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Synthesis, part of a Special Feature on New Methods for Adaptive Water Management

From Premise to Practice: a Critical Assessment of Integrated Water Resources Management and Adaptive Management Approaches in the Water Sector

Wietske Medema, Brian S. McIntosh, and Paul J. Jeffrey

ABSTRACT. The complexity of natural resource use processes and dynamics is now well accepted and described in theories ranging across the sciences from ecology to economics. Based upon these theories, management frameworks have been developed within the research community to cope with complexity and improve natural resource management outcomes. Two notable frameworks, Integrated Water Resource Management (IWRM) and Adaptive Management (AM) have been developed within the domain of water resource management over the past thirty or so years. Such frameworks provide testable statements about how best to organise knowledge production and use to facilitate the realisation of desirable outcomes including sustainable resource use. However evidence for the success of IWRM and AM is mixed and they have come under criticism recently as failing to provide promised benefits. This paper critically reviews the claims made for IWRM and AM against evidence from their implementation and explores whether or not criticisms are rooted in problems encountered during the translation from research to practice. To achieve this we review the main issues that challenge the implementation of both frameworks. More specifically, we analyse the various definitions and descriptions of IWRM and AM. Our findings suggest that similar issues have affected the lack of success that practitioners have experienced throughout the implementation process for both frameworks. These findings are discussed in the context of the broader societal challenge of effective translation of research into practice, science into policy and ambition into achievement.

Key Words: *adaptive capacity; adaptive management; integrated water resources management; sustainable water management; uncertainty*

INTRODUCTION

The switch to viewing socionatural (or “socioecological” as some authors prefer) processes and dynamics as complex and uncertain—as symptomatic of open systems of overlapping hierarchies—has its roots in systems theory (von Bertallanfy 1968), systems ecology (Allen and Starr 1982), and evolutionary economics (Nelson and Winter 1982). It is now widely accepted that complexity, variation, and uncertainty are inherent properties of linked social and natural processes, and that natural resource management strategies must somehow reflect these properties in the pursuit of sustainability (see, e.g., Hodgson 1993, Giampietro 1994, Clark et al. 1995, Funtowicz and O’Connor 1998). Various models and theories have been developed to provide general and causal explanations of complex socionatural dynamics. These include notably, from an ecological perspective, early work on resilience (Holling 1973), which led to the concept of perpetual cycles of accumulation, destruction, release, and renewal to explain and link a growing body of empirical knowledge (the panarchy theory of Gunderson and Holling 2001), and from an economic perspective, work on using models of coevolution to explain economic and linked ecological–economic change, in particular Nelson and Winter (1982) and Norgaard (1994) (see Jeffrey and McIntosh 2006 for a critique).

In addition to generating theories to better understand socionatural dynamics and to explain observed changes, work has been undertaken to provide management advice based on these theories. This work has generated what might be called management frameworks—prescriptions regarding how knowledge should be produced and used (modes of knowledge production and use) to achieve specified desirable (natural resource management) outcomes. The eventual translation of understanding into management prescription is a natural final step in scientific knowledge generation and also plays an important empirical “feedback” role in theory testing (Pickett et al. 1994), so the emergence of such frameworks for managing complexity and uncertainty in socionatural systems is not unexpected. Two specific examples of such frameworks are those termed Integrated Water Resource Management (IWRM) and Adaptive Management (AM). These frameworks will form the main focus of this paper and are introduced below.

Although management frameworks are not normally explicitly articulated as theories, they do, at root, provide guidance for interventions that generate benefit or utility and, therefore, embody testable statements about the relative effectiveness of different ways of producing and using knowledge to manage natural resources. One would expect that if a particular management framework posessed value, specified desirable outcomes would be achieved more frequently, with less effort, or to a greater extent or magnitude than would otherwise be the case. To be of value, a framework would need to (1) be based on a correct causal understanding of the (natural resource) phenomenon concerned (i.e., be based on a reliable body of scientific theory), and (2) have translated this understanding correctly into processes for producing and applying knowledge about management intervention into that phenomenon (i.e., be translated based on a sound understanding of organizational and institutional action and change). Therefore, management frameworks constitute, in principle, testable premises about how to manage a set of natural resource phenomena for the purpose of achieving specified outcomes. “Testable” in that it should be possible to empirically test the posited relationships between modes of knowledge production and natural resource domain outcomes for any framework. “Theory” in the sense that each framework will provide a conceptual system for understanding how to generate knowledge to effectively manage a particular natural resource, and for explaining the impact of different modes of knowledge production on natural resource outcomes.

