A new paradigm for water? A comparative review of integrated, adaptive and ecosystem-based water management in the Anthropocene

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A new paradigm for water? A comparative review of integrated, adaptive and ecosystem-based water management in the Anthropocene

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The failure of conventional approaches to achieve equitable and sustainable water management has prompted a new way of perceiving and acting with water. This is creating a ‘new water paradigm’ that emphasizes broader stakeholder involvement; integration of sectors, issues and disciplines; attention to the human dimensions of management; and wider recognition of the economic, ecological and cultural values of water. This article reviews three approaches arising within the new water paradigm: integrated water resources management; ecosystem-based approaches; and adaptive management. The article concludes that the strengths of each approach address different moral and ecological challenges. Combining these strengths, while minimizing tensions, may contribute to more effective water management in the Anthropocene.

Keywords: integrated water resources management; adaptive management; ecosystem-based approaches; water governance; new water paradigm; Anthropocene

Introduction

This article considers three related approaches to water management that are emerging in what can be considered a new water paradigm. This new paradigm reflects growing recognition that expanding human settlements, habitat conversion, pollution and climate change are threatening the world’s ecosystems (Millennium Ecosystem Assessment, 2005; Rockström et al., 2009). Human-induced global change has become so pervasive that some argue the earth has entered a new geological epoch: the Anthropocene (Clemenco, 2012; Crutzen, 2002; Steffen, Crutzen, & McNeill, 2007).

The key features of the Anthropocene are accelerated climate change associated with increased levels of greenhouse gases, altered biogeochemical and hydrological cycles, and extensive loss of habitat and biodiversity (Barnosky et al., 2011; Steffen, Grinevald, Crutzen, & McNeill, 2011). The term ‘Anthropocene’ has been adopted conceptually by the global change research community, but has yet to be accepted formally as a new geological epoch in Earth’s history (Steffen et al., 2011).

Driving the biophysical changes associated with the Anthropocene are extensive social changes, beginning with the expansion of human settlements following industrialization. The past five decades, in particular, have been a period of unprecedented growth, mechanization and globalization (Rockström et al., 2009). Human populations are now hyperconnected through rising numbers of motor vehicles and telephones; Internet-related information technologies; increasing direct foreign investment; growing rates of international tourism; and more urbanized lifestyles (Steffen et al., 2011; Young et al.,...
The expansion of human communities with growing needs for water, energy, oil, fertilizer and other resources has led to the degradation of ecosystems and the services they provide, including food and water provision, climate and disease regulation, nutrient cycling and cultural values (Millennium Ecosystem Assessment, 2005).

Water resources in the Anthropocene are threatened by increasing mean global temperatures, altered frequency and intensity of rainfall and evaporation, rising sea levels and altered discharge from rivers (Bates, Kundzewicz, Wu, & Palutikof, 2008). While demand for water is on the rise, nearly 80% of the world’s human population is already exposed to grave threats to water security, particularly in developing countries (Vörösmarty et al., 2010). The three management approaches discussed in this article – integrated water resources management (IWRM), ecosystem-based approaches (EBAs) and adaptive management (AM) – are emerging from a new pattern of thinking or ‘paradigm’ in water management, which is explored in the next section.

Background: the rise of a new water paradigm

Recognition of the Anthropocene has prompted reflection on water paradigms. A paradigm is a shared pattern of seeing and thinking about the world, based on socially maintained assumptions, values and practices (O’Leary, 2007). Paradigms are rarely examined because they are often unconscious, and foundational to how members of society interact with and in the world. However, the scale of change currently occurring requires examination of these assumed, implicit ways of being. A water paradigm is revealed through observing the assumptions people make about (1) the nature of the system being managed; (2) the goals of management; and (3) the best approach to solving problems and achieving goals (Pahl-Wostl, Jeffrey, Isendahl, & Brugnach, 2011). Until recently the paradigm for water (and resource governing and management in general) was science-based command and control.

