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Anticipatory modeling of biocomplexity in the Tisza River Basin: First steps to establish a participatory adaptive framework

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Abstract

Initial successes in flood control in the Tisza River Basin (TRB) have repeatedly given way to surprising and catastrophic reversals over the past 130 years since implementation of the original Vásárhelyi river engineering plan. Recurrent and parallel crises in economic, ecological and socio-cultural domains of the TRB suggest systemic linkages far broader than imagined in the economic paradigms that drove the reshaping of the TRB. Typical of 'policy resistance', these problems have 'wickedly' resisted repeated efforts to solve them. Future river basin management needs conceptual and methodological tools to develop more comprehensive models that account for the complexity of the wider diversity of these systemic linkages and the resultant non-linear dynamics. Biocomplexity is one attempt to elaborate a more comprehensive conceptual paradigm. This paper describes how the authors applied a method, causal loop diagramming, as a means to graphically examine what aspects of system structure might generate surprising and counter-intuitive policy reversals characteristic of wicked problems. We applied this method in advance of collaboration with stakeholders as a means to deepen our intuition about the system's complexity as a way to better prepare to facilitate participatory modeling exercises within the Adaptive Management (AM) tradition.

Keywords: Adaptive management; Resilience; System dynamics; Feedback loops; Conceptual models

1. Introduction

1.1. Biocomplexity: a richer picture of surprising change in human and natural systems

Managing a river basin appears less certain now than it did a century ago when flooding was the prime concern and engineering the solution (Pahl-Wostl, 2005). Rising flood damage trends witness the repeated and mounting failure of flood control, but on-going problems of water quantity or quality now appear to be but one part of a bigger problem. Parallel crises with river basin ecological, economic, social and cultural assets suggest a web of interactions more complex than the industrial-age world-views that drove the straightening of rivers. If the engineering optimization parameters or economic indicators that helped guide the industrialization of river basins appear inadequate to assess the functioning of these webs of interactions, then what ideas or models might allow us to understand and engage this entangled complexity? The *biocomplexity* concept (Freeman et al., 2001; Michener et al., 2001; Cottingham, 2002; Andelman et al., 2004) is one attempt to convey the uncertainty emerging not only from complex interactions within individual biological organs, organisms, communities or even sectors of socio-ecological systems, but also from the way relations shift dynamically *between and across* ecological, economic and socio-political domains (Carpenter, 2002; Folke et al., 2002). To capture the sense of non-linear dynamics that emerge from multi-scalar interactions

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within hierarchically structured systems, we use the term biocomplexity as yet one more perspective on the structure and behavior of *complex adaptive systems* (Carpenter, 2002; Gunderson and Holling, 2002).

1.2. Soft management: broad and flexible responses to surprise

A history of surprising reversals of initial policy success, "policy resistance" (Sterman, 2000, 2002; Gunderson et al., 1995) motivates the drive to understand and manage biocomplexity. Attempts to eliminate, at first, and then to merely control disturbances (flood, fire, pests) have only promoted larger and more profound disturbances (Gunderson et al., 1995; Gunderson and Holling, 2002). Stubborn resistance to many policy remedies has earned such problems the title of "wicked problems" (Rittel and Webber, 1973), as if evil intention is a metaphor for how intractable, unknowable and uncooperative the world can be. Wicked policy resistance has become increasingly evident in Tisza River Basin (TRB) as rising flood crest trends overtop every effort to raise and fortify the dikes, and regional agriculture and communities struggle to hold on (Sendzimir et al., 2004a). Blame for rising flood statistics or declining river valley economies and societies cannot simply be pinned on any one of "the usual suspects": exogenous drivers or ignorant human actors or policies. Studies of regional decline and collapse resulting from failure to manage macro-scale disturbances, such as fire, flood, and insect pest outbreaks, (Gunderson et al., 1995, 2002; Folke et al., 2002) suggest that to grasp biocomplexity we need to broaden inquiry from single factors to suites of factors, the webs of interactions linking them and their dynamic changes. Expanding the scope of inquiry is especially crucial now that river management itself, shielded from criticism during a century driven by the idea of technical progress, appears to have increased the basin's vulnerability to sources of change, such as climate. Efforts to control variability in river dynamics through more intensive and expensive forms of management continue to mount in cost as flooding increases in frequency and intensity (Horvath et al., 2001). The imperative to prevent injury, death and economic devastation has usually funneled most resources into defensive and reactionary assets. These investments sustain a vast engineering infrastructure and an impressive emergency response capability at the expense of reducing efforts to explore and learn. While this reactive trap is recognized (Molnar, 2003; Sendzimir et al., 2004b; Linerooth-Bayer and Vári, submitted for publication), broad understanding, and more importantly the capacity to apply that understanding and adapt to sources of stress and change, remains far behind the evolving reality. The move from the "hard" and narrow technical approach to management to a more adaptive and comprehensive "soft" path (Gleick, 2003; Pahl-Wostl, 2005) reflects the search to integrate a broader base of concepts (encompassing natural, technical and social sciences as well as stakeholder experience) and thereby forge more flexible strategies to create more durable solutions in river basin management.

