Three Steps toward Sustainability

1. Figure out where the system is;
2. Understand how the actions and interactions of the agents in the system determine the current state and drive state change (treating climate as one of many factors in the system that affect well-being);
3. Explore the potential effects of alternative human behaviours and/or social-economic-political settings under various future scenarios (including social and/or environmental changes).

Analyses and Implementations

1. Assessing well-being at large scales
   - Remote Sensing + GIS + social-economic data
2. Analyzing multi-source & multi-level causes of well-being
   - Quantitative + qualitative analyses (surveys + interviews)
3. Predicting the future & exploring the dynamics of the system
   - Agent-based model + network analysis + mathematics

A Conceptual and Methodological Framework for Studying Sustainability of CHES and its Applications in the Poyang Lake Region of China

Qing Tian, PhD Candidate

General Goals:
- Advance sustainability science by (i) concretizing and quantifying sustainability from the perspective of CHES, guided by the science of complexity, and (ii) proposing analyses useful for achieving sustainability and methodologies for implementing these analyses;
- Mainstream climate change into development by (i) including human adaptation into the broader sustainable development agenda, and (ii) integrating useful ideas from vulnerability analysis with a larger framework of sustainability.

Theoretical Background: The Science of Complexity

Systems Dynamics:
- Use multiple system-level variables to represent the state
- Explain the dynamics by interconnected changes of these variables
- Differential equations & mathematics

Complex Adaptive Systems (CAS)
- Explain global patterns by the actions and interactions of the agents at the micro level
- Agent-based & network modeling

A Conceptual Framework for Studying Sustainability in the Dimension of Climate Change/Variability

Two key concepts for characterizing sustainability of a CHES: WELL-BEING and RESILIENCE

Well-being describes the state of a system at one point in time. Resilience describes the state of a system in the dynamic term.

A system is RESILIENT if it does not experience sudden transition between CRITICAL states (specified by thresholds of variables) in the face of social or environmental shocks.

A system is SUSTAINABLE if its development has reached a certain level, and it is resilient.

Notes:
- Exposure of the human system to climate change/variability is determined by the environment;
- Development level includes various aspects of development in economic achievement, education and health;
- Sensitivity reflects how human development is affected by climate change/variability.

Some Simplified States and Implications

<table>
<thead>
<tr>
<th>Development</th>
<th>Exposure</th>
<th>Sensitivity</th>
<th>Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>No problem</td>
</tr>
<tr>
<td>H</td>
<td>L</td>
<td>H</td>
<td>Stupid – needs to locate the sensitive part of the development and improve</td>
</tr>
<tr>
<td>H</td>
<td>H</td>
<td>L</td>
<td>Smart</td>
</tr>
<tr>
<td>H</td>
<td>H</td>
<td>H</td>
<td>Serious problem – need to seek for both engineering and “soft” measures to reduce sensitivity</td>
</tr>
<tr>
<td>L</td>
<td>L</td>
<td>L</td>
<td>Key issue is development, but make sure not to do stupid things</td>
</tr>
<tr>
<td>L</td>
<td>L</td>
<td>H</td>
<td>Key issue is development, also need to reduce sensitivity</td>
</tr>
<tr>
<td>L</td>
<td>H</td>
<td>L</td>
<td>Further develop, may need engineering work to keep sensitivity low</td>
</tr>
<tr>
<td>L</td>
<td>H</td>
<td>H</td>
<td>Worst case – migration away</td>
</tr>
</tbody>
</table>

What is Sustainability?

SUSTAINABILITY IS EMERGENT from
- the actions and interactions of multiple human players under the social-economical-political setting
- the biophysical processes of the environment
- the interactions between humans and the environment

ESSENTIALLY about the WELL-BEING of a CHES in a LONG time horizon

Multiple Dimensions of Sustainability

- Natural Resources
- Biodiversity
- Climate Change
- Human Health
- Pollution
- other