Command-and-control management is based on an assumption of ‘stationarity’ (predictable uncertainty) and reversible trajectories of change within natural systems (Milly et al., 2008). In the command-and-control paradigm the goal of water management is to maximize resource exploitation by reducing natural variability; this approach is typified by centralized, sectoral institutions, limited stakeholder involvement and expert-led problem solving focused on technical engineering solutions. Reducing problems to parts has been central to science-based management for over a century, but with the advent of the Anthropocene, this paradigm has been found wanting (Holling & Meffe, 1996; Pahl-Wostl, 2006). The novel challenges and opportunities of the Anthropocene demand approaches that foster adaptive capacity in preparation for unforeseen changes emerging from the complex interconnections and feedbacks between societies, economies and the environment (Berkes, Colding, & Folke, 2003; Berkes, Folke, & Colding, 1998; Ison et al., 2011; Walker, Holling, Carpenter, & Kinzig, 2004). Put simply, integrated and effective water management cannot be achieved if people and ecosystems are conceptualized as separate entities (Schmidt, 2013).

Mounting evidence of the failure of conventional approaches to ensure the sustainable and equitable use of water has led to discourse around the newly emerging water paradigm (Cook & Spray, 2012; Cortner & Moote, 1994; Pahl-Wostl, 2006; Pahl-Wostl et al., 2011). Although the new paradigm is still developing, some defining features discussed in this article are (1) the conceptualization of social-ecological systems as complex, adaptive systems that are inherently unpredictable and difficult to control (Pahl-Wostl, 2006); (2) a shift in the goals of water management to include sustainability, water security and adaptive...
capacity (Allan, Xia, & Pahl-Wostl, 2013; Engle & Lemos, 2010; Munang et al., 2013); and (3) the implementation of integrative and adaptive management approaches and dialogic problem solving focused on learning, governance and the human dimensions of management (Medema, McIntosh & Jeffrey 2008; Pahl-Wostl, 2006; Pahl-Wostl et al., 2011).

The developing water paradigm both requires and enables consideration of economic, ecological, social and cultural values of water. Within the new paradigm, decision making aims for a broader spread of benefits for people and ecosystems through wider stakeholder participation; inclusion of different types of knowledge; attention to the human dimensions of management (needs, wants, perceptions, values and behaviours); integration of issues, sectors and disciplines; and the desire to tighten the links between science, policy and practice (Gleick, 2000; Ison et al., 2011; Pahl-Wostl, 2008). Although these ideas are not particularly new, they have been gaining attention in water management communities in the last few decades.

While a paradigm, by nature, involves unconscious assumptions and mental models, the new water paradigm has manifested in conscious operational concepts such as IWRM, EBAs and AM. The underlying philosophy of IWRM and EBAs is similar in terms of their shared goals of equity, human well-being and sustainability, though they have slightly different emphases: EBAs on conservation and IWRM on sustainable development. AM complements and supports both approaches.

IWRM promotes sustainable social and economic development by providing a governance platform for actors to negotiate integrated land and water management at basin scales (Grigg, 2008; Saravanan, McDonald, & Mollinga, 2009). EBAs are more directed towards conservation, through strategies such as Ramsar’s “wise use of wetlands” (Finlayson, Davidson, Pritchard, Randy, & MacKacy, 2011) and the valuation of ecosystem services for improved decision making (De Groot, Wilson, & Boumans, 2002). AM implements policies as ‘experiments’, following a continuous cycle of planning, doing, monitoring and evaluating. It encourages structured learning about the system being managed, and informed, ongoing management responses (Allen, Fontaine, Pope, & Garmestani, 2011; Argent, 2009; Gunderson, 1999; Holling, 1978).

While AM and EBAs have a strong scientific foundation in complex adaptive systems theory (Gunderson & Holling, 2001), IWRM has its roots in the theory of communicative rationality and the need to gain legitimacy through participatory processes (Saravanan et al., 2009). Despite their different origins and goals, the concepts of IWRM, AM and EBAs are increasingly converging in water management. This has occurred through calls from policy and management scholars for water management to be both integrated and adaptive (Pahl-Wostl, 2006; Pahl-Wostl et al., 2011). At the same time, water ecologists have sought to include ecosystem service assessments or other EBAs within an IWRM framework (Jewitt, 2002; Rebelo et al., 2013; Roy, Barr, & Venema, 2011). The following sections provide a brief review of the origin, practice and issues relating to each concept before considering their contributions to improved water management in the Anthropocene.

