Journal of Environmental Management 109 (2012) 93–100

Contents lists available at SciVerse ScienceDirect

Journal of Environmental Management

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

Review

Ecosystem services and integrated water resource management: Different paths to the same end?

Brian R. Cook*, Christopher J. Spray [1]

UNESCO IHP-HELP Centre for Water Law, Policy and Science, University of Dundee, Peters Building, Perth Road, Dundee DD1 4HN, Scotland, UK

ARTICLE INFO

Article history:
Received 27 June 2011
Received in revised form
7 May 2012
Accepted 16 May 2012
Available online 12 June 2012

Keywords:
Ecosystem services
IWRM
Knowledge
Implementation
Lessons
Gap

ABSTRACT

The two concepts that presently dominate water resource research and management are the Global Water Partnership's (GWP, 2000) interpretation of Integrated Water Resource Management (IWRM) and Ecosystem Services (ES) as interpreted by the Millennium Ecosystem Assessment (MA, 2005). Both concepts are subject to mounting criticism, with a significant number of critiques focusing on both their conceptual and methodological incompatibility with management and governance, what has come to be known as the 'implementation gap'. Emergent within the ES and IWRM literatures, then, are two parallel debates concerning the gap between conceptualisation and implementation. Our purpose for writing this review is to argue: 1) that IWRM and ES have evolved into nearly identical concepts, 2) that they face the same critical challenge of implementation, and 3) that, if those interested in water research and management are to have a positive impact on the sustainable utilisation of dwindling water resources, they must break the tendency to jump from concept to concept and confront the challenges that arise with implementation.

1. Introduction

Water management has undergone a succession of dominant frameworks: from comprehensive management with the Tennessee Valley Authority (1930s), to multi-purpose basin management (1950s), to the present push for ES-based governance. We assert that the emergence of each 'paradigm' can, in large part, be traced to the difficulties that arise when individuals apply pure, objective, and rational ideas within the uncertain, subjective, and biased contexts of human understanding, social factors, and governance. With each shift, having become frustrated with the inadequacies of a 'flawed' concept, debate and development appear to start anew. We suggest that this cycling is a way to avoid the paralysis that accompanies the implementation gap (Miner, 1984). In engaging with the ES literature, we have been struck by its similarities with IWRM. Given the growing prominence of ES, we believe this is an opportune moment to ask what lessons can be drawn from criticisms of IWRM. The aim is to help revitalise IWRM and to help fortify ES in light of emergent criticisms. This paper asks what challenges are likely to arise as researchers continue to promote ES-based governance?

The subdivision of literature into two distinct bodies is, of course, artificial. That said, water resource management can be divided into two roughly distinct groups; at present, these groups appear largely to be isolated from one another. As opposed to a complete review of these discourses, which have been conducted independently elsewhere (Liu et al., 2010; Mitchell, 2005), we have selected those works that address implementation. Our review is divided into three sections. The first describes ES with emphasis on its underlying assumptions and on calls to implement the concept. In addition to establishing the similarity between ES and IWRM, the second section reviews existing criticisms of IWRM. The criticisms allow us to explore the challenges that have impaired a concept that is, we argue, virtually identical to ES. The third section draws lessons from the criticisms.

Water resource research and management faces a juncture. Broadly, there is growing disenchantment with IWRM, which is creating an opportunity for ES to fill the vacuum. We conclude that while ES might be used to strengthen sustainable water resource management, those looking to implement the concept are mimicking the process that scuttled a highly similar forerunner. While there may be no avoiding the challenges that accompany implementation, ES researchers must confront their embedded assumptions and ask whether more detailed knowledge of human

* Corresponding author. Tel.: +44 (0)1382 386467; fax: +44 (0)1382 388671.
E-mail addresses: b.r.cook@dundee.ac.uk, brian.cook@unimelb.edu.au (B.R. Cook), c.j.spray@dundee.ac.uk (C.J. Spray).
[1] Tel.: +44 (0)1382 386467; fax: +44 (0)1382 388671.

0301-4797/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jenvman.2012.05.016

dependence on the environment can form the basis of more sustainable management of socio-ecological challenges?

2. The ecosystem services framework

2.1. The basis of ecosystem services

Building on ecology-focused frameworks (CBD, 2005), the Millennium Ecosystem Assessment (MA) (MA, 2005: v) articulates the dominant interpretation of ecosystem services (Milder et al., 2010; Norgaard, 2010; Pascual et al., 2010), defining it as pertaining to

> "the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious, and other nonmaterial benefits".

The MA is used to conceptualise the connections between humanity and the sustained functioning of the environment. It is shaped by the presumption that the wellbeing of the environment is inseparable from the wellbeing of the people who utilise that environment, extending consideration beyond tangible commodities to the processes that enable consumption. The definition distinguishes finite natural capital and the potentially sustainable services that ecosystems generate. For example, it emphasises how wetlands provide water filtration or flood defence, how forests regulate air quality, and, less clearly, how natural environments contribute to human wellbeing. The MA helps researchers extend the temporal scale of existing human-centred interpretations of sustainability (Bruntland Report, 1987) to include appreciation for the resources that are required to sustain the natural environment (DeFries et al., 2004; Foley et al., 2005). Recognition for the role of the natural environment as provider, but simultaneously as a victim of pollution and overconsumption, underlies ES, thereby providing consideration for the basic needs of the ecosystem.

A critical aspect of the ES discourse is the differentiation between ecosystem functioning and ecosystem services. Jax (2010: 68) notes that "distinctions between services, functions, and processes are not made in a consistent way", leading him to decouple the "components and processes which are used, required, or demanded from ecological systems" (services) and the natural processes that enable those benefits (functioning). This includes recognition that a minimal level of biotic and abiotic resources is required for an ecosystem to function, with human wellbeing ultimately dependent on these underlying processes. This distinction is most easily explained using research of environmental flows (Richter et al., 2003). For example, Yang et al. (2009) explore the minimal water needed to sustain river ecosystems in order to determine sustainable abstraction levels. As Williams et al. (2003: 67) declare, "life on earth depends on the ability of the environment to provide essential services" as much as it does on the tangible resources themselves. Barkmann et al. (2008: 50) provide a clearer differentiation between function and services, arguing that services are the products derived from a functioning environment, explaining that "if an ecosystem provides a material good, such as water used for irrigation, the process of provisioning the material good is an ecosystem service". Following this view, it is the delivery and maintenance of a commodity by an ecosystem that is the service.

