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Governance structures for ecosystem-based adaptation: Using policy-network analysis to identify key organizations for bridging information across scales and policy areas

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ARTICLE INFO

Article history:
Received 25 August 2011
Received in revised form
11 March 2013
Accepted 16 March 2013
Published on line

Keywords:
Information exchange
Policy network analysis
Bridging organizations
Ecosystem services
Climate change
Soil regulation
Central America

ABSTRACT

Ecosystem service degradation, exacerbated by climate change, requires flexible and effective communication within governance systems to foster actions that reverse current trends and can cope with changing conditions. Key organizations bridge information to a variety of actors across administrative scales and policy areas in complex governance networks concerned with ecosystem services. In this paper, we use quantitative analysis of information flows, perceived influence and competence within a multi-actors' governance network to identify key information bridging organizations (BrO) for an example involving soil regulation services in a watershed in Costa Rica. Here, heavy soil erosion (due to intense cultivation on steep slopes, and increasing frequency of extreme precipitation events) affects both farmers (by loss of fertile topsoil) and hydroelectric generation (by rapid siltation of reservoirs downstream). To gauge the information-bridging capacities of organizations we use the network parameter betweenness centrality, and we created two new parameters to measure the extent of cross-scale and cross-policy area exchange of information of the organizations. The regional agricultural extension office is identified, among others, as a crucial BrO in keeping with other studies of agricultural systems. The results also show that network analysis provides an empirical basis for understanding information flows and influence in governance networks, in order to identify key organizations. In this manner, we can diagnose potential bottlenecks, when these organizations lack the resources to achieve their mandates and need support to strengthen their efforts in information provision and influence in governance for ecosystem services.

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1462-9011/$ – see front matter © 2013 Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.envsci.2013.03.004

1. Introduction

The Millennium Ecosystem Assessment documents the rapid growth in demand for and decline in supply of ecosystem services (ES)[1] (MEA, 2005), a situation made even more disturbing when the disruptive effects of climate change are considered (Fischlin et al., 2007). Coordinated adaptation efforts are required for these social–environmental systems, within complex institutional and governance contexts, if ES supplies are to better meet ES demands under the pressures of climate change (Hulme, 2005; Bodin and Crona, 2009). Yet often those relying on a specific type of ES are spatially and administratively separate from (i) those who influence the quality and quantity of that ES provision and (ii) those who generate, analyze and disseminate information that is relevant for managing those ES. Managing *soil regulation services* (SRS) at the watershed scale is a case in point. Farmers on upstream sites clearly have individual incentives to avoid erosion and retain soils on their farms, but often lack necessary technical knowledge, equipment, capital, time or cooperation of others to identify and implement good practices to reduce erosion. Downstream neighbors and more distant water users, such as hydroelectric facilities, bear costs that could be avoided if formal or informal governance would bring forth more resources for upstream erosion control. Yet the potential positive externalities of SRS in avoiding siltation of reservoirs are not internalized into decisions of the concerned actors, unless governance mechanisms, mutual support and information-sharing can be established (Southgate and Macke, 1989; Pimentel et al., 1995; Guo et al., 2000). Climate change is expected to increase the intensity of rainfall, and thus increase erosion, in many tropical countries, including Costa Rica, the location of interest in this paper. Although actors involved in SRS management need appropriate information to guide adaptation choices, societal ecosystem-based adaptation responses are typically in the initial stages of compiling information about future climate impacts and analyzing feasible responses (IUCN, 2008; UNCBD, 2009; Vignola et al., 2009; Eastaugh et al., 2009).

How information is created and transferred within complex and ambiguous social networks is a topic of growing interest for research on environmental governance (Adger, 2003; Folke et al., 2005; Pelling and High, 2005). Information-sharing among organizations is shaped by an existing set of formal and informal institutional structures and governance arrangements that determine the capacity for collective responses to ES degradation problems (Uitto, 1997; Koiman, 1999; Hodge, 2001; Ostrom, 2007). Governance structures frame, oversee and implement resource management policies from broader levels of governance (e.g. regional or national or international) to individual land users at the local level (Adger et al., 2005a).

Recent studies have identified the role of boundary organizations in supporting information and knowledge exchange across scales among organizations belonging to different communities such as science, government, and civil society (Agrawala et al., 2001; Cash et al., 2003; Turton et al., 2007). This research indicates many factors play roles in determining whether a given entity serves as a key boundary organization within a specific institutional context. In this paper we consider whether key potential boundary organizations can be identified with quantitative analysis of information flows and reputation within a policy network. We seek to examine the bridging positions of key organizations, to identify the potential for bottlenecks in the flow of information (e.g. if the organization lacks the resources to maintain its current function and status in the network). We use the term ''bridging organization'' (BrO) to refer to potential boundary organizations that play important roles in sharing information across domains and scales. This term has been used in the past (Brown, 1991) in related contexts, though in reference to local organizations with horizontal and vertical linkages in developing countries.[2] Our approach to identifying BrOs addresses only some of the characteristics of boundary organizations. An analysis of these broader characteristics would require more qualitative assessments to identify, among other things, their history of relations and trust creation with partners as well as effective creation and use of boundary objects and standardized packages from these interactions (Guston, 2001).

The main contribution of this paper is its use of a quantitative survey and network analysis (Borgatti, 2009) to characterize information flows in a network of organizations and actors involved in Costa Rica water management and governance. The case study is situated in the Birris sub-watershed of central Costa Rica, where high rates of erosion caused by farming practices on steep volcanic slopes lead to siltation that reduces the output of important hydroelectric facilities, greatly increasing costs for power replacement and siltation removal.

The paper has the following structure. In Section 2 we discuss concepts and definitions for governance, scales and the importance of bridging organizations relevant for ecosystem-based adaptation to climate change. We also introduce concepts of network analysis employed in this paper. In Section 3, we describe briefly the case study, highlighting the drivers of SRS degradation and the contexts shaping actors who provide and would benefit from enhancing SRS in the Birris watershed. In Section 4, we present the methods, including how the network was bounded, the structure of policy network questionnaire and how the network analysis was conducted. In Section 5 we present results, followed in Section 6 with discussion, with particular attention to one organization, the watershed's regional agricultural extension office which can play an important role in the different stages of problem-detection and solutions' design and evaluation.

2. Relevant concepts

This section briefly introduces three concepts that comprise the intellectual landscape in which the paper is situated,

[1] These include: *provisioning services* such as food, water, timber, and fiber; *regulating services* that affect climate, floods, disease, wastes, and water quality; *cultural services* that provide recreational, esthetic, and spiritual benefits; and *supporting services* such as soil formation, photosynthesis, and nutrient cycling (MEA, 2005, p. 9).

[2] We thank an anonymous reviewer for this suggestion.