

**Arctic People in Complex Adaptive Systems:
The Case of Climate Change**

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Context

Many of our environmental problems, including climate change, are complex systems problems. Because of long time lags, they cannot be adequately addressed by the familiar scientific approach of developing and testing hypotheses serially.

Conventional disciplines and disciplinary approaches in the natural and social sciences are inadequate to deal with problems involving the interaction of humans with their environment. These coupled social and ecological systems (social-ecological systems for short) need to be understood and approached as complex adaptive systems.

To do this, we need to address a number of key attributes of complex systems not observed in simple systems:

- nonlinearity
- uncertainty
- emergence
- scale
- self-organization

New tools needed to deal with complex systems and **wicked problems**, those “with no definitive formulation, no stopping rule, and no test for a solution” (Ludwig, *Ecosystems* 4: 758-764, 2001).

What does complex systems theory say about social-ecological systems?

(1) Scale

“More is different” (Philip Anderson, 1972, Science):

- Reductionist approaches have limited explanatory power because reality has a hierarchical structure;
- Each level along the hierarchical scale is independent, to some degree, of the levels above and below;
- Thus, each level requires new concepts and principles.

- Social-ecological systems can be studied at various levels, with some similarities and some key differences.
- Understand the human component in all its social complexity -- not simply a blackbox producing feedbacks.
- Processes at the household, community, regional, national, international levels require different concepts and principles.
- These levels have to be analyzed separately but also simultaneously across scale.
- Thus, scale and social context are key considerations for the study of social-ecological systems.

(2) Resilience as an Emergent Property

Emergence: systems properties that cannot be predicted or understood simply by examining the parts of the system.

Emergence is something that happens at the system level but not at the component (or individual) level.

Example: Neurons in the brain do not exhibit consciousness, but all of them together in a network exhibit the emergent property of consciousness.

Thus, emergent properties provide a window for the study of system-wide phenomena.

In our work (Berkes, Colding, Folke, eds. *Navigating Social-Ecological Systems*, Cambridge Univ Press, 2002), we have been using the emergent property, resilience, for the study of the phenomena of change.

Resilience

- organizing concept to deal with social-ecological system dynamics;
- particularly suitable for the study of change because it deals with the flexibility of responses to stress, and
- it focuses on the capacity for learning, self-organization and adaptation at multiple scales.

Resilience

- originally formulated by C.S. Holling 1973;
- used in exploring ecosystem dynamics;
- more recently applied to social-ecological systems.

Resilience has three defining characteristics: (Resilience Alliance 2001 www.resalliance.org)

- the amount of change the system can undergo and still retain the same controls on function and structure, or **buffering (or absorptive) capacity**;
- the degree to which the system is capable of **self-organization**; and
- the ability to build and increase the capacity for **learning** and adaptation.

(L.H. Gunderson and C.S. Holling, eds. *Panarchy*. Island Press, 2002.)

Applications: Arctic Climate Change

Climate change and impacts are occurring at multiple levels of the hierarchical scale in social-ecological systems. Focus: institutions.

There are cross-scale interactions, linking institutions both *horizontally* (across space) and *vertically* (across levels of organization). [Terminology follows Oran Young; Young and Berkes chapters in Ostrom et al., eds. *The Drama of the Commons*, NRC/NSF, 2002].

No single level is the “correct” one for analysis; the system must be analyzed simultaneously across scale.

Resilience, an emergent property, helps focus on the adaptive capacity of communities to deal with climate change. Three kinds of responses or mechanisms:

- (1) Known **adaptive strategies** to environmental variability in the arctic ecosystem;
- (2) Observed **coping responses** to climate change; and
- (3) New institutional mechanisms for cross-scale interactions.

(1) Known Adaptive Strategies

The adaptive capacity to absorb perturbations will in part depend on culturally available response options. These long-term adaptive responses among the Inuit include:

- **Mobility and group size flexibility**

Inuit society was “organized to facilitate constant regrouping of economically self-supporting households to maximize resource capture and distribution.”

- **Flexibility of seasonal cycles of resource use**

Inuit lived with unpredictability, harvesting what was available and switching species opportunistically.

- **Detailed local knowledge (TK) and related skills**

Diversification is well known as a risk-spreading strategy related to uncertainty. Detailed TK enables diversification

- **Sharing mechanisms and social networks**

Food sharing was important among the Inuit for mutual support and risk minimization.

- **Inter-community trade**

Sharing on a more extensive scale.

(2) Observed Coping Responses (Sachs Harbour)

- **Modifying timing of harvest activity**

Changing when harvesting takes place; adjusting the timing of seasonal calendar.

- **Modifying location of harvest activity**

Erosion at one fishing lake -- fish at other lakes instead. More bare ground -- travel along the coastal sea-ice.

- **Modifying method of harvest activity**

Not enough snow to travel in spring -- use all-terrain vehicles instead of snowmobiles

- **Adjusting the species harvested**

Catching more of what is available (e.g., *qaaqtaq* (least cisco; pintail and mallards) to compensate for failing hunts.

- **Minimizing risk and uncertainty**

Need to monitor river breakup more closely; “you really need to have experience to travel on the sea ice now.”

(3) New mechanisms for cross-scale interactions

- Knowledge-sharing between scientists and Arctic peoples, e.g., Beaufort Sea 2000 conference;
- Appreciation of traditional environmental knowledge as key to understanding change at the local level;
- Various co-management mechanisms (e.g., five co-mgmt bodies, including Fisheries Joint Mgmt Committee, under the *Inuvialuit Final Agreement*); and
- Cross-scale institutional linkages at the international level, e.g., Arctic Council and ACIA

Conclusions

Three kinds of mechanisms:

- Long-term, culturally evolved **adaptive strategies** to dealing with environmental variability in the arctic ecosystem;
- Short-term **coping responses** to climate change, such as switching species and adjusting “when, where, how” of hunting; and
- New **institutional mechanisms** for cross-scale interactions, providing for tighter coupling between levels and speeding up feedbacks among them

All of them help increase social-ecological resilience and build adaptive capacity – but up to a limit.