1.3. Adaptive management: experimentally developing the soft path

Adaptive management (AM) is a method of integrating research and policy that has been frequently tested over three decades of experimental applications to understand and manage crises of collapsed fisheries, agriculture, forestry and rangeland grazing (Holling, 1978; Walters, 1986; Gunderson et al., 1995; Gunderson and Holling, 2002). AM and similar iterative approaches to learning are key elements in the quest to "soften" the hard path by adding flexibility while sustaining the scientific rigor and technical competence of management (Pahl-Wostl et al., submitted for publication). It offers a framework to functionally link research, policy and local practice into a structured learning cycle (Walters, 1986; Gunderson et al., 1995; Gunderson and Holling, 2002). AM increases adaptive capacity by shifting linear decision making processes (crisis → analysis → policy) to a cyclic learning process that iteratively integrates how we modify problem bounding and definition, policy formulation, implementation and monitoring in order to track and manage change in the world (Fig. 1). Research, policy and public debate have been meshed with some success in AM-inspired projects to renovate the Kissimmee (Light and Blann, 2000) and Colorado rivers (Walters et al., 2000). As with the TRB, the historical causes and resultant problems were far better, if incompletely, understood than the pathway back to a resilient system. Especially in the case of the Kissimmee River renovation, the AM approach allowed managers to work with the public in mutually deriving such a pathway. They integrated stakeholder education and feedback and pilot research projects in the floodplain with computer modeling simulations of different policy implementations. The potential to apply an integrative soft path solution in the TRB has been raised in the last two years by the onset of parallel pilot studies of innovative approaches to engineering, agriculture, habitat restoration in the floodplain (Siposs and Kis, 2002; Molnar, 2003). However, opportunity is laced with danger arising from accumulated frustration among TRB residents with failure of decades of research to generate concrete means to stem the rising trends of flooding and socio-economic decline. Research, policy and

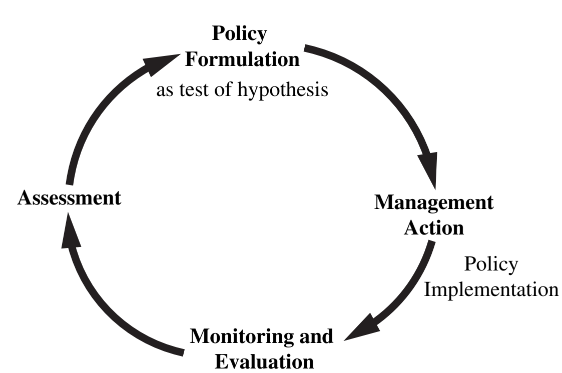

Fig. 1. Adaptive management process as a structured learning cycle that iteratively links four phases: assessment, formulation, implementation, and monitoring.