**Integrated water resources management**

IWRM is one response to the failure of conventional management regimes to tackle water problems by assisting in the controversial, value-laden nature of decision making (Engle, Johns, Lemos, & Nelson, 2011; Grigg, 2008). IWRM aspires to simultaneously address two complex problems: sustainable development and cross-sectoral planning (Jeffrey & Gearey, 2006). The mandate for ‘integrated’ resource management emerged as early as the
1930s in the United States (Jeffrey & Gearey, 2006; Mukhtarov, 2008), but was formally introduced internationally at the 1977 United Nations Water Conference (Biswas, 2004). The concept of IWRM remained relatively obscure until it was revived and heavily promoted by the Global Water Partnership following the World Summit in Rio de Janeiro in 1992 (Rahaman & Varis, 2005).

IWRM is most frequently defined as a process that “promotes co-ordinated development and management of water, land and related resources, in order to maximise economic and social welfare in an equitable manner without compromising the sustainability of vital systems” (Global Water Partnership, 2000, p. 22). The Dublin-Rio principles outline the five foundations of IWRM: (1) recognizing water as a finite and vulnerable resource; (2) encouraging broad stakeholder participation in decision making; (3) strengthening the role of women in water management; (4) recognizing the social and economic value of water; and (5) promoting the integration of economic efficiency, social equity and ecosystem sustainability. Thus, IWRM is rooted in governance and institutional mechanisms to enhance social and economic well-being, with the additional aim of not compromising environmental sustainability.

Despite these foundational principles, the vagueness of IWRM as a concept has drawn criticism. For example, Biswas (2008b) argues that the broad definition of IWRM allows managers to continue with ‘business as usual’, while claiming to be applying innovative global thinking. Although IWRM has been heavily promoted internationally, empirical studies clearly demonstrating its benefits are scarce (Biswas, 2008a; Jeffrey & Gearey, 2006; Mukhtarov, 2008). The most commonly cited barriers to implementation are the ambiguities in defining IWRM and the science behind its development (Biswas, 2008b); the difficulty of reforming ingrained institutions (Grigg, 2008); and the ‘one size fits all’ approach that disregards local conditions (Moss, 2003). The principles of IWRM may even contravene democracy by encouraging centralization (Rahaman & Varis, 2005) and “rigid mega-bureaucracies” (Biswas, 2004) rather than decentralized, local, community-led planning and management. Molle (2008) argues that IWRM is a “nirvana concept” because it applies a version of rationality that may be appropriated to push political agendas and hence preserve the very institutional barriers it was intended to overcome.

The disharmony between the normative and descriptive aspects of IWRM is observed in what Jeffrey and Gearey (2006) refer to as its “schizophrenic character”. Saravanan et al. (2009) explain the tension in embracing the ideal that rational decisions will arise from shared dialogue, while acknowledging the impossibility of achieving true integration because of fundamental power differentials between stakeholders. Mukhtarov (2008) also observes disconnection between the apparent post-modernist agenda of IWRM, with an emphasis on context and the inclusion of a multiplicity of views, and the clear conceptual links with rational strategic planning that strives for objectivity and predetermined targets.

In addition to the split character of IWRM, water management jurisdictions based on catchment boundaries, necessary for effective IWRM, may be considered inappropriate on the grounds that catchments are non-economic or social units that lack relevance in society (Grigg, 2008). In addressing issues of ‘fit’ between ecosystems and institutions (Folke, Pritchard, Berkes, Colding, & Svedin, 1998, 2007), IWRM may create ‘interplay’ problems between water and other relevant institutions such as planning, agriculture and environmental conservation (Moss, 2003). Thus, there is still fundamental disagreement on what needs to be integrated, how to achieve this, who will provide leadership, and who will pay (Biswas, 2004; Grigg, 2008).
Ecosystem-based approaches

EBAs share a similar philosophical operating framework with IWRM. They promote an integrated approach that influences perceptions and management of social-ecological systems towards the goals of sustainable use and equity (Cook & Spray, 2012; Finlayson et al., 2011). These approaches are a collection of strategies that aim for the integrated management of land, water and societies as components of ecosystems, which are considered to be the integrating units. EBAs seek balance – conservation on the one hand and sustainable human use on the other – while aspiring to maintain and restore the natural structure and functioning of ecosystems (Convention on Biological Diversity, 2000).

