Sustainability in the context of integrated human and natural systems

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Center for Complex Engineering Systems (CCES) Workshop
3 November 2011

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Sustainability: What are the challenges?

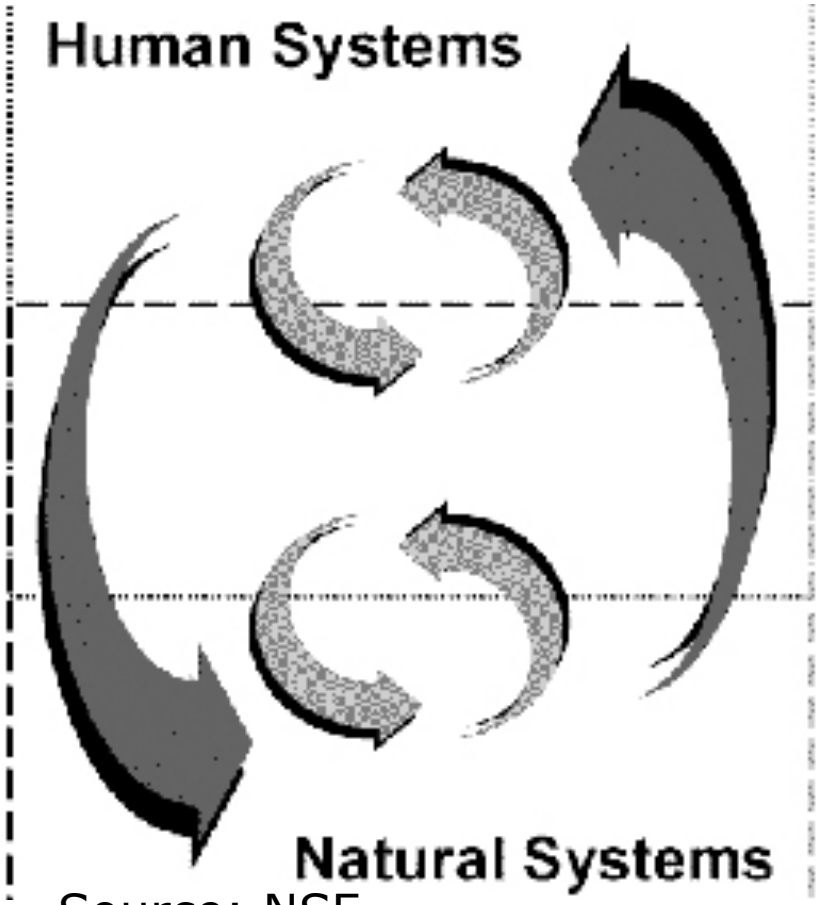
- Sustainable Development defined by World Commission on Environment and Development (1987): **development that meets the needs of the present, without compromising the ability of future generations to meet their own needs**
- Humans "are modifying physical, chemical, and biological systems in new ways, at faster rates, and over larger spatial scales than ever recorded on Earth." (Lubchenko, 1998)

What are the Major Challenges for a sustainable society?

- **Economic**: production, employment, income, wealth, markets, trade
- **Sociopolitical**: national and personal security, liberty, justice, rule of law, education, health care, arts, civil society/ culture
- **Environmental**: air, water, soils, mineral resources, biota, climate

[Holdren, 2008]

Impossible to understand human (or natural) systems in isolation



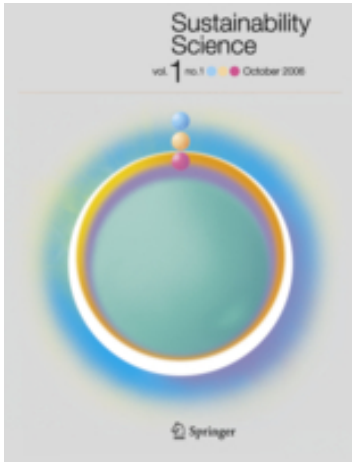
Source: NSF

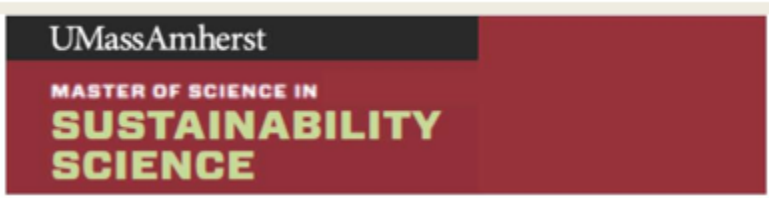
- Dynamic, coupled interactions
- Complexity

