Climate Change Uncertainty and Risk: from Probabilistic Forecasts to Economics of Climate Adaptation

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Schedule (1/2)

1) 20.2.2017 Logistics, Introduction to probability, uncertainty and risk management  
2) 27.2.2017 Predictability of weather and climate, seasonal prediction, seamless prediction (Reto via skype)  
   Exercise 1 Toy Model  
3) 6.3.2017 Detection/attribution, forced changes, natural variability, signal/noise, ensembles (Reto via skype)  
4) 13.3.2017 Probabilistic risk assessment model: from concept to concrete application - and some insurance basics  
   Exercise 2 Toy Model  
5) 20.3.2017 Model evaluation, multi model ensembles and structural error combined with: Model calibration, Bayesian methods for probabilistic projections (Reto via skype)  
6) 27.3.2017 Toy Model presentation (8-10h, thus no lecture)  
7) 3.4.2017 Climate change and impacts, scenarios, use of scenarios, scenario uncertainty vs response/impact uncertainty  
   Exercise 3 climada – intro step-by-step, damage calculation
Schedule (2/2)

8) 10.4.2017 Basics of economic evaluation and economic decision making in the presence of climate risk
   Exercise 4 climada – dealing with uncertainty and effect of insurance

17.4.2017 *Easter Monday and no lectures this week*

9) 24.4.2017 The cost of adaptation - application of economic decision making to climate adaptation in developing and developed region
   Exercise 5 climada – climate scenario, economic growth and adaptation

1.5.2017 *Labor day*

10) 8.5.2017 Shaping climate-resilient development – valuation of a basket of adaptation options
   Exercise 6 climada – preparation of presentation

11) 15.5.2017 "Reflect on what we covered so far" - open questions and issues
   Presentation preparation (facultative exercise hour)

12) 22.5.2017 climada presentations - **look into open questions and issues**

13) 29.5.2017 climada presentations - plus course wrap-up

Final written report (2 exercises, presentation) due Friday 23 June 2017
More than twenty Economics of Climate Adaptation (ECA) studies worldwide

- **US Gulf Coast:** Hurricane risk to the energy system
- **New York:** Cyclones and surge risk to a metropolis
- **Hull, UK:** Flood and storm risk to urban property
- **China:** Drought risk to agriculture
- **Bangladesh:** Flood risk to a fast-developing city
- **Florida:** Hurricane risk to public and private assets
- **El Salvador:** Flood and landslide risk to vulnerable people
- **Guyana:** Flash flood risk to a developing urban area
- **Mali:** Risk of climate zone shift to agriculture
- **Tanzania:** Drought risk to health and power generation
- **Samoa:** Risk of sea level rise to a small island state
- **Caribbean:** Hurricane risk to small islands
- **India:** Drought risk to agriculture
- **US Gulf Coast:** Hurricane risk to the energy system
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http://www.wcr.ethz.ch/research/casestudies.html

TEST CASE ON SAMOA – FOCUS ON RISKS AGGRAVATED BY SEA LEVEL RISE
Samoa case study: High climate change

**Samoa**
Risk of sea level rise to a small island state

- **Today**: 25 USD
- **2030**: +30 USD, -44%

- **Risk today** (annual expected damage)
- **Additional risk due to economic development**
- **Additional risk due to climate change**
- **Total climate risk**: Future risk in 2030
  - Residual risk remains as not all damages are avoidable, such as low frequency-high severity events
- **Climate adaptation**: Risk reduction potential through cost-efficient adaptation measures

Source: ECA group
Samoa: Risk of sea level rise to a small island

Reduced loss per USD invested (USD)

- Cost-efficient measures
- Non-cost-efficient

- Back away, reef revival, mangroves
- Mobile barriers, sandbags
- Relocation of specific exposed buildings
- Stilts and flood-proof buildings
- Dikes and seawalls
- Moveable buildings

Total climate risk: 77 mn USD

Cost-efficient adaptation

Residual loss 2030

Source: ECA group
The implementation of 4 cost efficient measures may avert 53% of the expected loss in 2030

Samoa case study

Source: ECA group
The CCRIF offers parametric hurricane and earthquake insurance policies to 16 CARICOM governments. The policies provide immediate liquidity to participating governments. Member governments choose how much coverage they need up to an aggregate limit of USD 100 million.

The mechanism will be triggered by the intensity of the event (e.g. winds exceeding a certain speed). The facility responded to events and made payments (USD 33 Mio to date):

- Dominica & St. Lucia after earthquake (2007)
- Turks & Caicos after Hurricane Ike (2008)
- Haiti (2010)

Swiss Re and other overseas reinsurers, program placed by Aon Benfield Ltd. derivative placed by World Bank Treasury.
Decision making, risk and uncertainty

1. Problem definition, Goal
2. Decision criteria
3. Risk analysis
4. Identify options
5. Options appraisal
6. Decision (?)
7. Implementation
8. Monitoring

Problem defined correctly?
Criteria met?

