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Review

Panarchy and community resilience: Sustainability science and policy implications

Fikret Berkes[a,*], Helen Ross[b]

[a] University of Manitoba, Natural Resources Institute, 70 Dysart Rd., Winnipeg, Manitoba R3T 2N2, Canada
[b] The University of Queensland, School of Agriculture and Food Sciences, Gatton, QLD 4343, Australia

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ABSTRACT

How does the resilience concept of nested relationships (panarchy) contribute to sustainability science and policy? Resilience at a particular level of organization, the community level in our case, is influenced by internal processes at that level. But it is also impacted by actions at lower levels of organization (individuals, households), and by drivers of change originating at higher levels (national level policies, globalized market forces). We focus on community level social-ecological systems, looking upwards and downwards from there. Our objective is to explore the connections of the community to other levels, the ways in which community resilience is impacted, and the implications of this for sustainability. Conventional disciplines specialize at different levels, a barrier to investigating multi-level interactions. Use of the panarchy concept helps contribute to the interdisciplinary understanding of resilience at the community (and other levels) by drawing attention to cross-scale relationships. From the effect of individual leadership to the implication of pandemics that move swiftly across levels, examples illustrate a diversity of ways in which community resilience is shaped in a multi-level world.

1. Introduction

Consider the charge of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES): to assess biodiversity and ecosystem services at local, regional, and global levels (IPBES, 2016). Consider the vision for rebuilding after the 2011 Japan earthquake and tsunami: rebuilding bottom-up, customized by region, and centered on local communities, with focus on *satoyama* (forest) and *satoumi* (coastal marine) social-ecological systems (Takeuchi 2011). What these examples have in common is an emphasis on the multi-level nature of a problem, calling for the panarchy approach, that addresses nested levels. Scale issues are a key to understanding and managing social-ecological systems, and the panarchy concept provides insights regarding scale. As Allen et al. (2014: 578) put it, panarchy "provides a framework that characterizes complex systems of people and nature as dynamically organised and structured within and across scales of space and time".

Resilience is the ability to respond to stresses and shocks while preserving system identity and main system functions (Walker et al., 2004). Resilience thinking has been part of sustainability science for some time, and panarchy is a key concept of resilience; in fact, it is the main title of the classic book on resilience (Gunderson and Holling, 2002). However, there has been relatively little use of the panarchy concept in environmental science and policy discussions until recently, although there are examples that illustrate the concept well. Wild sockeye salmon fisheries of Bristol Bay, Alaska, are well managed at the local stock and regional levels. However, this fishery has been in crisis because of declining revenues due to competition from globalized salmon farms that produce a large and steady supply of high-quality salmon, even though it is not sockeye. Hence, international aquaculture at the global level can negatively impact a well-managed wild salmon fishery and fisher livelihoods in Alaska, which itself has no salmon aquaculture (Robards and Greenberg, 2007). Marine ecosystems provide good examples of cross-level and interdisciplinary interactions. Jacques (2015) pointed out that stresses often grow in scale from local to global, for example, from pollution and warming in the water column, to single stock collapses, to degraded marine ecosystems. Thus, it may be important to think of fishery systems as a hierarchical global integrated system, or panarchy, to avoid casting policy at the wrong scale (Jacques, 2015).

Initially conceived as an ecological concept of nested adaptive cycles, panarchy ideas can be applied to social-ecological systems,

* Corresponding author.
E-mail addresses: Fikret.Berkes@ad.umanitoba.ca (F. Berkes), Helen.Ross@uq.edu.au (H. Ross).

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human-environment systems in which the social (human) and ecological (biophysical) subsystems are considered together. Both subsystems consist of multiple levels, for example, a small watershed inside a larger watershed, or a nested set of institutions from local to international (Ostrom, 2009). The social and the ecological subsystems are linked by mutual feedback and are interdependent and co-evolutionary (Berkes and Folke, 1998).

In recognition of the growing but scattered literature on panarchy in social-ecological systems, this paper explores multi-level resilience with examples considering both social and ecological aspects. We focus our discussion to community resilience, rather than trying to cover all aspects of resilience. Hence, our objective is to explore the connections of the community level to other levels, and the ways in which these may influence community resilience. Our emphasis is on the relationship among levels within nested social-ecological systems, using a community-centered focus, rather than dealing broadly with resilience theory or narrowly with panarchy itself.