Sustainability Science

- Idea: research is necessary to facilitate this transition
  - *Advance basic understanding of the dynamics of human-environment systems; to facilitate the design, implementation, and evaluation of practical interventions that promote sustainability in particular places and contexts; and to improve linkages between relevant research and innovation communities on the one hand, and relevant policy and management communities on the other (goal statement, Harvard Sust. Sci Program)*
- What is necessary? Problem-focused, interdisciplinary, …

An emerging field of relevance to engineering systems





Core questions of sustainability science (Kates et al., *Science*, 2001)

- How can the dynamic interactions between nature and society--including lags and inertia--be better incorporated into emerging models and conceptualizations that integrate the Earth system, human development, and sustainability?
- How are long-term trends in environment and development, including consumption and population, reshaping nature-society interactions in ways relevant to sustainability?
- What determines the vulnerability or resilience of the nature-society system in particular kinds of places and for particular types of ecosystems and human livelihoods?
- Can scientifically meaningful "limits" or "boundaries" be defined that would provide effective warning of conditions beyond which the nature-society systems incur a significantly increased risk of serious degradation?
- What systems of incentive structures--including markets, rules, norms, and scientific information--can most effectively improve social capacity to guide interactions between nature and society toward more sustainable trajectories?
- How can today's operational systems for monitoring and reporting on environmental and social conditions be integrated or extended to provide more useful guidance for efforts to navigate a transition toward sustainability?
- How can today's relatively independent activities of research planning, monitoring, assessment, and decision support be better integrated into systems for adaptive management and societal learning?

Priority areas in Science, Engineering, & Education for Sustainability (NSF)

- research at the energy-environment-society nexus
- innovative computational science and engineering methods and systems for monitoring, understanding and optimizing life-cycle energy costs and carbon footprints of natural, social and built systems (including IT systems themselves)
- study of societal factors such as vulnerability and resilience, and sensitivity to regional change

Theoretical contribution from Sustainable Infrastructure Rating System

- *How can the dynamic interactions between nature and society--including lags and inertia--be better incorporated into emerging models and conceptualizations that integrate the Earth system, human development, and sustainability?*
- *innovative computational science and engineering methods and systems*

- Discussion?

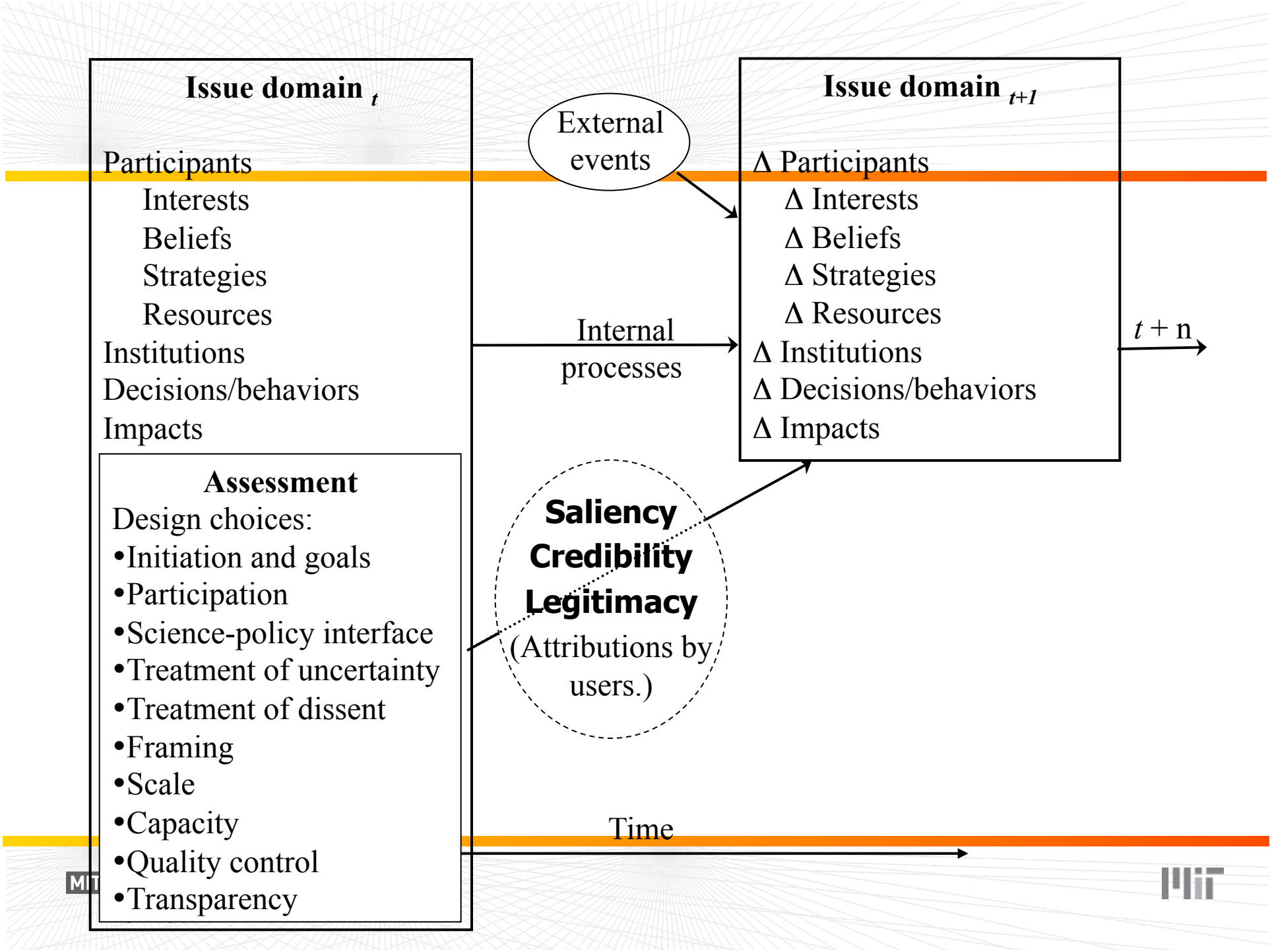
Challenge: Effective information and decision-support systems

