Thinking About the Future: A Social-Ecological Systems Approach to Sustainability

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Tight Disciplinary Boundaries: Resilient but not Sustainable by Themselves

- A BIG future need is developing analytical approaches that draw on disciplinary knowledge but help integrate interdisciplinary understanding.
- Need to overcome Academic Towers of Babble.
- How? By building a common framework and using it when developing and testing theory and models about Social Ecological Systems (SESs).
- Today, I will discuss the SES framework that I presented in PNAS 2007; Science 2009.
- Multiple colleagues here at this meeting have been working to improve it to make it more useful over time.
What is the Difference Between Frameworks, Theories and Models?

- **Frameworks** help to establish a general, nested, set of variables and their potential relationships.
  - Common language including careful definition of variables and their sub-variables, and potentially of their sub, sub variables.

- **Theories** posit causal relationships among variables that generate broad predictions

- **Models** are applications of a theory in which conditions are specified and precise predictions are made for a family of models – from simple to more and more complex models.

- As an example with us first discuss the IAD framework that has an Action Situation at its core.
Figure 2. A framework for institutional analysis. Adapted from E. Ostrom (2005: 15).
Many Years Have Been Devoted to Studying Action Situations

• A tool for the analysis of games, experimental settings, case studies, and the design of research instruments for collecting large sets of comparable data about a common set of micro-level variables

• Have studied action situations in the field that are embedded in urban police services, irrigation systems, forests, and other settings

• *Policy Studies Journal* (Feb 2011) devoted to an overview of this basic framework

• Internal structure of action situations helps to explain micro-level outcomes
The Internal Structure of an Action Situation

Exogenous Variables

ACTORS
  assigned to
  POSITIONS
  assigned to
  ACTIONS

INFORMATION about
CONTROL over
  Linked to
    POTENTIAL OUTCOMES

NET COSTS AND BENEFITS
  assigned to

*Source: Adapted from E. Ostrom (2005: 33).*
Contra the “Tragedy of the Commons” and Social Dilemma theory—observed resource users in many (but not all) local communities restricting harvesting and monitoring each other.

Developed a formal model that predicted overharvesting (Ostrom, Gardner, and Walker, 1992).

In the lab—without communication, subjects overharvested WORSE than Nash Equilibrium prediction!!

Face-to-face communication (cheap talk) enabled subjects to reduce harvesting and increase individual and joint payoffs.

When sanctioning rules introduced by experimenters, subjects reduced harvesting but overused the opportunity to sanction others.

An opportunity to communicate about use of sanctioning rules, subject achieve high joint outcomes (Janssen et al., Science, 2010).
Lab Experiments

- Enabled us to assess whether game theory identified universal behavior in social dilemma situations
  - The answer is NO
  - Being able to communicate (or design own rules) made no difference in game theory predictions. Subjects in a lab (a micro setting) used these conditions to improve outcomes substantially—as observed in many field settings

- Not all field settings are conducive to self-organization and sustainability

- Tried to assess which broader variables affect outcomes when designed databases to study a large number of irrigation and forestry systems

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A Broader SES Framework

• Building on 30 years of IAD research recognized the need to broaden our meta-disciplinary language to posit a broad set of structural variables that affect Action Situations and resulting interactions and outcomes

• Need to develop a method for unpacking the common components of a focal SES

• A focal SES could be a lake, an irrigation system, a fishery, a forest, or the global atmosphere

• Focal systems are composed of a set of four internal systems embedded in two external systems
Action Situations Embedded in Broader Social-Ecological Systems

- Social, Economic, and Political Settings (S)
- Resource System (RS)
- Resource Units (RU)
- Action Situation: Interactions (I) ↔ Outcomes (O)
- Governance System (GS)
- Actors (A)
- Related Ecosystems (ECO)

Source: Adapted from E. Ostrom (2007: 15182).
SESs are Complex Nested Systems

- Within each broad internal system are multiple second-level (as well as third, fourth, fifth or more) variables
- The broad second tier are important variables related to many potential action situations
- Slowly building common understanding of at least the second tier of SES variables is very important for improving interdisciplinary understanding
Second-Tier Variables of an SES

Social, Economic, and Political Settings (S)
S1- Economic development.  S2- Demographic trends.  S3- Political stability.
S4- Government resource policies.  S5- Market incentives.  S6- Media organization.

