



Review

Understanding enabling capacities for managing the ‘wicked problem’ of nonpoint source water pollution in catchments: A conceptual framework



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ABSTRACT

Nonpoint source (NPS) water pollution in catchments is a ‘wicked’ problem that threatens water quality, water security, ecosystem health and biodiversity, and thus the provision of ecosystem services that support human livelihoods and wellbeing from local to global scales. However, it is a difficult problem to manage because water catchments are linked human and natural systems that are complex, dynamic, multi-actor, and multi-scalar in nature. This in turn raises questions about understanding and influencing change across multiple levels of planning, decision-making and action. A key challenge in practice is enabling implementation of local management action, which can be influenced by a range of factors across multiple levels. This paper reviews and synthesises important ‘enabling’ capacities that can influence implementation of local management action, and develops a conceptual framework for understanding and analysing these in practice. Important enabling capacities identified include: history and contingency; institutional arrangements; collaboration; engagement; vision and strategy; knowledge building and brokerage; resourcing; entrepreneurship and leadership; and reflection and adaptation. Furthermore, local action is embedded within multi-scalar contexts and therefore, is highly contextual. The findings highlight the need for: (1) a systemic and integrative perspective for understanding and influencing change for managing the wicked problem of NPS water pollution; and (2) ‘enabling’ social and institutional arenas that support emergent and adaptive management structures, processes and innovations for addressing NPS water pollution in practice. These findings also have wider relevance to other ‘wicked’ natural resource management issues facing similar implementation challenges.

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1. Introduction

Managing nonpoint source water pollution (NPS pollution) in catchments is an important but challenging problem that influences water resources, ecosystems, and human wellbeing (van der Valk and Jolly, 1992; Carpenter et al., 1998; Smith, 2003; Parkes et al., 2010). It is one of many pressures impacting on catchments and waterways, alongside other issues such as modification of water flows, land use change, population growth, and climate change (Postel et al., 1996; Gleick, 2003; Foley et al., 2005; Whitehead et al., 2009; Vörösmarty et al., 2010). NPS pollution can impact on the provision of ecosystem services (MEA, 2005), and

contribute to the erosion of resilience and adaptive capacity in linked social-ecological systems (Berkes et al., 2003). Therefore, managing NPS pollution in catchments is important for water quality and water security, conservation and restoration of aquatic ecosystems and biodiversity, and building social-ecological capacity to adapt to change (Walker et al., 2004). However, despite efforts over recent decades to enact new water management paradigms (e.g. integrated catchment management, integrated water resource management, and adaptive management), NPS pollution remains a persistent problem in both developed and developing countries (UN-Water, 2011; OECD, 2012).

NPS pollution includes nutrients, sediments, toxicants and pathogens released into waterways that are generated from many sources across wide areas of catchments (Gunningham and Sinclair, 2005). It is commonly linked to human activities, such as urbanisation, deforestation and agriculture (Foley et al., 2005; Macleod et al., 2007; Bossio et al., 2010). Land use change and human land management activities can alter hydrological cycles, and lead to

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urban stormwater runoff (Ellis and Revitt, 2008; Brown et al., 2009; Carter et al., 2009; Walsh et al., 2009), agricultural runoff and erosion (Drewry et al., 2006; Moss, 2008; Bunn et al., 2010), and degradation of fresh and marine receiving waters (Carpenter et al., 1998). NPS pollution is distinguished from point source pollution, which refers to water pollution that is generated at particular locations, such as sewage treatment plants and industrial discharges (Hirsch et al., 2006; Carpenter et al., 1998). This distinction is significant because the problem of NPS pollution is a result or symptom of a much wider range of human activities which may be: long term in nature; socially, politically and institutionally complex; spatially diverse; and difficult to influence (Gunningham and Sinclair, 2005; Hirsch et al., 2006; Smith and Porter, 2010).

The issue of NPS pollution is not always recognised as a cross-cutting and systemic issue, and approaches to managing it in policy and practice vary. In Australia NPS pollution is not often explicitly focused on, outside some particular place-based initiatives (e.g. in the Great Barrier Reef, South-East Queensland, and Port Phillip Bay, Victoria). Elsewhere, it is either seen as 'too difficult', or assumed to be addressed by voluntary management activities within much broader natural resource management (NRM) arrangements (Bellamy, 2007; Robins, 2007; Seymour et al., 2008). In the USA, a combination of regulatory and voluntary management approaches are used, through devolved responsibility to states under the federal *Clean Water Act*, and the significant role of local watershed partnerships (Russo et al., 2008; Weitman, 2011), as well as large regional programs such as in Chesapeake Bay, the Gulf of Mexico, and the Great Lakes basins (Wolfin, 2008; MR/GoM WNTF, 2008; GLWQA, 2012). In Europe, the Water Framework Directive provides a high-level legal framework within which Member States are responsible for developing river basin-based approaches for meeting 'good ecological status' for all waters (CEC, 2007). Despite vastly differing contexts (e.g. environmentally, socially, institutionally, politically, historically), common themes among all of these approaches are: increasing emphasis on evidence-informed prioritisation of management investment; the involvement of multiple actors across management levels; an increasing focus on monitoring and evaluating environmental outcomes and change; and the use of a mix of cross-level institutional coordination mechanisms. However, none of these approaches are free from criticism (e.g. Boyd, 2000; Hipfel, 2001; Ollivier, 2004; Steyaert and Ollivier, 2007; Lane et al., 2009; EEB, 2010), and all face challenges of understanding and facilitating management action in complex, uncertain and changing situations.