Prominent within early analyses of ecosystem services were efforts to calculate the economic value of a functioning ecosystem, including Costanza et al.'s (1997) assessment of global values. More common, though, is to use marginal valuation as part of scenarios and of decision-making. To date, economic valuation represents the most frequent application of ES (Brauer, 2003; Liu et al., 2010; Pattanayak et al., 2010; Williams et al., 2003). More recently, interest has turned to the allocation of costs and benefits. This trend is most common within programmes that emphasise payments or trade-offs between service providers and beneficiaries (Kosoy and Corbera, 2010; Milder et al., 2010; Pattanayak et al., 2010).

With its origins in the natural sciences, the ecosystem services concept is grounded in empirical and positivist findings.[2] The concept, implicitly, operates on the assumption that a better accounting of natural capital will enable more effective management of the dynamic trade-offs between society and nature. ES-based management tends to require some form of quantification, having difficulty incorporating qualitative or intangible factors (Aronson et al., 2010; Balvanera et al., 2006; Liu et al., 2007; MA, 2005; Zander et al., 2010). As a result, discussions and analyses of trade-offs are overwhelmingly reliant on extending existing methods of quantification and commoditisation of resources to services. In sum, ES is used to extend quantification to more of the environment than has been typical, though environmental economists have long promoted this objective (Tisdell, 2007). Assertions by Bennett et al. (2009: 1401 italics added) are representative of the assumed strengths of this approach, arguing that

> "research that quantifies the provision of multiple services and the trade-offs and synergies among them and examines the ecosystem processes that link services *will lead to a better understanding* of how the relationships among ecosystem services can change over time and space".

By extending consideration to the supporting processes, ES helps to describe the limited capacity of the environment to attenuate the impacts of consumption. As Brauman et al. (2007: 69) explain, "the ecosystem services framework makes explicit the complex feedbacks and trade-offs among services and human beneficiaries", though "explicit" remains descriptive. Such accounts separate objective or quantified calculations from more subjective or qualitative accounts of how people perceive or interpret the environment. As Barkmann et al. (2008: 48) argue, ecosystem services are strictly indirect benefits and require "a precise differentiation between the descriptive realm of ecosystem functions and the evaluative realm of ecosystem services". Despite claims that ES is evaluative, the analyses are more accurately extensive descriptions of the natural environment and further descriptions of human dependence on that environment.

2.2. Ecosystem services, society, & governance

The desire to influence the perception and management of socio-ecological issues is a priority within the ES discourse (Aronson et al., 2010; Butler and Koontz, 2005; Milder et al., 2010; Norgaard, 2010; Pascual et al., 2010; Pavlikakis and Tsihrintzis, 1999; Reynolds et al., 2010; Smith and Clay, 2010; Zander et al., 2010). Carpenter et al. (2006: 1305), for example, suggest the need to appreciate "the dynamics of coupled human-natural systems", while Turner et al. (2003) argue that a more comprehensive knowledge base is required for effective policy and management.

Analyses of how ecosystems influence livelihoods are becoming common, for example with regard to impoverished communities in the developing world (Le Maitre et al., 2007; Reynolds et al., 2010). A key example of this trend is the recent £40 million research call by UK government on Ecosystem Services and Poverty Alleviation.

[2] Observations of the world do not need theory to be understood.

Despite this agenda, efforts to shape human perceptions and governance are thought to have been unsuccessful. Pattanayak et al. (2010) review the ES literature, finding no evidence that the commoditisation of services benefits vulnerable individuals. In another review, Liu et al. (2010: 73) declare that

> "it was found that the contribution of [ecosystem services valuation] to ecosystem management has not been as large as hoped nor as clear as imagined. This requires ESV researchers to do more than simply develop good ideas to influence policy. They need to understand how the political process affects outcomes and actively market the use of appropriate and feasible methodologies for promoting environmental policy".

Contemplating the few instances in which the ES concept has been applied to management, Brauman et al. (2007) emphasise the difficulty of bridging natural and human systems. They argue that trade-offs raise political and ethical considerations that are not suited to the ecological sciences as typically applied. Similar assessments include Pearce and Seccombe-Hett's (2000) recognition of how individual self-interest may undermine the protection of common resources; Balvanera et al.'s (2006) argument that the inclusion of human wellbeing requires a step beyond the scientific community; or Norgaard's (2010) assertion that institutional and ethical questions are most important. It is within such admissions that researchers of ecosystem services are *seeking to add the human dimension to the existing ecological-economic framework*. Perhaps Brauman et al. (2007: 68) best summarise this agenda, declaring that modern environmental problems "have accentuated the need to move beyond simple recognition of human dependence on the environment".

Steffen (2009: 1301) argues "without improved knowledge of the dynamics of social-ecological systems, it is almost impossible to design appropriate management tools or even the adaptive intervention experiments needed to inform policy and management". Arguments such as these exhibit the desire to recognise the social nature of management, but they also expose the assumption that poor management is rooted in a poor understanding of the natural environment; the implication is that the solution rests in further integration between science and governance (Aronson et al., 2010; Brauman et al., 2007; Liu et al., 2007, 2010, 2008; Zander et al., 2010). In most cases, integration refers to the social sciences, policy makers, or publics, but whether these references represent a willingness to incorporate forms of knowledge that differ from that common to the natural sciences is unclear. The answer, perhaps, rests in the location of these comments toward the end of publications (Fischer et al., 2007; Kremen, 2005; Liu et al., 2010; Steffen, 2009). Brauman et al.'s (2007: 90) concluding sentences are indicative, ending with the provocative yet unexplored declaration that

> "to effectively conserve and enhance ecosystem services, physical and social science must be expanded and integrated to identify, prioritize, and target ecosystems of concern. This broad area is fertile ground for transformative interdisciplinary work".