Resource Systems (RS)
- RS1- Sector (e.g., water, forests, pasture, fish)
- RS2- Clarity of system boundaries
- RS3- Size of resource system*
- RS4- Human-constructed facilities
- RS5- Productivity of system*
- RS6- Equilibrium properties
- RS7- Predictability of system dynamics*
- RS8- Storage characteristics
- RS9- Location

Governance Systems (GS)
- GS1- Government organizations
- GS2- Nongovernment organizations
- GS3- Network structure
- GS4- Property-rights systems
- GS5- Operational rules*
- GS6- Collective-choice rules
- GS7- Constitutional rules
- GS8- Monitoring and sanctioning processes

Resource Units (RU)
- RU1- Resource unit mobility*
- RU2- Growth or replacement rate
- RU3- Interaction among resource units
- RU4- Economic value
- RU5- Number of units
- RU6- Distinctive markings
- RU7- Spatial and temporal distribution

Actors (A)
- A1- Number of users*
- A2- Socioeconomic attributes of users
- A3- History of use
- A4- Location
- A5- Leadership/entrepreneurship*
- A6- Norms (trust-reciprocity)/social capital/*
- A7- Knowledge of SES/mental models*
- A8- Importance of resource (dependence)*
- A9- Technology used

Action Situations: Interactions (I) → Outcomes (O)
- I1- Harvesting levels of diverse users
- I2- Information sharing among users
- I3- Deliberation processes
- I4- Conflicts among users
- I5- Investment activities
- I6- Lobbying activities
- I7- Self-organizing activities
- I8- Networking activities
- I9- Monitoring by users

- O1- Social performance measures
  (e.g., efficiency, equity, accountability, sustainability)
- O2- Ecological performance measures
  (e.g., overharvested, resilience, biodiversity, sustainability)
- O3- Externalities to other SESs

Related Ecosystems (ECO)
- ECO1- Climate patterns
- ECO2- Pollution patterns
- ECO3- Flows into and out of focal SES

*Subset of variables found to be associated with self-organization

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How Does a Common Framework Help Us Understand Complex SESs?

- Helps identify variables that affect the structure of Action Situations leading to interactions and outcomes

- Helps us to study similar systems that share some variables while differing in others
  - Avoids overgeneralization (all resources should be privately or government owned) or overspecification (my case is different than yours!)

- To diagnose why some systems do not organize or break down over time, have to study broadly similar systems and examine which variables differ and how their differences affect interactions and outcomes over time
To Do Good Research—Must Choose a Question Carefully

• An important question is: When will the users of a CPR self-organize?

• Hardin said never!

• Many policies based on that conclusion
  – Governments must impose uniform solutions on all forests, or fisheries, or water systems in their jurisdictions
  – Many failures—and some successes

• But when will the users themselves organize?

• And why will some be sustainable over time while others collapse?
Updated Theory of Self-Organization

• Let us posit that each actor harvesting from a resource system compares the expected benefits of harvesting under existing operational rules, which may be open access, with the expected benefits using a new set of operational rules.

• Each user i must ask whether their incentive to change (Di) is positive or negative.

• If D is negative for all users – no change in rules

• Perceived benefits need to be greater than perceived costs for a minimal winning coalition

• Individual benefits and costs specified in a formal model are extremely difficult to measure in the field
Linking That Theory to the Framework

• How do we use the theory to rigorously study multiple cases when we can’t measure the benefits and costs at an individual level & aggregate them?

• Our current approach is to draw on extensive empirical studies that frequently identify three 2nd tier RS variables, one 2nd RU variable, five 2nd tier A variables, and one 2nd tier GS variable (starred on Table of Second-Tier Variables)

• These are the potentially relevant variables for diagnosing likelihood of self-organization
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- Investment activities
- Lobbying activities
- Self-organizing activities
- Networking activities
- Monitoring by users

Social performance measures
- Efficiency, equity, accountability, sustainability

Ecological performance measures
- Overharvested, resilience, biodiversity, sustainability

Externalities to other SESs

Related Ecosystems (ECO)
- Climate patterns
- Pollution patterns
- Flows into and out of focal SES

*Subset of variables found to be associated with self-organization
To Illustrate Use of Framework—Compare Three Cases in Mexico

- Rarely have quantitative information about the specific benefits and costs for particular users.