One practical aspect of the paper is that it seeks to raise issues that are relevant to both of the two strands (or bodies) of literature on community resilience. These two strands share common objectives even though their literatures are quite distinct (Norris et al., 2008; Berkes and Ross, 2013; Welsh, 2014). One strand has behavioural science origins and is derived from psychology of development and mental health (focused on individuals). It is frequently used in the disaster management literature (Norris et al., 2008). Many authors contributing to this literature extrapolate from one level to another uncritically. The second strand has ecological science origins. The present paper is written principally with this second strand in mind, social-ecological resilience (or Holling resilience). Given our emphasis on communities as social-ecological systems, the paper focuses on communities of place, while acknowledging the importance and relevance of communities of interest and recognising the social complexity of many communities.

Following a section on community resilience in the context of resilience theory, and a section on elements of the panarchy concept, the main part of the paper pursues illustrations of multi-level interactions. This is followed by a discussion on the implication of the cases for environmental science and policy, and a conclusion. The seven cases are chosen to represent different kinds of resilience and sustainability management involving a range of settings: lake ecosystem management; disaster management; river basin management; wetland protected area management; impacts of multiple environmental stresses; impacts of global economic drivers on local social-ecological systems; and pandemic disease management. They come from different geographical regions: North America, Australia, and Europe. The cases are chosen to represent the diversity of levels in a panarchy; they are chosen also because they are richly detailed and because we have first-hand knowledge or familiarity with most of them.

2. Community resilience within resilience theory

As defined by Magis (2010, 401), community resilience is the "existence, development and engagement of community resources by community members to thrive in an environment characterized by change, uncertainty, unpredictability and surprise." It is this potential ability to deal with change, uncertainty and surprise that has made resilience a promising concept in a number of disciplines and applied fields (Brown 2014, 2016). Social-ecological resilience recognizes the nested character (one inside the other) of social-ecological systems and the challenge of connectivity across levels (Chapin et al., 2009; Gunderson and Holling, 2002). Through its conceptualization of nested levels and multi-level interactions, this approach is suitable for analysing the effects of drivers originating at various levels, including the interplay among levels of governance. It can generate insights regarding policies to enhance resilience at appropriate levels (Brondizio et al., 2009; Allen et al., 2014).

Communities are not isolated. Resilience at the community level is strongly influenced by the actions and interactions of individuals and groups within the community. Thus, social aspects of resilience research need to pay attention to agency (Brown and Westaway, 2011). Also often neglected in resilience research are issues of power. Communities are rarely egalitarian, and power structures within a community, including power in decision-making, can strongly influence community resilience outcomes (Christensen and Krogman, 2012). However, communities are often also impacted by various drivers of change originating at higher levels of organization.

For example, the global demand for coffee may drive land use changes in Vietnam (Eakin et al., 2009), illustrating that the social component cannot be isolated from the ecological component of the system because of interactions between the two. Both ecological systems (Ahl and Allen, 1996) and social systems (Cash et al., 2006) are hierarchical (nested or multi-level) along various scales, as in a stand of trees within a forest, or a municipal government nested in a provincial/state government. Both function at several different levels along each scale. Here we adopt the definition of scale as the spatial, temporal, quantitative, or analytical dimensions used to measure and study any phenomenon, and levels as the units of analysis that are located at different positions on a scale (Cash et al., 2006; Gibson et al., 2000).

Social-ecological resilience thinking has been an emerging topic in environment and sustainability discourse, and has experienced a dramatic increase in the number of publications since the 1970s and especially since 1999 (Li and Marinova, 2013). Social-ecological resilience has an interesting history of transformation from an ecological idea to a concept used across a wide range of disciplines and policy areas concerned with crisis management and change in general (Welsh 2014). As Brown (2014, 107) puts it, "resilience is everywhere in contemporary debates about global environmental change". Walker and Cooper (2011, 144) note with some sarcasm that resilience is threatening to become "a pervasive idiom of global governance".

The original idea of ecological resilience (Holling, 1973) is derived from complex adaptive systems thinking. Resilience is a systems property, technically an emergent property of a system, one that cannot be predicted or understood simply by examining the parts of the system (Gunderson and Holling, 2002). It may be formally defined as the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks (Walker et al., 2004). Holling (1973) sought to develop a notion that could account for the ability of an ecosystem to remain cohesive even while undergoing perturbation. Parting with the notion of stability, he argued for a science of dynamic ecosystems which could deal with drivers and change, and which did not have deterministic outcomes such as "bouncing back" to a pre-determined equilibrium.

According to this line of reasoning, assumptions of stability were ecologically naïve, and the equilibrium approach created management risks by often trying to eliminate natural variability. For example, maximizing resource yields (e.g., maximum sustained yields), fashionable in post-World War II resource management science in fields such as forestry and fisheries, ignored natural variability. Further, by trying to obtain a constant, predictable yield from year to year, it inadvertently ran the risk of eroding system resilience. The resilience approach, with a focus on system integrity and due attention to natural variability and