016

KEY FINDINGS

1. **ENERGY IS THE SECOND LARGEST FRESHWATER USER** after agriculture. Water is used all along the energy value chain in primary energy production (coal, oil, gas, biofuels) and in power generation (hydro, cooling). 98% of the power currently produced needs water.

2. **THE RISKS POSED BY THE ENERGY-WATER-FOOD NEXUS WILL BECOME MORE SIGNIFICANT** because of growing demand for energy, water and food. Moreover, some of the regions that are currently water stressed are also likely to see significant economic development, population growth and changing consumption patterns, and a higher concentration of people and assets in critical areas, intensifying the risks posed by the nexus.

3. **ALONGSIDE GROWING DEMAND, INCREASING UNCERTAINTY ABOUT WATER AVAILABILITY and quality** – driven by climate change impacts such as declining freshwater availability, increased ocean temperatures and more extreme weather – will further increase the significance of risks posed by the nexus.

4. **ANALYSIS IN NATURE CLIMATE CHANGE** highlights that from 2014 to 2069, reductions in usable water capacity could impact two-thirds of the 24,515 hydropower plants analysed and more than 90% of the 1,427 thermal electric power plants assessed.

5. **IN MANY CASES, THERE IS A LACK OF LOCATION-SPECIFIC KNOWLEDGE ON WATER ISSUES** and a lack of modelling tools to adequately reflect risks posed by the nexus in energy infrastructure investment decisions. Such risks can be associated with large economic stakes: in 2015, hydropower facilities in Brazil sustained economic losses of more than US$4.3 billion due to drought-related energy and water rationing measures.

6. **THE RISKS POSED BY THE NEXUS ARE OFTEN EXACERBATED** by the lack of sound water governance such as well-defined water rights for competing users, water pricing and trading arrangements.

7. **CROSS-BORDER COOPERATION IS A KEY ISSUE.** 261 international trans-boundary basins cover 45% of the earth’s land surface, serve 40% of the world’s population and provide 60% of the earth’s entire freshwater volume. This affects the operation of planned and proposed energy infrastructures, and there is a need to ensure that adequate cross-border water management frameworks are in place.
Interconnection between hazards can only be understood in a systems thinking approach.

The plants, animals, and micro-organisms that are the bedrock of food production are in decline, according to a UN study.
Mitigation and Adaptation Studies

Class 19: Developing Foresight

Contents
- The Role of Paradigms
- Uncertainty or Probability?
- Foresight and Foreseeability
- Foresight, Foreseeability, and Decision Making
Foresight, Foreseeability, and Decision Making

What Works

Case Studies in the Practice of Foresight

Sohail Inayatullah
Futures study is the systematic study of preferred, probable, and possible futures including the worldviews and myths that underlie each future. Futures research has moved from external forces influencing the future—astrology and prophecy—to structure (historical patterns of change, of the rise and fall of nations and systems) and agency (the study and creation of preferred images of the future).

Futures studies has been eagerly adopted by planning departments in organizations and nations. Yet there are clear differences between the planning and futures framework. Planning seeks to control and close the future, while futures studies seeks to open up the future, moving from the future to alternative futures.

Inayatullah, 2013
From a focus on **predicting the future**, the modern discipline of futures studies has broadened to an **exploration of alternative futures** and deepened to investigate the worldviews and mythologies that underlie possible, probable and preferred futures.
From a focus on predicting the future, the modern discipline of futures studies has broadened to an exploration of alternative futures and deepened to investigate the worldviews and mythologies that underlie possible, probable and preferred futures.

To understand the future(s), one needs a cogent theoretical framework. Four approaches are crucial to foresight (Inayatullah, 1990). The first is predictive, based on empirical social sciences. The second is interpretive, based not on forecasting the future but on understanding competing images of the future. The third is critical, derived from poststructural thought and focused on asking who benefits by the realisation of certain futures and which methodologies privilege certain types of futures studies. While truth claims are eschewed, the price of epistemology is not: every knowledge decision privileges reality in particular ways (Shapiro, 1992; Foucault, 1973). The fourth approach is participatory action learning/research. This approach is far more democratic and focuses on stakeholders developing their own future, based on their assumptions of the future (for example, if the future is linear or cyclical) and what is critical to them (Inayatullah, 2007).
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The six pillars provide a theory of futures thinking that is linked to methods and tools, and developed through praxis. The pillars are: mapping, anticipation, timing, deepening, creating alternatives and transforming.
Foresight, Foreseeability, and Decision Making
Foresight, Foreseeability, and Decision Making

Tropical Forests in the Anthropocene

Yadvinder Malhi, Toby A. Gardner, Gregory R. Goldsmith, Miles R. Silman, and Przemyslaw Zelazowski
Foresight, Foreseeability, and Decision Making

"Wizard Clairvoyant" Exploring the Future with Simulations

I have a goal

Options

Models

Scientific knowledge

Transformation Scientists

Policy Maker

Economist

Engineer

Natural Scientist

Social Scientist

Ethicist

Plag, 2016
Foresight, Foreseeability, and Decision Making
Decision Making Under Uncertainty (DMUU):
Planning and preparing for a (somewhat) predictable future

• Choose a range of plausible trajectories (for droughts, heat waves, sea level rise, extreme events, ...)
• Determine the range of risks to be reduced based on these trajectories and vulnerabilities
• Adapt land use, building codes, protective measures accordingly
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Decision Making Under Foreseeability (DMUF):
Anticipating and preparing for surprises, developing general resilience

Imagining the “worst case” and facilitating adaptation to unpredictable future:
• understanding the vulnerabilities and comprehensively assessing the risks
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How do we assess, and plan for, events that have never happened?
Knowing the paradigms our knowledge creations and decision making are based on ...
Decision Making Under Foreseeability (DMUF): Having Foresight

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Abrupt changes are happening (e.g., Arctic sea ice, biodiversity); more likely to come.
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Paradigm shift to overcome normalcy bias:
Instead of
“Sea level is stable and coastlines don’t move”
(last 6,000 years) assume
“Sea level is variable and coastlines can migrate fast”