Relevant Theory on Information Effectiveness

- Why does some science influence policy, while much other science doesn't?
  - What are the main obstacles to linking scientific research and policy action?
  - What does this mean for us as thoughtful and interested scientists/citizens?
- Results of Global Environmental Assessment Project

Global Environmental Assessment Project (c. 1996-2006)

- Analysis of influence of global environmental assessments on policy
  - Global assessments: climate change; biodiversity; ozone
  - Water management in US Great Plains
  - Coastal zone mgmt in Hawai'i and Maine
  - ENSO forecasts and farmers in Zimbabwe
  - Fisheries management in North Atlantic
  - Air pollution issues in Europe and US
- Research methodologies: personal interviews, document analysis, participant observation


Issue domain t
Participants
Interests
Beliefs
Strategies
Resources
Institutions
Decisions/behaviors
Impacts
Assessment
Design choices:
•Initiation and goals
•Participation
•Science-policy interface
•Treatment of uncertainty
•Treatment of dissent
•Framing
•Scale
•Capacity
•Quality control
•Transparency
External events
Internal processes
Saliency
Credibility
Legitimacy
(Attributions by users.)
Issue domain t+1
Δ Participants
Δ Interests
Δ Beliefs
Δ Strategies
Δ Resources
Δ Institutions
Δ Decisions/behaviors
Δ Impacts
t + n
Time

What tends to make assessments effective?

- Salience
- Credibility
- Legitimacy
- These are *attributions* - multiple audiences each have their own individual views of these for a given assessment – they are not attributes of the assessment itself

Salience, Credibility, Legitimacy

- Salience – *Does the assessment address questions relevant to decisionmakers?*
  - The user must be aware of the assessment
  - The user must deem the assessment to be relevant to current policy or behavioral decisions
- Credibility – *Is the assessment scientifically supported?*
  - The user must be convinced that the facts and causal beliefs promoted in the assessment correspond to those that the user would have arrived at had they conducted the assessment.
- Legitimacy – *Were various stakeholder interests taken into account fairly during the assessment process?*
  - The user must believe the process was fair
  - The user must be satisfied that their interests were taken into account in the process

Ongoing challenges in modeling for decision-making

- How to link quantitative and qualitative information
- How to monitor and assess effectiveness
- Dependable Dynamism hypothesis
  - "The ability for an assessment/decisionmaking process to put off or modify scientific conclusions later, with confidence that they indeed will be addressed later." (Eckley, 2002)

Links to Education

Fall 2012: Sustainability Science and Engineering (ESD 120)

Spring 2012: Models and Assessment for Policy (ESD 864)

Summer course on sustainability through MIT Professional Education: 9-13 July 2012 [ESD 45.s]

http://web.mit.edu/professional/short-programs/courses/sustainability_principles_practice.html