Global Environmental Change 37 (2016) 69–78

Contents lists available at ScienceDirect

Global Environmental Change

journal homepage: www.elsevier.com/locate/gloenvcha

Learning for resilience-based management: Generating hypotheses from a behavioral study

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ARTICLE INFO

Article history:
Received 22 September 2015
Received in revised form 6 January 2016
Accepted 28 January 2016
Available online 16 February 2016

Keywords:
Loop learning
General resilience
Behavioral experiment
Adaptive management
Adaptive co-management
Adaptive governance

ABSTRACT

Encouragement of learning is considered to be central to resilience of social–ecological systems (SESs) to unknown and unforeseeable shocks. However, despite the consensus on the centrality of learning, little research has been done on the details of how learning should be encouraged to enhance adaptive capacity for resilience. This study contributes to bridging this research gap by examining the existing data from a behavioral experiment on SES that involves learning. We generate new hypotheses regarding how learning should be encouraged by comparing the learning processes of human-subject groups that participated in the experiment. Our findings suggest that under environmental stability, groups may be able to perform well without frequent outer-loop (or double-loop) learning. They can still succeed as long as they tightly coordinate on shared strategies along with active monitoring of SESs and user participation in decision-making. However, such groups may be fragile under environmental variability. Only the groups that experience active outer-loop learning and monitoring of SESs are likely to remain resilient under environmental variability.

1. Introduction

The dynamics of social–ecological systems (SESs) under global change are not well understood and are thus unpredictable (Polasky et al., 2011). Building the capacity to cope with unknown and unforeseeable shocks, or so-called general resilience, therefore requires continuous learning by actors to update the knowledge that they possess regarding the SESs they inhabit. Learning contributes to resilience via its positive influence on decision-making under uncertainty (Polasky et al., 2011; Biggs et al., 2015). The recognition of the importance of learning has given rise to several learning-focused management approaches that have garnered considerable interest over the years, such as adaptive management (Walters and Holling, 1990), adaptive co-management (Olsson et al., 2004; Plummer and Armitage, 2007), adaptive governance (Folke et al., 2005), and resilience engineering (Hollnagel et al., 2006). These approaches all embrace learning as a means to operationalize resilience-based management.

However, despite the consensus on the centrality of learning, little research has been done on the details of how learning should be encouraged to enhance adaptive capacity for resilience (Fabricius and Cundill, 2014). Several studies have highlighted the issue as an important research gap, pointing out that the evidence supporting learning in the resilience literature does not indicate what type of learning is most appropriate and under what conditions (Biggs et al., 2012, 2015). This puzzle has arisen because a host of different learning-related conditions can interact to shape the outcomes of learning. For example, different types of learning can be present, such as multiple-loop learning (Argyris and Schön, 1978; Keen et al., 2005) and individual and social learning (Reed et al., 2010). Learning can also be influenced by conditions such as the presence of diverse user participation in decision-making (Armitage et al., 2009), monitoring of and reflection on changes in SESs (Armitage et al., 2008), leadership and collaboration in the management process (Folke et al., 2005), and exchange of knowledge (Berkes, 2009). Which combination of such conditions contributes to resilience the most? More effective strategies for building resilience can be identified by exploring how such

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http://dx.doi.org/10.1016/j.gloenvcha.2016.01.009
0959-3780/

conditions combine to shape outcomes and which of the configurations are more essential to adaptive capacity than others. The current study tackles this question by conducting a comparative analysis of the empirical data from a behavioral experiment on SES that involves learning. By comparing the learning processes of human-subject groups that participated in the experiment, we search for empirical clues and generate hypotheses regarding how learning should be encouraged for resilience-based management.

Our comparative analysis is based on an existing laboratory behavioral experiment of an irrigated agricultural system (Anderies et al., 2013a). In this experiment, which is designed to study how humans solve collective action problems under disturbances, participants are faced with a set of decision problems on collective management of shared irrigation infrastructure under environmental variability. Such behavioral experiments are typically used to test a precise hypothesis under a controlled setting (Poteete et al., 2010). Our approach of applying comparative analysis to existing experimental data to generate, rather than to test, hypotheses is an unusual research path to take, but is not without precedent (see Pavitt, 2011; Perez et al., 2015). In essence, our approach reflects the methodological challenge raised by Basurto and Ostrom (2009) to advance theory development in the study of SESs, i.e., comparing rich details across multiple cases and combining theories to generate new hypotheses.