Examples such as these, in which integration is alluded to but unexplored, suggest that socio-ecological integration remains desirable but difficult or impractical. This represents the challenge that arises with calls for ES to be used to shape management. Beyond the assumption that scientific knowledge will strengthen management, there is little explanation for why or how this integration might differ from the scientific and technically-led management that, in many ways, helped to enable the over-exploitation at the root of many socio-ecological problems (Milder et al., 2010; Norgaard, 2010). Calls to incorporate stakeholder knowledge (Butler and Koontz, 2005; Liu et al., 2008; Zander et al., 2010) represent another example in which advocates of ES-based governance promote methods that contravene its scientific basis. To date, stakeholder knowledge has been used to contextualise scientific analyses, providing a point of comparison between what people think and how the ecosystem operates. There remains hesitancy within much ES research toward the validity of stakeholder knowledge. For example, while Barkmann et al. (2008: 59) accept that stakeholder knowledge can be included, they worry that "lay respondents" may lack the insight needed to make scientifically-useful statements. Brauman et al. (2007) offer stronger concerns, suggesting that decisions founded on misconceptions might exacerbate the negative impacts they associate with value-driven environmental management.

Overall, the integration of social and scientific knowledge remains an unresolved challenge to ES-based governance. Balvanera et al. (2006: 1146), for example, explain that, the problems ES researchers are attempting to address "have moved beyond the science community to the global stakeholder and policy community". Exploring the difficulties of implementing such collaborative research, Steffen (2009) warns that implementation may be impossible. Given the assessment that application of ES has been less successful than hoped for (Aronson et al., 2010; Liu et al., 2010), but also accepting the potential value of management that incorporates provisioning, regulating, supporting, and cultural services, we turn to the example of IWRM. We argue that efforts to implement ES should take heed of the criticisms levelled against what, we will argue in the next section, is a nearly identical concept.

3. The IWRM framework

Efforts to implement ES mirror longstanding debates over Integrated Water Resource Management (IWRM). After illustrating the similarities between IWRM and ES, we review the criticisms that have helped to undermine the implementation of IWRM. For the purposes of this discussion, these criticisms are divided into three parts: knowledge, society, and governance.

3.1. The similarity between IWRM and ecosystem services

The Global Water Partnership's (GWP) definition of IWRM is widely accepted as dominant, describing

> "a process which promotes the coordinated development and management of water, land and related resources in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (GWP, 2000: 22).

This definition exhibits clear similarities with ES. As opposed to a strict emphasis on water, which might be presumed given its title, entire ecosystems are key to IWRM. As Mitchell (2005) argues, it is illogical to talk of integrating a single resource. Medema et al. (2008) present a similar argument, interpreting IWRM as coordination across water and land resources, the involvement of stakeholders, the extension of consideration across spatial and temporal scales, and the integration of multiple disciplinary perspectives. Recent publications from the GWP confirm the persistence of this interpretation (GWP, 2010).

As with ES, the GWP definition of IWRM prioritises environmental health and its connections to individual, economic, and societal wellbeing (Banuri, 2009; Falkenmark, 2004; McDonnell, 2008; Medema et al., 2008; Mitchell, 2005; Savenije and Van der Zaag, 2008). Jonch-Clausen and Fugl (2001: 503) note that economic efficiency, social equity, and environmental and

ecological sustainability are the primary objectives. Four years before the MA (2005), in language identical to the MA, they argue that "the present use of the resource should be managed in a way that sustains the vital life-support systems, thereby not compromising use by future generations of the same resource", which harkens to the 1992 Convention on Biological Diversity. Reviews of IWRM underscore its role as a forerunner to ES. For example, Savenije and Van der Zaag (2008: 292) state that IWRM must include both natural and human dimensions of water while Banuri (2009: 1) emphasises the trade-offs needed to maintain socio-ecological integrity. As with ES, IWRM is used to emphasise the integration and balance of social and physical factors while, somewhat hypocritically, also arguing that water is central to social, economic, and environmental sustainability.

Like ES, IWRM is used to explore complex human-environment relations and to stress that competing interests must be integrated in order to implement successful policy. Medema et al. (2008: 31) suggest that IWRM "is a continuous process of balancing and making trade-offs between different goals and views in an informed way". Users of IWRM recognise increasing – or more likely recognise increasing recognition of – complexity within socio-ecological relationships. It is this complexity, characterised by nonlinear relations and criticisms of reductionism, within which IWRM is used to situate socio-environmental challenges. For example, Jonch-Clausen and Fugl (2001: 501) argue that complex relations are paramount for the resolution of water crises, there being

> "a need to find appropriate ways to co-ordinate policy making, planning and implementation in an integrated manner across sectorial, institutional, professional and basin boundaries and to take into account the even more complex co-ordination issues over the management of international watercourse systems".

Savenije and Van der Zaag (2008) provide a similar assessment, noting that the scope and complexity of water issues has driven management toward integrated approaches. This is similar to a comment by Mitchell (2005), who explains that complex and interconnected factors represent the rationale for IWRM.

The similarities between ES and IWRM are extensive. While IWRM may have originated to focus attention on the water-society interface and to respond to a perceived over-reliance on technical and science-based management, more recent examples show a balanced account of human-environment relations, which is the basis of ES.

3.2. Criticisms of IWRM

The similarities between IWRM and ES suggest an opportunity for the current wave of individuals pushing for the adoption of ES-based governance (see Norgaard, 2010) to consider criticisms that have arisen as a result of efforts to implement IWRM. The criticisms can be divided into those concerning knowledge, society, and governance. This division reflects themes within the literature concerning *integration-holism-transdisciplinarity* (knowledge), accounting for *participation-stakeholder-lay* factors (society) in order to *implement-utilise-have impact on* the management of socio-environmental issues (governance).

3.2.1. Knowledge

The most common criticism of IWRM involves the lack of a consistent definition. While the GWP (2000) has provided the de facto account for roughly a decade, it is criticised as being vague. IWRM is said to be ambiguous in its objectives, difficult or impossible to verify, and idealistic in its agenda (Biswas, 2004b; Petit and Baron, 2009). For example, Medema et al. (2008) argue that clarity is needed in terms of the claims, coordination, and integration of knowledge, rather than vague calls to cross boundaries or draw together disparate disciplines.

