Global Environmental Change 23 (2013) 264–280

Contents lists available at SciVerse ScienceDirect

Global Environmental Change

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

Diagnosing transformative change in urban water systems: Theories and frameworks

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ARTICLE INFO

Article history:
Received 23 May 2011
Received in revised form 8 July 2012
Accepted 29 July 2012
Available online 1 September 2012

Keywords:
Diagnosis
Strategic planning
Sustainability
Transformative change
Transition
Urban water

ABSTRACT

As urban water systems become increasingly stressed from climate change impacts, population growth and resource limitations, there is growing acceptance by scholars and practitioners of the need to transform practices towards more sustainable urban water management. However, insights into how strategic planning should be made operational to enable this transformation are limited; there is a need for a reliable diagnostic procedure that could assist planners, policy analysts and decision-makers in selecting and designing strategic action initiatives that best fit an urban water system's current conditions to enable desired system changes. This paper is the first step in the development of such a diagnostic approach by proposing a scope for an operational procedure that maps a system's current conditions and identifies its potential transformative capacity. It then reviews five existing analytic frameworks, which are influenced by transitions theory and resilience theory, and applies them each to a common empirical case study of successful transformative change in the stormwater management system of Melbourne, Australia. In this way, the paper explores how existing frameworks could potentially contribute to a diagnostic procedure for selecting and designing strategic action initiatives from the perspective of dynamic transformative change. The paper found that such a procedure should guide an analyst through steps that develop descriptive, explanatory and predictive insights to inform which strategic action initiatives best fit the current system conditions. The types of insights offered by different analytic frameworks vary, so a diagnostic procedure should be designed with a particular aim, problem or question in mind and the underpinning framework(s) selected accordingly.

1. Introduction

Urban water systems are under increasing pressure due to climate change, population growth, ongoing urbanization, environmental pollution, resource limitations and ageing infrastructure. These stresses threaten water supply security, heighten flooding risk and lead to deterioration of urban waterway health in cities around the world (Pahl-Wostl et al., 2010). The ensuing water management challenges will be exacerbated, particularly as global impacts of climate change become more severe (Bates et al., 2008), and there is now a growing awareness and acceptance of the need for urban water servicing to transition to more sustainable approaches so that the acknowledged complexity of interconnected social, technical and ecological challenges can be addressed (e.g. De Graaf and van der Brugge, 2010; Pahl-Wostl, 2009; Truffer et al., 2010).

To tackle the sustainability challenges facing cities, Grove (2009, p. 293) emphasizes that development of solutions will require "approaches that perceive cities as complex, dynamic, and adaptive systems that depend upon interrelated ecosystem services at local, regional, and global scales". Strategic planning in urban water sectors does not typically embrace this approach for developing solutions (Dominguez et al., 2009; Truffer et al., 2010). Therefore, system transformation (i.e. fundamental system-wide change in the structure of a system and the way it functions) is required for water servicing in cities to become more sustainable. Transformation in an urban water system would involve radical changes to the way in which water servicing is planned, designed, constructed, operated, managed, governed and valued, in order to achieve more sustainable outcomes. However, transformation of social and biophysical structures and processes is impeded by a range of barriers, including institutional inertia and fragmentation, lock-in due to technological path-dependencies, and inadequate organizational, professional and community capacity to engage in new management practices (Brown, 2008; Farrelly and Brown, 2011; Pahl-Wostl, 2009).

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0959-3780/$ – see front matter
http://dx.doi.org/10.1016/j.gloenvcha.2012.07.008

Urban water scholars are currently considering the question of which governance arrangements are suitable for overcoming these barriers to shift towards sustainable urban water management; for example, a network, hierarchical, market or hybrid governance approach (see, for example, Van de Meene et al., 2011). However, there remains limited research on how strategic planning should be made operational in order to enable a transformation towards more water sensitive practices (Farrelly and Brown, 2011).

Academic discourse is starting to explore the concept of planning for sustainability in a range of multi-sectoral or administratively integrated systems (for example, energy supply, transportation, natural resources). Recent literature argues for the need to avoid panaceas or blueprints (e.g. Cox, 2011; Ostrom, 2007, 2009; Pahl-Wostl, 2009; Pahl-Wostl et al., 2010), which have been widely critiqued as being too simplistic to cope with the complex, uncertain, nonlinear and changing contexts within which integrated systems are managed. The use of simplistic approaches carries the significant risk that adaptation strategies result in maladaptations, as highlighted by Barnett and O'Neill (2010) for the urban water sector in Melbourne, in which decisions made with good intentions failed to achieve their objectives and increased the vulnerability of the system.

