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Review

Critical insights for a sustainability framework to address integrated community water services: Technical metrics and approaches

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ABSTRACT

Planning for sustainable community water systems requires a comprehensive understanding and assessment of the integrated source-drinking-wastewater systems over their life-cycles. Although traditional life cycle assessment and similar tools (e.g. footprints and emergy) have been applied to elements of these water services (i.e. water resources, drinking water, stormwater or wastewater treatment alone), we argue for the importance of developing and combining the system-based tools and metrics in order to holistically evaluate the complete water service system based on the concept of integrated resource management. We analyzed the strengths and weaknesses of key system-based tools and metrics, and discuss future directions to identify more sustainable municipal water services. Such efforts may include the need for novel metrics that address system adaptability to future changes and infrastructure robustness. Caution is also necessary when coupling fundamentally different tools so to avoid misunderstanding and consequently misleading decision-making.

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Contents

1. Introduction

In developed regions of the world, community water services are mostly achieved through large engineered centralized systems and through "siloed" water management approaches. Water services defined herein include the provision of safe drinking water, removal and treatment of sewage, and stormwater control. These services have been successful in controlling waterborne disease (OECD, 2011), mitigating flood damage (Jongman et al., 2012) and supporting firefighting (OECD, 2010) at an inexpensive market price (i.e. not full-cost). Increasing water demand, shrinking water resources, more stringent water quality goals, and aging infrastructure have resulted in a major asset management financial gap in countries like the US (US-EPA, 2002), threatening future affordability. Future planning will be more complex with rapidly developing economies and urbanization (WHO, 2012), the necessity to provide adequate ecosystem services (Wenning and Apitz, 2012) and to adapt to more intensified climatic change (IPCC, 2012). Overall, because of increases in population and decreasing water availability, coupled with continuously increasing service costs, and deficiencies in water system resilience, our current water services are not sustainable for future generations (Chang et al., 2012; Strengers and Maller, 2012).

A system level view of integrated water services is necessary to develop more balanced and optimal solutions. Focusing on just one part of the system, such as drinking water or wastewater alone, even when using system analysis tools such as life-cycle assessment (Ghimire et al., 2012; Igos et al., 2014; Lederer and Rechberger, 2010; Lundin et al., 2000; Memon et al., 2007; Mo et al., 2010, 2011; Remy and Jekel, 2008; Tangsubkul et al., 2005a; Tidåker, 2003; Venkatesh and Brattebø, 2012; WHO, 2012) may result in shifting problems to other sectors and miss more effective solutions only possible when the full system is viewed. For example, a full system approach that considers water-fit-for-purpose could lead to the removal of firefighting flow from drinking water provision. Additionally, framing water services around resource recovery (e.g., energy recovered from food and fecal residuals; nutrients returned to food production; and water largely retained within the municipal region) would yield very different system configurations and likely more robust and sustainable water services (Ashbolt, 2011; Otterpohl et al., 2003).

A major shift in resource governance would also be necessary to achieve such coordinated actions (Pahl-Wostl et al., 2012). Complications are evident when jurisdictional issues are raised by the various, and often conflicting stakeholders of source water (Winz et al., 2009) and municipal water services (Malmqvist and Palmquist, 2005). It is therefore no surprise that stakeholder-driven, and systems based approaches (Beall et al., 2011; Chang et al., 2012; Dobbie and Brown, 2014; Lundie et al., 2008; Maheepala et al., 2010; Malmqvist and Palmquist, 2005; Schlüter and Pahl-Wostl, 2007; Winz et al., 2009; Zarghami and Akbariyeh, 2012) are increasingly seen as appropriate ways to address and solve the complexities inherent to community water systems, and their fundamental interactions with regulators and users. Integrated community water management addresses total water cycle management via the engagement of key stakeholders that include city planners, citizens, regulators, utilities and managers of source water for a developed region (Thomas and Durham, 2003).

This paper addressed the overarching question: What are the strengths and weaknesses of various sustainability assessment tools used as a part of integrated community water management, and how do they aid in the design of next-generation community water services? We review a set