Many criticisms of IWRM focus on the impediments to integrating the range of knowledge needed to manage controversial environmental problems. For example, Savenije and Van der Zaag (2008: 292) list: equity, poverty alleviation, gender relations at multiple scales, harm reduction, food security, and health as just some of the competing issues. McDonnell (2008: 133) adds the "status of engineering structures, ecological needs of flow, quality at ecologically significant parts of the area, and calendars of local cultural events". In response to the overwhelming range of potential factors, the often cited White (1998: 26) concludes that "the problems of accurate analysis of inter-sectorial linkages and of achieving institutional reforms in the planning process, are formidable. It would be sanguine to expect early or easy solutions".

Some criticisms of IWRM attack a perceived dominance of water resource management by engineering and physical scientists (McDonnell, 2008). Alternately, there are also those who criticise IWRM for insufficient adherence to scientific principles (Gourbesville, 2008; Jeffrey and Gearey, 2006; Mazvimavi et al., 2008; Petit and Baron, 2009). In response to arguments for further scientific knowledge, McDonnell (2008: 141) counters, arguing that

> "the biggest controversy is away from the basics of data provision and lies with the positivist, empiricist and technocratic approaches to analysis and information development. The notion that a series of layers of spatial data, linked through subsystem assessments and mathematical modelling and combined using weighting and matrix-based procedures, can give suitable knowledge of the complexities of environmental, economic and socio-cultural and political interactions, has not been substantiated through successful applications".

McDonnell (2008) also puts forward an incisive argument concerning the tendency to disregard knowledge that does not meet positivist expectations, or for the 'recycling' of data collected as part of tangentially related research. Compounding this challenge are wider criticisms of perception- and preference-based research, including the possibility of researcher bias and the assumption that lay individuals are capable of meaningful commentary.

3.2.2. Society

IWRM is criticised for being unable to explain the dynamic role of social influences on management, including factors such as competition, conflict, bias, subversion, interests, and active opposition (Bellamy and Johnson, 2000; Braga and Lotufo, 2008; Chéné, 2009; Das Gupta et al., 2005; Merrey, 2008; Shrubsole, 1996). Society, it is argued, is an active participant that produces, distorts, and opposes knowledge and practice (Ako et al., 2010; Anderson et al., 2008; Braga and Lotufo, 2008; Brown and Farrelly, 2009; Mitchell, 2008; Petit and Baron, 2009; Pres, 2008; Rahaman and Varis, 2009). The inability to integrate and make sense of society's influence, then, is seen as a fundamental flaw. This includes aspects such as the role of unequal power relations, the informal processes that contribute to knowledge, and the networks that underlie management. For example, whereas past up- and downstream analyses focused on the physical environment through measures of quantity and quality, there is growing acceptance for the need to account for the social interactions occurring within the same spatial context (Nhapi et al., 2005; Norman and Bakker, 2009; Rahaman and Varis, 2009; Varis et al., 2008).

IWRM is criticised for its breadth, such that many individuals are able to suit the concept to their interests. That IWRM can be

criticised both for too much and not enough adherence to scientific principles speaks to this criticism. While a general definition may enable complementary interests to congregate, this elasticity also allows researchers and practitioners to hide inconsistencies (Biswas, 2004a, 2008). Petit and Baron (2009: 53) argue that this malleability allows, for example, social development advocates and neoliberal free-marketers to claim the same perch, leading to significant confusion. They argue that

> "IWRM proposes a model whose objective is to reduce/eliminate the engagement of the State in water management, with a consequent reinforcement of public-private partnerships and the adoption of management principles based on efficiency and equity, while highlighting the capacity of market instruments to fulfil this objective".

Alternatively, IWRM is commonly interpreted as a means of resisting the neoliberalisation of water resources, with many authors using IWRM to encourage social development through pro-poor initiatives that challenge reliance on free markets (Al Radif, 1999; Brown and Farrelly, 2009; Rahaman and Varis, 2009).

The failure to accommodate socio-cultural elements results in a situation where such factors are presumed to be important but cannot be included. Chéné (2009: 3), for example, citing the Committee for Sustainable Development, argues that

> "water issues are not only technical and institutional issues: they have also intrinsic political content which has to be explicitly considered in order to be able to solve effective difficulties linked to competition among stakeholders and interests".

Similarly, Merrey (2008: 905) concludes that "connections are not only hydrological and ecological but also – indeed primarily – political". These arguments touch upon the difficulties that arise when social and natural elements are considered in tandem.

3.2.3. Governance

In addition to the inability to account for the role of society, there is a further group of criticisms that focus on the failure to incorporate IWRM into governance (Chéné, 2009; Garcia, 2008; Jonker, 2007; Petit and Baron, 2009; Saravanan et al., 2009; Twomlow et al., 2008; Varis et al., 2008; White, 1998). Perhaps the most important criticism is that IWRM ought by now to have had measurable positive impact. Without evidence of success, it is argued, IWRM is a hollow concept without merit (Biswas, 2004a). While Mitchell (2005, 2008) and Shrubsole (1996) outline a number of cases in which IWRM has contributed positively, Mitchell accepts that it generates a large number of non-prioritised recommendations which do not necessarily solve problems. Instead, a growing number of authors accept that, despite significant expenditures and widespread accolades, there is little tangible evidence in favour of IWRM (Blanco, 2008; McDonnell, 2008; Merrey, 2008; Saravanan et al., 2009; Savenije and Van der Zaag, 2008), describing a 'consensus without practice' (Chéné, 2009).

IWRM is also criticised for assuming that it can be easily transferred from concept to governance (Al Radif, 1999; Brown and Farrelly, 2009; McDonnell, 2008; Savenije and Van der Zaag, 2008). For example, it is argued that developing nations lack the capacity to enforce IWRM, leading to wasted resources in locations where improvements to water management are most needed (Merrey, 2008). IWRM is also criticised for failing to overcome the silo mentality within governments (Mitchell, 2005). This division leads to the creation of boundaries, which in turn represent points of conflict that IWRM has been unable to circumvent. Those using IWRM, it is argued, are no more able than others to reconcile the overlapping socio-ecological systems of water and environmental management. Finally, using somewhat circular reasoning, lack of success is used to argue that those responsible for management have deemed IWRM of little utility, questioning its value outside academic debates (Braga and Lotufo, 2008; Chéné, 2009; Medema et al., 2008; Merrey, 2008; Mitchell, 2008).