Instead, scholars argue that diagnostic approaches need to be developed, which typically aim to determine the nature, cause or source of some problem, undesirable outcome or system state by taking complexity into account in a systemic fashion (Cox, 2011; Ostrom and Cox, 2010; Pahl-Wostl, 2009). Despite these recent calls, to date there has been an absence of published scholarly articles that present a dedicated diagnostic procedure that can be applied in practice with the explicit purpose of determining the potential transformative capacity in urban water systems (or other integrated systems) to assist with the selection and design of strategies (Chapin III et al., 2010; Dolata, 2009; Smit and Wandel, 2006).

Chapin III et al. (2010, p. 247) argue that the scholarly literature currently provides "neither sufficient theory nor empirical evidence to identify [the] relative importance [of different strategic approaches] in the complex dynamics that play out in specific situations". Such insights would be critical for diagnostic procedures that aim to identify which strategic actions are likely to lead to a desired future. For example, a city in drought may lead policy analysts to consider increasing the volumetric water supplies through the introduction of seawater desalination plants and adopting regulative tools such as household water restrictions – both strategic actions. However, without sufficient diagnosis of the transformative capacity of the current system, there may be a poor fit between these strategic initiatives. For example, such initiatives could result in unanticipated and undesirable consequences, such as higher water consumption by communities, increased greenhouse emissions from desalination plants, or loss of critical social infrastructures such as parks, street trees and sports ovals due to water restrictions (Werbeloff and Brown, 2011). This current practical reality is exacerbated by the distinct lack of a reliable diagnostic procedure in the analyst's toolbox. Theoretical and empirical insights are thus required to understand the links between strategic action and the complex dynamics of transformative change in order to develop theoretically grounded frameworks for supporting planning and decision-making in systems where sustainability transformations are desired.

This paper is the first step in the development of a diagnostic procedure that could assist planners, policy analysts and decision-makers in understanding an urban water system's current conditions in order to select and design strategic action initiatives that are likely to enable transformative change. It has two clear objectives. First, it proposes a scope for an operational diagnostic procedure. Second, it reviews existing frameworks that are influenced by transitions theory and resilience theory and applies them each to a common empirical case study of successful transformative change in the stormwater management system of Melbourne. The case study application reveals insights into how each framework could contribute to a diagnostic procedure for selecting and designing strategic action initiatives from the perspective of dynamic transformative change.

The research approach for the first objective involved: (a) reviewing literature on transition studies, resilience thinking, integrated systems and diagnostic approaches in order to define what is meant by a *diagnostic procedure for transformative change in urban water systems*; and (b) synthesizing findings from the literature review to propose an operational scope for the design of such a diagnostic procedure. The approach for the second objective involved: (a) selecting frameworks identified in the literature review based on criteria derived from the first aim; (b) applying the selected frameworks to a common case study of successful transformative change in an urban water system; and (c) using the findings from the frameworks' application to identify how each could potentially underpin the development of a diagnostic procedure with the operational scope proposed from the first aim.

2. Diagnostic approaches for urban water system transformation

2.1. Defining an urban water system

The first step is to define what is meant by *urban water system*. From a systems thinking perspective, the urban water system consists of many different structures; these may be social (e.g. rules, knowledge, values), ecological (e.g. rivers, wetlands, green infrastructure) or technological (e.g. pipes, pumps, dams). Urban water systems can therefore be understood as social–ecological systems, in which technology provides a critical interface between the social and ecological structures (unlike many natural or common-pool resource systems). In urban social–ecological systems such as water servicing, actors fundamentally shape the functionality of the system by their implicit and explicit choices about infrastructure and technology (e.g. design standards, licensing agreements, funding priorities).

The urban water system can be considered to comprise five different types of variables (Fig. 1). *Structures* may be either social or biophysical (ecological or technological), for example, institutions, rivers and pipe networks. *Processes*, which may be social or biophysical, produce and reproduce the system structures. *Actors* (individuals or organizations) influence system structures by shaping processes through their practices, and in turn, their practices are shaped by the structures. The system's *context* creates conditions which influence its functioning but are derived outside its boundaries (for example, political, economic, social or environmental domains). Finally, the system's functional *outcomes* are dependent on the interplay between the other four variables.

Urban water servicing is therefore defined here as a social–ecological system that comprises social and biophysical structures, which actors can shape through different processes under local contextual conditions to achieve outcomes in the system functioning. Understanding how transformative change in such a system can be enabled therefore requires a capacity to analyse each of these variables in detail. Diagnostic approaches are proposed as a useful way forward (Cox, 2011; Ostrom and Cox, 2010; Pahl-Wostl et al., 2010).

2.2. Defining a diagnostic approach

Young (2002, 2008) explores the concept of diagnostics, describing the approach as one in which the individual elements