The idea of ‘ecosystem management’ was widely promoted by the United Nations Environment Programme and the Millennium Ecosystem Assessment (2005), becoming popular in North America in the 1990s (Finlayson et al., 2011; Roy et al., 2011). The concept of ‘wise use’ in the Ramsar Convention on Wetlands (1971) is an early and persisting example of an EBA, promoting the view that the sustainable human use of wetlands is not necessarily in competition with wetland conservation (Finlayson et al., 2011; Rebelo et al., 2013). EBAs have been applied in planning for marine, wetland and terrestrial system use and conservation. More recently, channelling the adaptive forces of nature through ecosystem-based adaptation is gaining support as a critical response to the impacts of climate change. Munang et al. (2013) discuss how this approach has provided a flexible, cost-effective and ‘no risk’ alternative to built infrastructure in cases such as the restoration of mangroves for flood protection in riparian areas.

The Millennium Ecosystem Assessment (MEA) conceptualizes EBAs as holistically encompassing the links between wetland ecosystem services, drivers of change, and human well-being and poverty reduction. The ecosystem services framework defines and analyzes the linkages and dependencies in human–economy–nature interactions (Burkhard, Petrosillo, & Costanza, 2010). The MEA groups ecosystem services into four broad categories: provisioning, such as the production of food and water; regulating, including the control of climate and disease; supporting, such as photosynthesis, nutrient and water cycling, and crop pollination; and cultural, encompassing spiritual and recreational benefits. Many of the services provided by ecosystems are external to the classical conception of the economy that uses market mechanisms to maximize human well-being through efficient resource allocation (Pattanayak, Wunder, & Ferraro, 2010).

EBAs create an incentive for conservation by making explicit the trade-offs in ecosystem services associated with different resource-use options. In economics, trade-offs can be expressed as opportunity costs. When a choice needs to be made between mutually exclusive options, the opportunity cost refers to the value of the forgone alternative. Thus, an EBA incorporating ecosystem services analysis would consider the opportunity cost arising when a given ecosystem good is harvested (Gordon, Finlayson, & Falkenmark, 2010). In theory, realizing the value of ecosystem functions and services could internalize environmental costs into the market economy and thereby aid the transition to ‘greener’ economies (Munang, Thiaw, & Rivington, 2011). In terms of practical application, it is assumed that people will change their behaviour to correct imbalances in trade-offs if there is an economic benefit and a clear rationale as to why change is needed (Munang et al., 2011).

EBAs have faced criticisms similar to those regarding IWRM, including ambiguity in definitions and a disappointing migration from theory to practice. Despite some success stories (e.g. the transition of governance in the Great Barrier Reef Marine Park, Australia, to an EBA, outlined by Olsson, Folke, & Hughes, 2008), evidence suggests that the
application of EBAs has not been overwhelmingly favourable. Finlayson et al. (2011), exploring the implementation of the ‘wise use’ approach 40 years after its inception, finds that efforts to sustainably exploit the ecosystem services provided by wetlands and other systems have been largely unsuccessful. In addition, the contribution of ecosystem services valuation to ecosystem management efforts has not been as clear-cut or convincing as imagined (Liu, Costanza, Farber, & Troy, 2010).

Ecosystem services, when traded off or valued in the monetary system, can be seen as an attempt to commodify nature. Valuing nature based on how well it serves human wants and needs erodes its intrinsic value, creating a moral dilemma (McCaulay, 2006). In addition, ecosystem services assessments may create a situation where decision making is based on an instrumental logic of maximizing human satisfaction, rather than doing what is right (Vatn, 2010). These concerns with ecosystem services can be understood with a brief side-track into classical philosophy.

Philosophers have long recognized and named two types of claims about the world: empirical claims about how the world is, or will be; and moral claims about what ought to occur (VanDeVeer & Pierce, 2003). These claims are fundamentally different: empirical claims can be found, through measurement, to be true or false, while moral claims are always contextual. Moral questions of what we ‘ought’ to do can be and are informed by empirical data: the more we know, the better we can act. The anxiety that many feel with regard to ecosystem services assessments is that the market, with its narrow set of values, is being used as a proxy for moral decision making. Human values become central to water management decisions when considering issues such as levels of acceptable degradation in freshwater systems, and prioritizing various uses for finite water resources (i.e. production, recreation or conservation). Thus, many would argue that while ecosystem services assessments provide information for decision making, moral considerations can only be addressed by defining collective values through legislative debate and participatory processes.

