Sustainability Science: Core questions, Grand challenges

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Sustainability Science Seminar
Center for International Development at Harvard
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Sustainability Science?

• An emerging field of ‘use-inspired’ research and innovation that, like ‘health science’ or ‘agricultural science’ before it …

• Is defined by the practical problems it addresses, in this case problems of sustainable development

• Focuses on (strongly) interacting human and environmental systems.

• Discovers, draws from and integrates a variety of practical knowledge plus findings from natural, social, engineering, and medical sciences.
Which problems?
Origins of “Sustainability” thinking

• Conservationist thinking
  – Sustainable yields, “exotic” wildlife (1800s)

• Environmental science thinking
  – Vernadsky’s “biosphere and noosphere” (1940s)
  – NASA’s “Mission to Planet Earth” (1980s)

• Political (“radical”) thinking
  – Ghandi’s “too much wealth, too much poverty” (1972)
  – Latin America Commission “Our Own Agenda” (1990)
    • not “how to manage”, but “who decides”…
<table>
<thead>
<tr>
<th>WHAT IS TO BE SUSTAINED:</th>
<th>FOR HOW LONG?</th>
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<tbody>
<tr>
<td>NATURE</td>
<td>25 years</td>
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<td>&quot;Now and in the future&quot;</td>
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<td>Forever</td>
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<td>LIFE SUPPORT</td>
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<td>Ecosystem Services</td>
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<td>WHAT IS TO BE DEVELOPED:</td>
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<td>PEOPLE</td>
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<td>Child Survival</td>
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<td>ECONOMY</td>
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<td>Productive Sectors</td>
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<td>Consumption</td>
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<td>SOCIETY</td>
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Goals for Sustainable Development

• Global consensus on international norms...
  – Meeting human needs
    • feed, house, nurture, educate, employ...
  – Preserving life support systems
    • water, air, oceans, ecosystems...
  – Reducing hunger and poverty
    • with special attention to the most vulnerable.

• Local reinvention for effective action
  – WSSD on the limits of intl. action, the need for place-based, solution-oriented partnerships...
The science focus: Interdependence among the goals of sustainable development

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<th>air quality</th>
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<th>resource degradation</th>
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The domain of sustainability science

Sustainability Science

Sustainability Goals

Social Systems

Environmental systems
Sustainability Science?

• Is defined by the practical problems it addresses, in this case problems of sustainable development.

• Focuses on (strongly) interacting human and environmental systems.

• Discovers, draws from and integrates a variety of practical knowledge plus findings from natural, social, engineering, and medical sciences to produce…

• An emerging field of ‘use-inspired’ research and innovation like ‘health science’ or ‘agricultural science’ before it, is neither ‘basic’ nor ‘applied’…
Quadrant Model of Scientific Research

<table>
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<tr>
<th>Quest for fundamental understanding?</th>
<th>Considerations of use?</th>
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<tr>
<td>No</td>
<td>No “Soaking and poking”</td>
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<td>Yes</td>
<td>Yes Pure applied research (Edison)</td>
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<td>Yes Pure basic research (Bohr)</td>
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<td>Use-inspired basic research (Pasteur)</td>
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(redrawn from Stokes, 1997)
“Core (scientific) Questions”

- Improved understanding

Pure basic research
(Earth Systems Science)

Use-inspired basic research
(Sustainability Science)

“Grand (problem-solving) Challenges”

- Improved policy and technology

Purely applied R&D
(WEHAB R&D)

Existing understanding

- Existing policy and technology

(redrawn from Stokes, 1997)
Transcendent issues

- H-E systems as complex, adaptive systems
- Place-based integration
- Cross-scale challenges
- Epistemological dilemmas of method and quality control for integrating scientific and practical knowledge
Core Questions

• Driving forces
  – The origins of “transitions” beyond the demographic
  – Production-consumption relationships

• Impacts / consequences
  – Nature of “limits,” carrying capacities, tipping points
  – Vulnerability and resilience of couple H-E systems to multiple stresses

• Guidance
  – Incentives for environment-conserving innovation / development;
    • PES-like ventures
  – Institutions for governing H-E systems (“Beyond panaceas”)
  – Valuing outcomes in H-E systems
  – Designing effective knowledge-action systems
‘Grand challenges’ defined …

• Of the most important problems of sustainable development, those for which…

• Science and technology have the potential for making important contributions to practical solutions, but…

• That potential is not being realized due to barriers of one sort or another (e.g. inadequate theory, methods, data; insufficient training or other capacity; shortfalls in funding or other motivations for scientists and engineers).

• ‘Grand Challenges’ are to identify those problems and to remove the barriers that impede progress.
Grand challenge candidates (pre-AAAS)

• Accelerate trends in fertility reduction
• Reverse declining trends in agricultural production in Africa, sustain elsewhere
• Accelerate improvements in use of energy and materials;
• Accommodate 2-3x increase of today’s urban population in sustainable manner;
• Restore degraded ecosystems, while conserving biodiversity elsewhere.
What research is being done today?

• Analysis of papers in the sustainability science domain published over the last decade shows
  – use-inspired core
  – multidisciplinary character
  – new institutions blooming… (AAAS)
  – dispersion of publishing/ presentation venues…
Disciplinary foundations

- Environmental sciences and studies  ~30%
- Ecology  ~15%
- Engineering  ~10%
- Planning  ~10%
- Water  ~ ~ 5%
- Economics  ~ ~ 5%
- Agriculture  ~ ~ 5%
- Energy  ~ ~ 5%
- Geography  ~ ~ 5%
- Urban studies  ~ ~ 5%
Where sustainability science is published

• Growth rate of >15%/year, with >150 excellent papers now each year
• No dominant journal…
  – Annals Assoc Amer Geogr. ~5%
  – Environmental Science and Technology ~4%
  – Ecological economics ~3%
  – Intl. j. sustainable development and world ecology ~3%
  – J. of cleaner production ~2%
  – Agricultural ecosystems and environment ~2%
  – Sustainable development ~2%
  – Water science and technology ~2%
  – Forest ecology and management ~2%
  – Energy policy ~1%
  – Climate policy ~1%
  – Geographical journal ~1%
Solutions to dispersion?

• (virtual) Forum on Science and Innovation for Sustainability
  – sustainabilityscience.org
• Annual research meeting / San Servolo (?)
• Publication venues
  – Reviews: Annual Review of Environment and Resources
  – Policy: Environment – Science and policy for sustainable development
  – Research:
    • Proceedings of the National Academies: Sustainability Science
    • Environment, Development and Sustainability
    • International Journal of Environment and Sustainable Development
    • Journal of Environment and Development
    • Sustainability Science
    • Sustainability: Science, Practice and Policy
Recent PNAS articles on Sustainability Science

- Ostrom, E. and H. Nagendra (2006). "Insights on linking forests, trees, and people from the air, on the ground, and in the laboratory."