We examined the learning process of the experimental groups in terms of the following conditions: types of loop learning, user participation in decision-making, monitoring of and reflection on changes in SESs, group coordination in decision-making, sharing of knowledge, and initial level of knowledge from individual learning. Various configurations of the conditions emerged among the groups. For example, members of some groups coordinated on shared strategies with little loop learning while members of other groups often experienced loop learning. Of special interest is whether there is a configuration of conditions linked to successful group performance under environmental stability but which might be linked to failure under environmental variability. Understanding such a configuration can suggest hidden fragilities of seemingly well-functioning SESs that are typically only revealed through failure.

This paper first provides a theoretical background on how the learning process unfolds in SESs, then explains why our irrigation experiment likely offers empirical clues to understanding the details of learning processes linked to resilience. In the Section 2, we provide a brief overview of the design of the irrigation experiment, the protocol used to measure the learning-related conditions, and the analytical approach used for comparative analysis. The remaining sections proceed through two stages of analysis. First, we analyzed which configurations of the conditions are likely to be linked to successful group performance under environmental stability. Second, we explored which configurations are likely to be linked to the resilience of that performance under environmental variability. Our findings suggest that resilient groups are characterized by frequent outer-loop learning (learning that involves revisions of shared goals or assumptions) and monitoring of and reflection on changes in SESs. We hypothesize that social capacity to learn and revise shared goals or assumptions in a flexible way through monitoring and evaluation is necessary for enhancing the general resilience of SESs.

1.1. Feedback-driven learning processes in SESs

A group of actors typically gain knowledge about the SES they inhabit through the feedback loop processes shown in Fig. 1. These processes involve iterations of monitoring of changes or outcomes in the SES, assessment of the monitored information leading to updated knowledge, and adjusting of subsequent management actions (Pahl-Wostl, 2009). Such feedback-driven learning, or so-called loop learning, can occur at two levels: inner-loop (or single-loop) and outer-loop (or double-loop) (Argyris and Schön, 1978; Keen et al., 2005). Inner-loop learning is defined as learning that involves updating of specific practices or actions to better meet existing goals or assumptions. This learning focuses on the question: Are we doing things right? Outer-loop learning entails changes in shared goals or assumptions. This type of learning concerns the question: Are we doing the right things? Note that there is another higher level of loop learning (triple-loop learning) which involves changes in deep-seated beliefs and mental models (Pahl-Wostl, 2009). Triple-loop learning is not considered in this study because of the ambiguity associated with interpreting

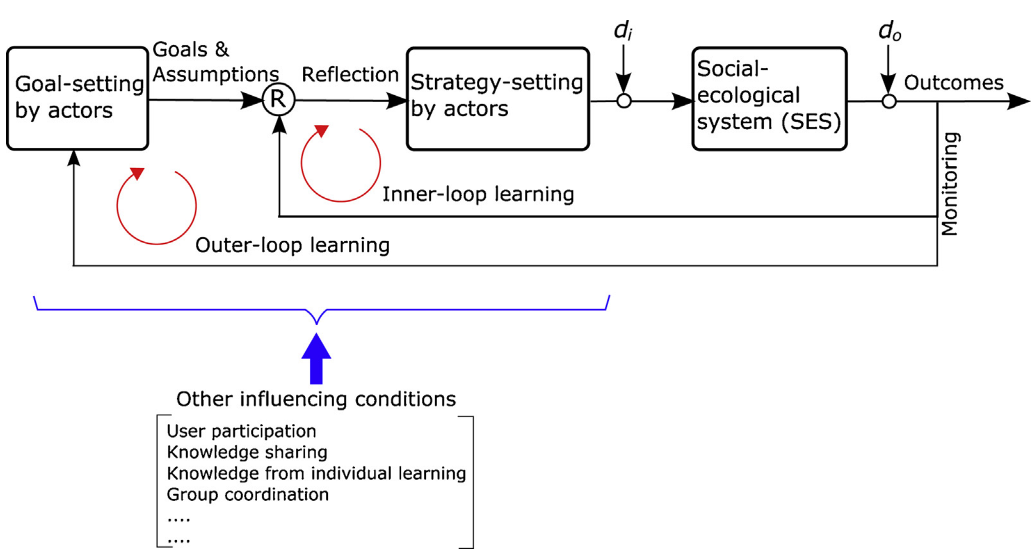

Fig. 1. A conceptual diagram of how feedback-driven learning occurs in SESs. The inner-loop (or single-loop) learning entails fine-tuning of specific strategies or actions to better meet existing goals or assumptions. The outer-loop (or double-loop) learning involves updating of goals or assumptions that underlie specific strategies. The circle with letter R represents the process of monitoring of and reflection on past outcomes. The arrow denoted by d_i represents internal issues (e.g., collective action problems). Environmental variability is represented by the arrows denoted by d_o (e.g., natural disasters). Several conditions, e.g., user participation in decision-making, knowledge sharing, etc., can influence the loop learning processes. This figure is adapted from Anderies (2015).