Adaptive management

Both IWRM and EBAs aim for integration, which can be achieved, in theory, through the AM approach. AM involves ‘learning by doing’, as adaptive practitioners treat management interventions as experiments (Allen et al., 2011; Holling, 1978; Light, 2002; Walters & Holling, 1990). This approach uses feedback mechanisms from the environment (biophysical and/or social) to shape policy, followed by further systematic experimentation and learning, in a never-ending cycle (Berkes et al., 2003). Thus, although AM can reduce uncertainty in decision making, it is primarily a means to enable decision making despite uncertainty (Allen et al., 2011; Pahl-Wostl et al., 2007). This acceptance of uncertainty makes AM a radical departure from conventional command-and-control management. AM recognizes people and ecosystems as inherently complex, unpredictable and difficult to control, and encourages ongoing learning, rather than reduction, as the key to coping with complexity and uncertainty.

AM has been widely promoted as a solution to complex natural resource management problems and a supporting approach to integration. However, while a small but increasing number of projects have been able to effectively apply adaptive management to complex problems (e.g. Allan & Stankey, 2009), it remains more an ideal than a reality (Allen & Gunderson, 2011). The issues faced by would-be adaptive managers are similar to those discussed for IWRM and EBAs: little evidence of success; ambiguity of definition; complexity; institutional barriers; risk; and cost (Medema, McIntosh, & Jeffrey, 2008).
A recent review of AM by Westgate, Likens, and Lindenmayer (2013) found that over-use and misrepresentation of the term ‘adaptive management’ was frequent in the peer-reviewed literature. The most significant obstacles to implementing AM are cultural rather than technical: ingrained institutional norms of action rather than reflection; box-ticking rather than learning; and encouragement of competition rather than cooperation (Allan, 2012).

IWRM, EBAs and AM have arisen in different disciplines, in response to different immediate problems. Our contribution to the new water paradigm discourse is to consider the complementarities and tensions between IWRM, EBAs and AM and how their strengths may contribute to improved water management in the Anthropocene.

Managing water in the Anthropocene: the role of IWRM, EBAs and AM

Despite the criticisms of IWRM, EBAs and AM, and disappointment with their level of implementation, each has particular strengths and addresses systemic issues. Combining these strengths, while minimizing tensions, is desirable for effective water management in the Anthropocene. Table 1 summarizes the strengths, as identified in the text above, that IWRM, EBAs and AM could contribute to improved water management. This tabulation demonstrates the complementarities between the approaches: where one approach is weak, another is strong. When viewed together (and in their ideal form in this table), they address all of the criticisms of conventional management. This suggests pathways for more effective, combined use.

Furthermore, Table 1 relates the strengths of IWRM, EBAs and AM to different pressures of the Anthropocene. Social-ecological changes in the Anthropocene have occurred over multiple spatial and temporal scales, involving many actors across levels and sectors and occurring in many different contexts. The inherently complex social and biophysical interdependencies within social-ecological systems mean there is a high degree of uncertainty about the future trajectories of change. As a result, building adaptive capacity to respond to unforeseen changes has been advocated as a key goal of water management (Engle & Lemos, 2010; Pahl-Wostl, 2006; Pahl-Wostl et al., 2011), as well as generating “enabling social and institutional arenas” that support innovation and emergent adaptive approaches at the local level (Patterson, Smith, & Bellamy, 2013). Encouraging combined use of IWRM, EBAs and AM is consistent with the argument made by Ingram (2008) that the application of diverse “solutions” that embrace multiple perspectives and appeal to different ways of knowing is more likely to be effective than a single universal remedy.