4. Discussion: drawing lessons from IWRM

The criticisms of IWRM represent established versions of the criticisms emerging in response to ES (Kosoy and Corbera, 2010; Liu et al., 2010; Milder et al., 2010; Muradian et al., 2010; Norgaard, 2010; Pascual et al., 2010; Pattanayak et al., 2010). Whether focused on the diversity of knowledge, on the influence of social factors, or on the unpredictability of governance, efforts to overcome the implementations gap (for either ES or IWRM) must address these criticisms. In such contexts, analyses that enable people to learn from similar efforts are needed. We have identified three themes that, we hope, will initiate further transfers of knowledge between researchers and managers involved in debates concerning these two similar concepts. We have structured this discussion from the vantage of strengthening ES, but this is not to presume the demise of IWRM or that the lessons cannot flow in both directions.

4.1. Connecting environmental and human wellbeing

At first glance, the most significant difference between ES and IWRM is the relative importance of environmental capital. While this is an accurate assessment of early IWRM research, more recent iterations have made clear the importance and inseparability of social and ecological health. While ES can be thought to have originated with emphasis on environmental wellbeing and IWRM for social wellbeing, they both appear to have reached the same point (i.e. negotiating trade-offs between human and environmental needs with the aim of fostering sustainability). At present, the key difference is that IWRM has been used over a much longer period and, as Thuo (2009) argues, when human and environmental interests have been in conflict, it has been the environment that has been sacrificed. For ES-based governance, its shorter track record means that aspirations for parity between environmental and social wellbeing has yet to be tested, but it is difficult to imagine many political decisions favouring the environment when people (i.e. voters) are in need. Another way of interpreting the situation is to differentiate the two concepts along temporal lines, with both aiming to improve sustainable development but with ES taking a longer term into consideration.

Recent versions of both concepts address what Gleick (2000: 132) identifies as one of the most important failings of twentieth century water management:

> "the failure to understand the connection between water and ecological health, and the links between the health of natural ecosystems and human wellbeing".

In practice there remain residual trends within both ES and IWRM research, with ES implicitly directed toward environmental sustainability and IWRM toward exploitative human relations, poverty alleviation, and a more equitable distribution of resources (Jonker, 2007; McDonnell, 2008; Petit and Baron, 2009). Key to both concepts is the need to consider the relationship between overconsumption and sustainability. Global consumption is far from sustainable, with consumption skewed toward affluent nations and people. In terms of applying either concept, the ability to temporarily over-consume with the objective of establishing a sustainable long-term human-environment relationship (albeit

with lowered levels of natural capital) is missing. With a poor appreciation for the structural factors driving overconsumption, neither perspective connects the people who draw upon natural capital with the capital needed to sustain ecosystems. In attributing equal value to the environment, both ES and IWRM treat the ecosystem as a stakeholder, confronting interpretations that divide society from nature (Whatmore, 2002). In challenging this separation, the co-dependence of human and environmental wellbeing is more evident. Unfortunately, describing that inter-dependence has yet to translate into improved governance, though this is a well-recognised research agenda (Liu et al., 2010; Norgaard, 2010; Turner et al., 2010).

4.2. The need for clear definition(s) and agenda(s)

The MA has, to date, helped ES avoid the accusations of ambiguity that have undermined IWRM. This has prevented ES from being appropriated by vested parties, accused of being a buzzword, or faced the suggestion that it is used only to secure research funding, but the move to implement ES-based governance is prompting such concerns (Norgaard, 2010). There is growing frustration within the ES literature toward the inconsistent uses of terms and concepts, most prominently with reference to subjects (i.e. water) that can be interpreted simultaneously as a benefit and a service. For example, with reference to ecosystem functioning, Jax (2010: 4) declares that "some philosophical problems hover in the background of the implicit mixing of different meanings". The MA (2005) provides a relatively stable foundation for research but its applicability to governance remains uncertain. The definition emphasises a reconceptualisation of the natural world that extends appreciation beyond tangible commodities toward nature's means of production. By avoiding objectives – like the use of IWRM to change social relations – ES has avoided many of the criticisms directed toward IWRM, but the move to reshape socio-ecological problems opens such avenues.

Individuals involved in ES research might take heed from the vagueness criticism. As efforts to implement ES proceed, interested parties are working to extend the concept into social and governmental spheres. With the addition of multiple interests, ES is becoming vulnerable to the 'multiple disparate uses' or 'inconsistent definition' criticisms that have undermined IWRM. To date, the definitional inconsistencies of ES have been accepted by a relatively supportive group of researchers, but the move to apply the concept raises the stakes in terms of people's lives and livelihoods. Inconsistencies in such contexts are unlikely to be accepted. It is important to recognise the ramifications of efforts to insert the ES concept into governance, as there is a risk that such objectives will distract from the innovativeness of accounting for provisioning, regulating, supporting, and cultural services. This criticism is significant. Following from criticisms of 'high-jacking', negative assessments of IWRM appear to be growing more numerous and more substantive. As Merrey (2008: 899) argues "not only has IWRM outlived its usefulness as a guide to action, clinging to its principles… may now be retarding progress toward achieving poverty reduction goals".

4.3. The complexity of socio-ecological challenges

As has been the case for IWRM, the most significant challenge to ES-based governance is integrating social and ethical factors alongside the environmental sciences into environmental management (Muradian et al., 2010; Norgaard, 2010; Pascual et al., 2010). Efforts to apply ES to development, poverty alleviation, and human wellbeing (Aronson et al., 2010; Le Maitre et al., 2007; MA, 2005; Milder et al., 2010; Pattanayak et al., 2010; Reynolds et al., 2010; Smith and Clay, 2010) are based on the assumption that understanding human-dependence will improve governance. Unfortunately, descriptions of human dependence on the environment, however detailed, are unlikely to be a sufficient basis for the management of contested socio-ecological issues. The assumption that valuation and quantification can account for social factors remains unproven. In reaction to this assumption, those who prioritise the marginalised worry that commoditisation will enable power-holding individuals to further entrench their advantages (Castree, 2008; Kosoy and Corbera, 2010; Robertson, 2006). There is little to suggest that determining the value of provisioning, regulating, sustaining, or cultural services will accomplish anything other than create markets for what has been common or disregarded. The assumption that market forces will ensure environmental sustainability or social equity remains theoretical.