IPCC and UKCIP
Guidebook for practitioners

Objectives

- Provide decision makers with the facts and methods necessary to design and execute a climate adaptation strategy

Focus of the guidebook:

- Detailed **stakeholder engagement process**
- Step-by-step approach
- **climada** simulation engine support

Roadmap and business case for adaptation funding

Loss assessment

Cost/benefit analysis

What if we …
- … specify our 'risk appetite' in line with our development priorities
- … incorporate further criteria relevant to us in addition to cost-benefit ratio
- … (re-)prioritise risk mitigation and transfer measures based on our priorities
- … calculate an adaptation business case incl. investment plan
- … develop a roadmap incl. priority initiatives
- … use roadmap and business case for funding discussions
- … speed-up implementation with the additional funding and further increase resilience
Summary: Driver of future expected loss – asset growth versus climate change

Expected loss from exposure to climate
High climate change scenario, $b

Florida case study
- 2008: $17
- Increase from economic growth, no climate change: $9
- Increase from high climate change: $7
- Total expected loss: $33 (+94%)

India case study
- 2008: $0.24
- Increase from economic growth, no climate change: $0.13
- Increase from high climate change: $0.20
- Total expected loss: $0.57 (+139%)

China case study
- 2008: $1.3
- Increase from economic growth, no climate change: $0.7
- Increase from high climate change: $0.5
- Total expected loss: $2.6 (+92%)

United Kingdom case study
- 2008: $0.056
- Increase from economic growth, no climate change: $0.023
- Increase from high climate change: $0.017
- Total expected loss: $0.096 (+71%)

www.swissre.com/rethinking/climate
Global overview: Expected loss averted by adaptation measures

Percent of expected loss (high climate change scenario), 2030¹

100% = total expected loss

<table>
<thead>
<tr>
<th>Country</th>
<th>Remaining loss</th>
<th>Non-cost-effective measures, CB&gt;1</th>
<th>Cost-effective measures, CB&lt;1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mali</td>
<td>14</td>
<td>18</td>
<td>65</td>
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<tr>
<td>Guyana</td>
<td>68</td>
<td>65</td>
<td>18</td>
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<tr>
<td>UK</td>
<td>53</td>
<td>47</td>
<td>65</td>
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<tr>
<td>Samoa</td>
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<td>48</td>
<td>18</td>
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<tr>
<td>China²</td>
<td>48</td>
<td>19</td>
<td>44</td>
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<tr>
<td>India</td>
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<td>Tanzania</td>
<td>43</td>
<td>13</td>
<td>44</td>
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<tr>
<td>Florida</td>
<td>40</td>
<td>40</td>
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</tbody>
</table>

¹ Based upon select regions analyzed within the countries (e.g., Mopti, Mali; Georgetown, Guyana Hull, UK; North and Northeast China; Maharashtra, India; Central regions of Tanzania; Southeast Florida, U.S.)
² Based upon moderate scenario data and analysis

www.swissre.com/rethinking/climate
Finding the right balance between prevention, preparedness and risk transfer
The purpose of a model

- A prediction for the future
- A tool to test different scenarios
- A tool to test hypothesis about the system and to better understand it
- A framework to compare different options and put them on a common scale
Do we trust a model?

- “A vigorous Climate Prediction Project [] would ensure that the goal of accurate climate predictions at the regional scale could begin to aid the global society in coping with the consequences of climate change.” (http://wcrp.wmo.int/documents/WCRP_WorldModellingSummit_Jan2009.pdf)

- “New models that exploit extreme scale computing could determine the future frequency, duration, intensity, and spatial distribution of droughts, deluges, heat waves, and tropical cyclones.” (http://www.sc.doe.gov/ober/ClimateReport.pdf)

- “Verification and validation of numerical models of natural systems is impossible. This is because natural systems are never closed and because model results are always nonunique.” (Oreskes et al. 1994)

- “…what these instances of fit [between their output and observational data ] might confirm are not climate models themselves, but rather hypotheses about the adequacy of climate models for particular purposes.“ (Parker 2009)
Do We Need Better Predictions to Adapt to a Changing Climate?

- “Given the deep uncertainties involved in the prediction of future climate, and even more so of future climate impacts, and given that climate is usually only one factor driving the success of adaptation decisions, we believe that the “predict-then-act” approach to science in support of climate change adaptation is significantly flawed.”

- “…use climate models to provide information that can help evaluate alternative responses to climate change, without necessarily relying on accurate predictions as a key step in the assessment process. The basic concept rests on an exploratory modeling approach whereby analysts use multiple runs of one or more simulation models to systematically explore the implications of a wide range of assumptions and to make policy arguments whose likelihood of achieving desired ends is only weakly affected by the irreducible uncertainties.”

(Dessai et al. EOS 2009)
To close the loop: Notes on validity – adaptation

Unrealistic? incremental conceptional

Modelled Not modelled

Changing reality → e.g. climate change

Reality → Model: Abstraction
Described in Model

Model → Reality : Interpretation (Verification/Falsification/Calibration)