In theory, the combined strengths of IWRM, EBAs and AM may assist with water management in the following ways. Broad stakeholder participation across scales, disciplines and sectors, which is promoted by IWRM and AM, builds adaptive capacity by including people with a variety of skills and experience and creating opportunities for knowledge sharing through the formation of networks. Increased networking, communication and information sharing provide pathways for coping with institutional complexity in the Anthropocene. Institutions and monitoring based on hydrological boundaries, as encouraged by IWRM, may improve cohesion between biophysical processes and institutional arrangements. Furthermore, the political process of IWRM is a platform for promoting shared values and resolving conflicts as global water security declines in the Anthropocene. Thus, while IWRM is particularly focused on improving real participatory justice, incorporating AM builds the capacity of management regimes to navigate biophysical uncertainty.
Table 1. How integrated water resources management (IWRM), ecosystem-based approaches (EBAs), and adaptive management (AM) address the shortcomings of conventional water management and encourage improved water management in the Anthropocene.

<table>
<thead>
<tr>
<th>Shortcomings of conventional water management</th>
<th>Pressures of the Anthropocene</th>
<th>IWRM</th>
<th>EBAs</th>
<th>AM</th>
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<tr>
<td>Centralized, sectoral institutions and narrow stakeholder involvement create issues of legitimacy and justice</td>
<td>Institutional complexity (globalization; nested governance across multiple scales; mismatch between institutional boundaries and biophysical processes)</td>
<td>IWRM provides a political platform for broad stakeholder participation, negotiation and promotion of shared values; it encourages decision making based on hydrological boundaries</td>
<td>EBAs are a pathway towards cost-effective, ‘no risk’ climate change adaptation</td>
<td>A wider range of participants in learning is possible, and multiple ways of knowing are encouraged</td>
</tr>
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<td>Institutions are inflexible and slow to respond to biophysical feedbacks</td>
<td>Climate change (including increased risk of extreme events); rapid and pervasive biophysical change</td>
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<td>Utilitarian view of water aims to maximize resource exploitation for economic gain, resulting in poor recognition of the multiple values and benefits of water for people and ecosystems</td>
<td>Environmental degradation and loss of biodiversity; dominance of human activities over natural processes; globally increasing and progressively urbanized human population; increasing standards of living and changing patterns of consumption influencing trade and agricultural economies; resource shortages</td>
<td>Encourages equity in water access to promote community development; recognizes ecosystems as legitimate ‘users’ of water requiring allocation</td>
<td>Systemic ecosystem rehabilitation is encouraged as a means to build resilience and maintain ecosystem services; identifying and/or valuing a broad range of ecosystem services can inform water management decisions through realizing the broader benefits and costs/disbenefits of various management options</td>
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Table 1 – continued

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<th>Shortcomings of conventional water management</th>
<th>Pressures of the Anthropocene</th>
<th>IWRM</th>
<th>EBAs</th>
<th>AM</th>
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<tr>
<td>Presumption of stationarity (predictable uncertainty); problem solving is focused on technical engineering solutions and reductionism</td>
<td>Irreversible social-ecological state changes (regime shifts); change beyond historical coping ranges is increasingly unpredictable</td>
<td>Systems thinking and practice is encouraged; EBAs aim to preserve and enhance the natural structure and function of ecosystems</td>
<td>AM is process-based learning in complex, adaptive systems; it enables decision making despite uncertainty</td>
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EBAs, with their focus on the conservation and restoration of natural processes, may slow environmental degradation and biodiversity loss in the Anthropocene. In particular, EBAs have been proposed as a pathway toward ‘no risk’ climate change adaptation (Munang et al., 2013). The grounding of EBAs and AM in complex adaptive systems theory encourages resilience thinking and practice. This includes the consideration of possible thresholds and irreversible state changes in the Anthropocene. The systematic planning, learning and policy improvement cycles in AM are critical for enabling management action and rapid learning despite the uncertain conditions of the Anthropocene. In an ideal situation, IWRM, EBAs and AM all provide opportunities for social learning. The complexities of the Anthropocene require a strong focus on social learning as a response to complexity, rather than the traditional method of scientific reduction (Pahl-Wostl, 2006).

Merging aspects of IWRM, EBAs and AM is unlikely to be easy. A number of socio-political, value-based, temporal and spatial tensions and trade-offs may arise in the new water paradigm when institutions strive to be both integrative and adaptive (Table 2). For example, the integration of a broad range of stakeholders holding different perspectives enhances legitimacy and access to local knowledge at the expense of the flexibility present in a small technical team of managers. However, flexibility can be maintained in participatory processes if participants are willing to delegate decision making (Engle et al., 2011).