The assumed relationship between 'knowledge of socio-ecological context' and 'management' evident within the ES discourse is uni-dimensional. Much like the complex feedbacks that produce environmental systems, the material interactions between knowledge and place are dynamic and ongoing (Bakker and Bridge, 2006). The question of how ES-based analyses can remain valid while the socio-ecological system changes is presently unknown and unexplored. There is an implicit assumption that unsustainable management is the result of misunderstanding the natural capital on which consumption is dependent. This neglects the degree of understanding that people have, as well as the structural forces that limit their options (Sillitoe and Marzano, 2009). Furthermore, society is often willing to make decisions that contravene scientific assessments. Researchers of ES must ask whether or how improved knowledge of human dependence on the physical environment is likely to address the self-interest that shapes environmental decision-making.

The possibility exists, given current population growth and unequal power relations, that resources may be insufficient to ensure both sustainability and equitable distribution. With focus on describing human dependence on the natural environment, the debate surrounding ES is silent to the possibility that it will prove that some individuals, regions, or nations will never enjoy a sustainable standard of living. There exists, also, the possibility that society may not care to make the sacrifices needed to ensure sustainability for future generations. We know that individuals can choose to trade environmental sustainability for immediate gains, whether out of individual self-interest or because they have no choice. The scientific method has been shown repeatedly to be a poor basis for the management in such instances (Sarewitz, 2004; Wynne, 1996).

5. Conclusions

IWRM is accused of being a sacred concept; ES appears to be on a similar path. IWRM has withstood numerous attacks, suggesting that despite its faults it retains value for those interested in water and environmental management. However, there is a large and growing body of literature critical of IWRM, with some arguing its imminent demise. It is into this context that ES may come to the fore. There is presently an opportunity to make use of the history of IWRM by drawing on its criticisms to strengthen water and environmental research and management. There will be further criticisms and challenges, but if individuals promoting ES are able to pre-empt those that are already evident, the concept might more quickly address its weaknesses and build upon its strengths. With efforts to implement ES well underway, consideration is needed for how implementation might proceed, what benefits this would enable, and what compromises will be required.

There are clear similarities between IWRM and ES, particularly within discussions focused on their conceptual or theoretical characters or merits. In terms of definitions and uses, there are sufficient examples to argue that IWRM and ES have reached very similar junctures related to implementation. Historically, when confronted with the realities of implementation, concepts are amended or discarded and the cycle is repeated. The relative freshness of ES coupled with the long history of criticisms directed at IWRM provides an opportunity to engage with the challenges of implementation. Given the long history of 'implementation gaps' the similar paths may serve to temper prognostications of a method or toolbox able to 'solve' socio-ecological problems. Instead, it is probable that the 'implementation gap' is not something to be filled, but rather something to be traversed; concepts like ES and IWRM, then, appear to be tools to aid in that endeavour.

Acknowledgement

The authors would like to thank Terry Dawson for comments on an early draft, as well as to the referees.