- With good fieldwork, however, can make an estimate of the differences among cases on a key set of diagnostic variables similar to those that are starred in the framework and discussed above.

- Illustrate the variables discussed above with an example for the Gulf of California studied by Xavier Basurto.

Three Fishing Villages in the Gulf of California, Mexico

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Left to right. **Photo #1**: Two adult specimens of the sessile bivalve mollusk commonly known as sea pen shell (*Atrina tuberculosa*) and harvested by small-scale fishers of the three communities under study. **Photo #2**: Shows two abductor muscles pertaining to the two individuals of photo #1. Sea pen shells are harvested for their abductor muscle, which reaches high prices in the Mexican national seafood market. Fishers are paid up to $20 USD per kilogram at the beach – therefore there is great demand for them. Only shrimp and abalone reach such high prices. Their U.S. analogue are bay scallops. **Photo #3**: Typical small-scale fishing boat used in the Gulf of California, Mexico. Benthic mollusks are harvested by diving (photo #4), note the air compressor in the middle of the boat in photo 3 that provides air to the diver in photo #4. Diver in **Photo #4** is walking on the bottom (using plastic boots) harvesting sea pen shells in a shallow fishing area.
Comparison of Variables Posited to Affect Likelihood of Self Organization: Three Coastal Fisheries in the Gulf of California

<table>
<thead>
<tr>
<th></th>
<th>Kino</th>
<th>Peñasco</th>
<th>Seri</th>
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</thead>
<tbody>
<tr>
<td><strong>Actors (A)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1 (number of actors)</td>
<td>Rapid growth</td>
<td>Rapid growth</td>
<td>Slow growth</td>
</tr>
<tr>
<td>A5 (local leadership)</td>
<td>Absent</td>
<td>Present</td>
<td>Present</td>
</tr>
<tr>
<td>A6 (norms of trust and reciprocity)</td>
<td>Lacking</td>
<td>High levels</td>
<td>High levels</td>
</tr>
<tr>
<td>A7 (shared local knowledge-mental models)</td>
<td>Lacking</td>
<td>High levels</td>
<td>High levels</td>
</tr>
<tr>
<td>A8 (dependence on resource)</td>
<td>Low</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>A9 (technology used)</td>
<td>Same</td>
<td>Same</td>
<td>Same</td>
</tr>
<tr>
<td><strong>Governance System (G)</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>GS4 (formal property rights)</td>
<td>Absent</td>
<td>Absent</td>
<td>Present</td>
</tr>
<tr>
<td>GS5 (operational rules)</td>
<td>Present</td>
<td>Present</td>
<td>Present</td>
</tr>
<tr>
<td>GS8 (monitoring and sanctioning)</td>
<td>Mostly absent</td>
<td>Mostly present</td>
<td>Mostly present</td>
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<tr>
<td><strong>Resource System (R)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RS3 (resource size)</td>
<td>Large</td>
<td>Small</td>
<td>Small</td>
</tr>
<tr>
<td>RS5a (indicators of productivity)</td>
<td>Least available</td>
<td>Moderately available</td>
<td>Mostly available</td>
</tr>
<tr>
<td>RS7 (predictability)</td>
<td>Least predictable</td>
<td>Moderately predictable</td>
<td>Moderately predictable</td>
</tr>
<tr>
<td><strong>Resource Units (RU)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RU1 (Resource unit mobility)</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Successfully self-organized</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Two SESs did Self-Organize

- Peñasco and Seri SESs were similar on most variables, but
  - Local leadership (A5) in Kino was absent
  - Trust and reciprocity (A6) in Kino were absent
  - Resource size (RS3) of Kino was MUCH larger
  - Indicators of the productivity of the system (RS5a) less in Kino than the other two
  - Predictability of system (RS7) less for Kino
- Kino definitely differed from the other two SESs even without quantitative measures of important variables

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Kino Bay = Open Access

Sea pen shells have been overexploited (Moreno et al., 2005)

This is a picture showing the number of boats working off Kino Bay fishing grounds. Kino Bay is an open-access regime. Our boat counts regularly yielded 70+ boats, a symptom of their inability to control access to other fishers. As a result of the open-access regime, their sea pen shell fishery (sea pen shells = a sessile mollusk that lives buried in the sand) has been overexploited. In this context, overexploitation is measured by fishers’ inability to sustain constant harvesting of sea pen shells year-round before they become too scarce and small in size. In contrast, the Seri are able to sustain their fishery over time.
In the Seri village of Punta Chueca (which means crooked point), the Seri have developed a common-property regime to govern their sea pen shell fishery, and successfully control the number of boats that have access to their fishing grounds. At any given time, you observe only 10-15 outboard motor boats using their fishing grounds.
Two SESs Self-Organized but Were They Sustainable?