Engle et al. (2011) observe that in situations where the use of technical scientific information is high, there is a perception that power is unequally distributed. Participatory social learning processes run the risk of becoming a battlefield where more powerful and better-organized interest groups can legitimately negotiate a system that is clearly to their advantage and not necessarily best for the common good or environmental sustainability. Power may play out in the framing and process of deliberations, or in deciding who is invited to the negotiating table. In addition, participatory processes are often expensive and time-consuming, which is at odds with short-term organizational and economic efficiency. Finally, over-formalization of institutions and processes may constrain the learning, innovation and self-organization that often occur in more informal settings (Engle et al., 2011; Pahl-Wostl et al., 2007). If these tensions can be successfully managed, there are clearly benefits to be accrued from integrated and adaptive water management, which may be further enhanced by considering the role of EBAs.

In theory, the inclusion of ecosystem services assessments within an IWRM framework provides improved information to guide decision making (Jewitt, 2002; Reid-Piko, Crase, Horwitz, & Butcher, 2010; Roy et al., 2011). However, the strong grounding of AM and EBAs in the sciences is a source of tension in democratic decision-making processes, which use more than just scientific information. The “information deficit” model of science communication (Sturgis & Allum, 2004) refers to the assumption

<table>
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<th>Tensions</th>
<th>Trade-offs</th>
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<td>Socio-political</td>
<td>Technocratic flexibility vs. pluralistic accountability</td>
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<td>Technical knowledge use vs. democratic decision making</td>
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<td>Institutional stability vs. risky and potentially costly action</td>
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<td>Value-based</td>
<td>Social learning processes vs. concessionary negotiation tactics</td>
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<td>Temporal</td>
<td>Efficiency vs. deliberation</td>
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<td>Boundary/spatial</td>
<td>Self-organization at various scales vs. formalized institutions at the basin level</td>
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permeating many scientific approaches to management that people will change their opinions and behaviour when presented with new information (e.g. an assessment of ecosystem services). Observations of human behaviour show a more complex relationship between knowledge/information, attitudes and actions (Sturgis & Allum, 2004). When making moral decisions about what ought to happen, people also draw on ethical and religious beliefs, culture, history and personal experiences. The scientific and economic basis of AM and EBAs is important for managing water, but not sufficient. Genuine engagement through political processes, as part of IWRM, that appeals to people’s hopes, values and morals through deliberative processes is essential for solving water management problems, which are so often human-value problems (Groenfeldt & Schmidt, 2013).

This review has illustrated how the underlying philosophy of EBAs and IWRM is remarkably similar in terms of their shared goals of equity, human well-being and sustainability. Jewitt (2002) believes that despite the impediments of IWRM, it has provided an enabling context for EBAs. There is a strong mandate within the water management community to manage water within an economic framework. Some researchers and practitioners view water management as a process where human and environmental needs are traded off, while others argue that through participatory processes and social learning, new understandings, shared goals and solutions may emerge that are more beneficial than the positions that result from a process of trading off (Ison et al., 2011). Cook and Spray (2012) note that ecosystem service trade-offs raise political and ethical considerations that cannot be addressed through value-neutral scientific and economic approaches. Political, ethical and moral considerations can only be addressed through deliberation and the definition of a collective vision for society.

Ultimately, stakeholder participation in IWRM processes (such as catchment and basin water management planning) remains an important platform for society to negotiate resource use in the Anthropocene. Critics of IWRM say it is ill-equipped to achieve equity in the face of social influences on management, such as competition, conflict, bias, subversion, interests and active opposition – forces which may be present in any social interaction (Cook & Spray, 2012). The links between water management regimes, the approaches they use (including IWRM, EBAs and AM), the emergence of new understandings and actions, and the sustainability outcomes for the water system is an area requiring further empirical research. Ultimately, IWRM, EBAs and AM are not working perfectly, but they do complement each other. Building on the strengths and managing the tensions between these concepts could lead to a more robust, systemic approach to water management as social and environmental interactions become more complex in the Anthropocene.

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