References

Ako, A.A., Eyong, G.E.T., Nkeng, G.E., 2010. Water resources management and integrated water resources management (IWRM) in Cameroon. Water Resources Management 24, 871–888.
Al Radif, A., 1999. Integrated water resources management (IWRM): an approach to face the challenges of the next century and to avert future crises. Desalination 124, 145–153.
Anderson, A., Karar, E., Farolfi, S., 2008. Synthesis: IWRM lessons for implementation. Water SA 34, 665–669.
Aronson, J., Blignaut, J.N., de Groot, R.S., Clewell, A., Lowry, P.P., Woodworth, P., Cowling, R.M., Renison, D., Farley, J., Fontaine, C., Tongway, D., Levy, S., Milton, S.J., Rangel, O., Debrincat, B., Birkinshaw, C., 2010. The road to sustainability must bridge three great divides. Ecological Economics Reviews, 225–236.
Bakker, K., Bridge, G., 2006. Material worlds? Resource geographies and the 'matter of nature'. Progress in Human Geography 30, 5–27.
Balvanera, P., Pfisterer, A.B., Buchmann, N., He, J.S., Nakashizuka, T., Raffaelli, D., Schmid, B., 2006. Quantifying the evidence for biodiversity effects on ecosystem functioning and services. Ecology Letters 9, 1146–1156.
Banuri, T., 2009. Integrated water resources management: seeking sustainable solutions to water management. Natural Resources Forum 33. 1–1.
Barkmann, J., Glenk, K., Keil, A., Leemhuis, C., Dietrich, N., Gerold, G., Marggraf, R., 2008. Confronting unfamiliarity with ecosystem functions: the case for an ecosystem service approach to environmental valuation with stated preference methods. Ecological Economics 65, 48–62.
Bellamy, J.A., Johnson, A.K.L., 2000. Integrated resource management: moving from rhetoric to practice in Australian agriculture. Environmental Management 25, 265–280.
Bennett, E.M., Peterson, G.D., Gordon, L.J., 2009. Understanding relationships among multiple ecosystem services. Ecology Letters 12, 1394–1404.
Biswas, A.K., 2004a. Integrated water resources management: a reassessment – a water forum contribution. Water International 29, 248–256.
Biswas, A.K., 2004b. Integrated water resources management: a reassessment – response. Water International 29, 531–533.
Biswas, A.K., 2008. Integrated water resources management: is it working? International Journal of Water Resources Development 24, 5–22.
Blanco, J., 2008. Integrated water resource management in Colombia: paralysis by analysis? International Journal of Water Resources Development 24, 91–101.
Braga, B.P.F., Lotufo, J.G., 2008. Integrated river basin plan in practice: the Sao Francisco river basin. International Journal of Water Resources Development 24, 37–60.
Brauer, I., 2003. Money as an indicator: to make use of economic evaluation for biodiversity conservation. Agriculture Ecosystems & Environment 98, 483–491.
Brauman, K.A., Daily, G.C., Duarte, T.K., Mooney, H.A., 2007. The nature and value of ecosystem services: an overview highlighting hydrologic services. Annual Review of Environment and Resources 32, 67–98.
Brown, R.R., Farrelly, M.A., 2009. Delivering sustainable urban water management: a review of the hurdles we face. Water Science and Technology 59, 839–846.
Bruntland Report, 1987. Our Common Future. Oxford University Press, Oxford.
Butler, K.F., Koontz, T.M., 2005. Theory into practice: implementing ecosystem management objectives in the USDA forest service. Environmental Management 35, 138–150.
Carpenter, S.R., DeFries, R., Dietz, T., Mooney, H.A., Polasky, S., Reid, W.V., Scholes, R.J., 2006. Millennium ecosystem assessment: research needs. Science 314, 257–258.
Castree, N., 2008. Neoliberalising nature: the logics of deregulation and reregulation. Environment and Planning A 40, 131–152.
CBD, 2005. Handbook of the Convention on Biological Diversity Including Its Cartagena Protocol on Biosafety, third ed. Secretariat of the Convention on Biological Diversity, Montreal.
Chéné, J.M., 2009. Integrated water resources management: theory versus practice. Natural Resources Forum 33, 2–5.
Costanza, R., dArge, R., deGroot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., Oneill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., vandenBelt, M., 1997. The value of the world's ecosystem services and natural capital. Nature 387, 253–260.
Das Gupta, A., Babel, M.S., Albert, X., Mark, O., 2005. Water sector of Bangladesh in the context of integrated water resources management: a review. International Journal of Water Resources Development 21, 385–398.
DeFries, R.S., Foley, J.A., Asner, G.P., 2004. Land-use choices: balancing human needs and ecosystem function. Frontiers in Ecology and the Environment 2, 249–257.
Falkenmark, M., 2004. Towards integrated catchment management: opening the paradigm locks between hydrology, ecology and policy-making. International Journal of Water Resources Development 20, 275–281.
Fischer, J., Manning, A.D., Steffen, W., Rose, D.B., Daniell, K., Felton, A., Garnett, S., Gilna, B., Heinsohn, R., Lindenmayer, D.B., MacDonald, B., Mills, F., Newell, B., Reid, J., Robin, L., Sherren, K., Wade, A., 2007. Mind the sustainability gap. Trends in Ecology & Evolution 22, 621–624.
Foley, J.A., DeFries, R., Asner, G.P., Barford, C., Bonan, G., Carpenter, S.R., Chapin, F.S., Coe, M.T., Daily, G.C., Gibbs, H.K., Helkowski, J.H., Holloway, T., Howard, E.A., Kucharik, C.J., Monfreda, C., Patz, J.A., Prentice, I.C., Ramankutty, N., Snyder, P.K., 2005. Global consequences of land use. Science 309, 570–574.
Garcia, L.E., 2008. Integrated water resources management: a 'Small' step for conceptualists, a giant step for practitioners. International Journal of Water Resources Development 24, 23–36.
Gleick, P.H., 2000. The changing water paradigm – a look at twenty-first century water resources development. Water International 25, 127–138.
Gourbesville, P., 2008. Challenges for integrated water resources management. Physics and Chemistry of the Earth 33, 284–289.
GWP, 2000. Integrated Water Resource Management. In: Technical Advisory Committee Background Paper Number 4. Global Water Partnership, Stockholm.
GWP, 2010. Development Lessons from Water Management. Global Water Partnership, Drottninggatan, Sweden.
Jax, K., 2010. Ecosystem Functioning. Cambridge University Press, Cambridge.
Jeffrey, P., Gearey, M., 2006. Integrated water resources management: lost on the road from ambition to realisation? Water Science and Technology 53, 1–8.
Jonch-Clausen, T., Fugl, J., 2001. Firming up the conceptual basis of integrated water resources management. International Journal of Water Resources Development 17, 501–510.
Jonker, L., 2007. Integrated water resources management: the theory-praxis-nexus, a South African perspective. Physics and Chemistry of the Earth 32, 1257–1263.
Kosoy, N., Corbera, E., 2010. Payments for ecosystem services as commodity fetishism. Ecological Economics 69, 1228–1236.
Kremen, C., 2005. Managing ecosystem services: what do we need to know about their ecology? Ecology Letters 8, 468–479.
Le Maitre, D.C., O'Farrell, P.J., Reyers, B., 2007. Ecosystems services in South Africa: a research theme that can engage environmental, economic and social scientists in the development of sustainability science? South African Journal of Science 103, 367–376.
Liu, J.G., Dietz, T., Carpenter, S.R., Alberti, M., Folke, C., Moran, E., Pell, A.N., Deadman, P., Kratz, T., Lubchenco, J., Ostrom, E., Ouyang, Z., Provencher, W., Redman, C.L., Schneider, S.H., Taylor, W.W., 2007. Complexity of coupled human and natural systems. Science 317, 1513–1516.
Liu, Y.Q., Gupta, H., Springer, E., Wagener, T., 2008. Linking science with environmental decision making: experiences from an integrated modeling approach to supporting sustainable water resources management. Environmental Modelling & Software 23, 846–858.
Liu, S., Costanza, R., Farber, S., Troy, A., 2010. Valuing ecosystem services theory, practice, and the need for a transdisciplinary synthesis. Ecological Economics Reviews 1185, 54–78.
MA, 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington D.C.
Mazvimavi, D., Hoko, Z., Jonker, L., Nhapi, I., Senzanje, A., 2008. Integrated water resources management (IWRM) – from concept to practice. Physics and Chemistry of the Earth 33, 609–613.
McDonnell, R.A., 2008. Challenges for integrated water resources management: how do we provide the knowledge to support truly integrated thinking? International Journal of Water Resources Development 24, 131–143.
Medema, W., McIntosh, B.S., Jeffrey, P.J., 2008. From premise to practice: a critical assessment of integrated water resources management and adaptive management approaches in the water sector. Ecology and Society 13.
Merrey, D.J., 2008. Is normative integrated water resources management implementable? Charting a practical course with lessons from Southern Africa. Physics and Chemistry of the Earth 33, 899–905.
Milder, J.C., Scherr, S.J., Bracer, C., 2010. Trends and future potential of payment for ecosystem services to alleviate rural poverty in developing countries. Ecology and Society 15.
Miner, J.B., 1984. The validity and usefulness of theories in an emerging organizational science. Academy of Management Review 9, 296–306.