- Is self-organization sufficient?
- No!
- Organizing a group of users to establish their own operational rules is the outcome of a collective choice action situation
- Following rules over time is an operational action situation
- Seri fishery is sustainable but not Peñasco
What Happened??

- The reserve set up in Peñasco was so successful, it attracted fishers from miles away after they had overfished their own fisheries and destroyed them.
- Mexican government did not support the right of the Peñasco fishers to define their own rules.
- Mexican government did support the rights of an specific indigenous communities to make own rules.
- Key design principles of sustainable SESs were *not* present in Peñasco.
Which Design Principles Were Absent?

- Boundaries of actors and resource are clear
- Congruence between benefits and costs
- Actors had procedures for making own rules
- Regular monitoring of actors and resource conditions
- Graduated sanctions
- Conflict-resolution mechanisms***
- Minimal recognition of rights by government***
- Nested enterprises***
New Findings re Design Principles

- Reviewed 90+ studies (by other scholars from around the world) asking whether design principles were associated with successful resource governance systems
- Found substantial support for principles
- Have proposed a better framing of three principles so that ecological factors (such as physical boundaries) are not confounded with social factors (such as group membership) – e.g. Boundary Rules 1A and 1B
What Are The Next Essential Steps

- Over-time research in multiple sites to assess what combination of variables are associated with sustainable ecological and social conditions over time
- Focus on small to medium scale CPRs
- Working to identify core attributes of forestry, water, and fishery SESs and study these rigorously using meta analysis and new fieldwork
- Further analysis of existing cast studies & new research
- Let’s look at important findings for forestry research
Importance of Local Monitoring

- An initially surprising finding for many researchers (but not those of us who conducted earlier field work and lab experiments)
  - Monitoring by local forest users of the harvesting practices by other users is strongly associated with improved forest conditions
  - Early studies by Gibson et al., Hayes and Ostrom, and Nagendra found that user monitoring strongly associated with better forest conditions
  - Three recent studies find local monitoring to be very important—Coleman and Steed in *Ecol. Econ.* (2009); Coleman in *JPAM* (2009), Chhatre and Agrawal in *PNAS* (2009)
Study of 100 Forests in 14 Countries

- Data collected by International Forestry Resources and Institutions (IFRI) research program
- Database contains variables in the SES framework
- Coleman and Steed found when local user groups have right to harvest from the forest, they are more likely to engage in monitoring and sanctioning
- Counterintuitive to many that giving the right to harvest trees from a forest may actually improve forest conditions
- But harvesting rights improve the possibility of long-term benefits from a forest and the benefits that one can obtain from keeping others from overharvesting

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Chhatre and Agrawal (PNAS)

- Recent analyses of 80 forests in 10 tropical countries examine tradeoffs and synergies between level of carbon storage in forests and their contributions to livelihoods
- Larger forests more effective in enhancing carbon and livelihoods
- Even stronger when local communities have strong rule-making autonomy and incentives to monitor
- Keeping local users out of forests is NOT the way to increase sustainability of forest resources!!!
Plans for Future Work

- Working with colleagues in Germany, Netherlands, Norway, Switzerland, Sweden, and at IU
- Slowly revising framework to improve it
- Developing clear definitions of key terms to have a common interdisciplinary language
- A foundation for theoretical applications and future empirical studies
- Major need to study SESs over time!
- Will examine which propositions hold in regard to diverse resource systems at diverse scales
Welcome Suggestions from Many Scholars


For details and online submission form see: www.planetunderpressure2012.net
Questions?
Revised SES Framework with Multiple First-Tier Components

Related Social, Economic, and Political Systems (S)

Related Ecosystems (ECO)

Direct causal link

Focal Action Situations
Interactions (I) ↔ Outcomes (O)

Governance Systems (GS)

Actors (A)

Resource Systems (RS)

Resource Units (RU)

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