Addressing problems of NPS pollution requires a focus on purposeful, concerted and coordinated management action within catchments (Ison et al., 2007; Steyaert and Jiggins, 2007; Ison, 2010). A significant challenge that arises is understanding how to enable and enact (i.e. 'implement') local management action, which is itself embedded within wider multi-scalar contexts. Consequently, we argue that this requires a systemic and multi-level perspective, and a focus on building capacities that can enable management action over long timeframes within the uncertain, ambiguous, and changing situations faced. This paper aims to better understand this challenging problem. Managing NPS pollution is a 'wicked problem' (Rittel and Webber, 1973; APSC, 2007; Head, 2008a), and implementing management action is not necessarily linear or straightforward, but a result of the dynamics of social, institutional and biophysical interactions, multiple drivers of change, and patterns of behaviour of multiple actors in particular contexts that evolve over time. Furthermore, knowledge and management objectives also evolve over time. Thus rather than focussing on specific management actions *per se*, we propose that it is important to focus on capacities that enable purposeful and concerted local management action within uncertain and changing

situations. While there is empirical literature available that explores at least some enabling capacities in particular cases, what is lacking is a more comprehensive understanding of these from a cross-situational perspective. The specific nature and forms of local management action will differ in different contexts and over time. What we need to know however, is: what are the kinds of enabling capacities that more generally underpin local management action across different contexts? This question is the focus of the paper.

This paper reviews theoretical and empirical literature relating to the wicked problem of NPS pollution, focussing on enabling capacities that influence implementation of local management action. The literature considered encompasses international peer-reviewed and grey literature concerned with management and governance of catchments, water and natural resources; particularly literature concerned with implementation, action and change. In our review we first frame the problem of managing NPS pollution in catchments as a wicked problem, and describe implementation as a key challenge. Secondly, we identify and describe a range of enabling capacities that can influence implementation in a nested and embedded, multi-level catchment situation. Finally, we synthesise these factors as a conceptual framework for understanding and analysing implementation of local management action from a systemic perspective.

2. Framing the problem of nonpoint source water pollution

2.1. Nonpoint source water pollution as a wicked problem

Catchments involve "connectedness, complexity, uncertainty, conflict, multiple stakeholders and... multiple perspectives" (Ison et al., 2007). The problem of managing NPS pollution is embedded within this setting, and has been recognised as a wicked problem (Smith and Porter, 2010) because it is highly multi-actor, multi-scalar, dynamic, uncertain, and unclear (Table 1). Particular characteristics of the problem are the multiple pollution sources, drivers, actors and management arrangements, and outcomes. In general, features of wicked problems include: unclear, unstable and cross-sectoral issues; social complexity and shared responsibility; historical contingency; and systemic interconnectedness (APSC, 2007; Bellamy, 2007; Head, 2008a), and are inseparable from deeper "issues of values, equity, and social justice", and power (Pritchard and Sanderson, 2002). NPS pollution is also a multi-scalar issue (Cash et al., 2006) commonly involving tensions and mismatches between spatial and temporal scales relating to environmental change (both degradation and improvement) and human management and institutional processes (e.g. policy cycles and on-the-ground management action) (Cumming et al., 2006). In this light, we observe that the social and institutional dimensions are particularly poorly understood, which constrains opportunity for more effective management action.

Therefore NPS pollution is a wicked problem that cannot be addressed completely by rational, sector-bounded, and single-level approaches to policy, planning and implementation (APSC, 2007; Head, 2008a). This highlights the limitations of 'implementation planning' alone and the need to focus also on building enabling capacities, in recognition of the context in which management efforts are occurring (Bellamy et al., 2001; Ingram, 2008; Collins and Ison, 2010). The purpose of implementation of local management action may therefore be less about seeking to achieve pre-defined targets or outcomes, and more about supporting progress towards trajectories of management capacity building and social-ecological change (Westley et al., 2011) in contextually relevant ways (Ingram, 2008). This aligns with the concept of catchment management as an emergent phenomenon that "arises out of a set of practices for managing catchments in particular contexts ... [where]

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