Mitchell, B., 2005. Integrated water resource management, institutional arrangements, and land-use planning. Environment and Planning A 37, 1335–1352.
Mitchell, B., 2008. Resource and environmental management: connecting the academy with practice. Canadian Geographer-Geographe Canadien 52, 131–145.
Muradian, R., Corbera, E., Pascual, U., Kosoy, N., May, P.H., 2010. Reconciling theory and practice: an alternative conceptual framework for understanding payments for environmental services. Ecological Economics 69, 1202–1208.
Nhapi, I., Holch, W., Mazvimavi, D., Mashauri, D.A., Jewitt, G., Mudege, N., Swatuk, L.A., Beukman, R., 2005. Integrated water resources management (IWRM) and the millennium development goals: managing water for peace and prosperity. Physics and Chemistry of the Earth 30, 623–624.
Norgaard, R.B., 2010. Ecosystem services: from eye-opening metaphor to complexity blinder. Ecological Economics 69, 1219–1227.
Norman, E.S., Bakker, K., 2009. Transgressing scales: water governance across the Canada–US Borderland. Annals of the Association of American Geographers 99, 99–117.
Pascual, U., Muradian, R., Rodriguez, L.C., Duraiappah, A., 2010. Exploring the links between equity and efficiency in payments for environmental services: a conceptual approach. Ecological Economics 69, 1237–1244.
Pattanayak, S.K., Wunder, S., Ferraro, P.J., 2010. Show me the money: do payments supply environmental services in developing countries? Review of Environmental Economics and Policy 4, 254–274.
Pavlikakis, G.E., Tsihrintzis, V.A., 1999. Ecosystem management: a holistic approach to the management of the natural resources. In: Brebbia, C.A., Uso, J.L. (Eds.), Ecosystems and Sustainable Development Ii, pp. 385–394.
Pearce, D.W., Seccombe-Hett, T., 2000. Economic valuation and environmental decision-making in Europe. Environmental Science & Technology 34, 1419–1425.
Petit, O., Baron, C., 2009. Integrated Water Resources Management: from general principles to its implementation by the state. The case of Burkina Faso. Natural Resources Forum 33, 49–59.
Pres, A., 2008. Capacity building: a possible approach to improved water resources management. International Journal of Water Resources Development 24, 123–129.
Rahaman, M.M., Varis, O., 2009. Integrated water management of the Brahmaputra basin: perspectives and hope for regional development. Natural Resources Forum 33, 60–75.
Reynolds, T.W., Farley, J., Huber, C., 2010. Investing in human and natural capital: an alternative paradigm for sustainable development in Awassa, Ethiopia. Ecological Economics 69, 2140–2150.
Richter, B.D., Mathews, R., Wigington, R., 2003. Ecologically sustainable water management: managing river flows for ecological integrity. Ecological Applications 13, 206–224.
Robertson, M.M., 2006. The nature that capital can see: science, state, and market in the commodification of ecosystem services. Environment and Planning D-Society & Space 24, 367–387.
Saravanan, V.S., McDonald, G.T., Mollinga, P.P., 2009. Critical review of integrated water resources management: moving beyond polarised discourse. Natural Resources Forum 33, 76–86.
Sarewitz, D., 2004. How science makes environmental controversies worse. Environmental Science & Policy 7, 385–403.
Savenije, H.H.G., Van der Zaag, P., 2008. Integrated water resources management: concepts and issues. Physics and Chemistry of the Earth 33, 290–297.
Shrubsole, D., 1996. Ontario conservation authorities: principles, practice and challenges 50 years later. Applied Geography 16, 319–335.
Sillitoe, P., Marzano, M., 2009. Future of indigenous knowledge research in development. Futures 41, 13–24.
Smith, C.L., Clay, P.M., 2010. Measuring subjective and objective well-being: analyses from five marine commercial fisheries. Human Organization 69, 158–168.
Steffen, W., 2009. Interdisciplinary research for managing ecosystem services. Proceedings of the National Academy of Sciences of the United States of America 106, 1301–1302.
Thuo, S., 2009. Viewpoints. Natural Resources Forum 33, 87–89.
Tisdell, C., 2007. Economics of Environmental Conservation, second ed. Edward Elgar Publishing, Aldershot.
Turner, R.K., Paavola, J., Cooper, P., Farber, S., Jessamy, V., Georgiou, S., 2003. Valuing nature: lessons learned and future research directions. Ecological Economics 46, 493–510.
Turner, R.K., Morse-Jones, S., Fisher, B., 2010. Ecosystem valuation A sequential decision support system and quality assessment issues. Ecological Economics Reviews 1185, 79–101.
Twomlow, S., Love, D., Walker, S., 2008. The nexus between integrated natural resources management and integrated water resources management in Southern Africa. Physics and Chemistry of the Earth 33, 889–898.
Varis, O., Rahaman, M.M., Stucki, V., 2008. The Rocky road from integrated plans to implementation: lessons learned from the Mekong and Senegal river basins. International Journal of Water Resources Development 24, 103–121.
Whatmore, S., 2002. Hybrid Geographies: Natures, Cultures, Spaces. California: Thousand Oaks.
White, G., 1998. Reflections on the 50-year international search for integrated water management. Water Policy 1, 21–27.
Williams, E., Firn, J., Roberts, M., McGlashan, D., 2003. The value of Scotland's ecosystem services and natural capital. European Environment 13, 67–78.
Wynne, B., 1996. May the sheep safely graze?: a reflexive view of the expert-lay knowledge divide. In: Risk, Environment & Modernity. Sage, London, pp. 44–83.
Yang, Z.F., Sun, T., Cui, B.S., Chen, B., Chen, G.Q., 2009. Environmental flow requirements for integrated water resources allocation in the Yellow River Basin, China. Communications in Nonlinear Science and Numerical Simulation 14, 2469–2481.
Zander, K.K., Garnett, S.T., Straton, A., 2010. Trade-offs between development, culture and conservation – willingness to pay for tropical river management among urban Australians. Journal of Environmental Management 91, 2519–2528.