Admittedly, however, no single empirical test will lead to falsification of the management framework for the relationships between modes of knowledge production, and domain outcomes will be probabilistic and potentially affected by multiple factors outside the scope of the framework, e.g., budget availability, the skills and knowledge of the people involved in implementing them, political will. This means that management frameworks cannot be considered scientific theories in a strict Popperian sense, but should still legitimately be considered theories given that the days of Popperian hegemony over scientific knowledge have long gone (Pickett et al. 1994, Williams 2001, Nowotony et al. 2001).

A final important point to note concerning management frameworks is that they are often developed within the (largely academic) research literature. This means that the community developing the framework is unlikely to be the community implementing the framework, although it must be noted that management frameworks are usually not, by virtue of their purpose, developed in complete isolation from practical realities. However, such separation can lead to a mismatch between research and management, or between research and practice, with researchers seeking to acquire rather than apply knowledge, and to produce generalizations rather than local solutions (Bosch et al. 2003).

Both IWRM and AM have multi-decade histories of development and application—IWRM from the first UNESCO International Conference on Water in 1977 and AM from the early work of Carl Walters (Walters and Hilborn 1978). Integrated water resource management is particularly concerned with pursuing what might be termed an integrationist agenda; the integrated and coordinated management of water and land as a means of balancing resource protection while meeting social and ecological needs and promoting economic development (Odendaal 2002). Adaptive management stems from the recognition that, even though interactions between people and ecosystems are inherently unpredictable (Gunderson et al. 1995), there is a need to take management action (Johnson 1999). Adaptive management is a process to cope with uncertainty in understanding centered on a learning model where natural resource “management actions are taken not only to manage, but also explicitly to learn about the processes governing the system” (Shea et al. 1998).

Both IWRM and AM make claims about how best to organize knowledge production for sustainability in natural resource use under conditions of complexity—IWRM focusing on integration and coordination, AM focusing on handling uncertainty. In addition, both frameworks have been criticized as not living up to their ambitions, in suffering from problems in translation from research to practice. For example, Biswas (2004) has argued that the kind of institutional and organizational integration demanded by IWRM may not be possible. However, as interest continues unabated within the research literature in developing and applying both IWRM and AM to water management, there is a need to stand back and critically reflect on the success of these frameworks. The aim in doing so is to contribute to improving the way in which water resources and water use are managed by identifying the source of and solutions to problems encountered in implementing management frameworks developed on the back of scientific theory within research literature. In particular, this paper will seek to answer the following questions:

- What claims does each framework make about how best to organize knowledge production for improved natural resource outcomes?
- How is each framework supposed to operate and how have they been implemented in practice?
- To what extent does evidence from implementation support the claims made by each framework?
- To what extent are problems in realizing the benefits promised by both frameworks related to common problems of translation from research to practice rather than the theories and evidence upon which the individual frameworks were developed?

We will proceed by reviewing, in turn, the claims, approaches to implementation, and challenges and lessons learned, first for IWRM, then for AM. We shall then synthesize our findings and draw conclusions for improving the dialogue between research and practice in the context of water management.

INTEGRATED WATER RESOURCES MANAGEMENT

The Goals of IWRM

The Global Water Partnership (GWP) provides perhaps the most quoted definition of IWRM: “a process that promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems” (Global Water Partnership - Technical Advisory Committee (GWP-TAC) 2000). Thomas and Durham (2003) describe the concept as “a sustainable approach to water management that recognises its multidimensional character—time, space, multidiscipline and stakeholders—and the necessity to address, embrace and relate these dimensions holistically so that sustainable solutions can be brought about.” One of the central aims of IWRM is to promote coordination and integration as a means of achieving more holistic water management and improving water resource sustainability (Jønch-Clausen and Fugl 2001, Braga 2001). It is this balancing of goals and views of interdependent players that separates “integrated management” from other forms of management practice (Grigg 1999), and that is a vital element of IWRM (Radif 1999).

Integrated water resource management is proposed to create a clearer link between, and better understanding of, human and ecosystem requirements and the interactions between them (Wallace et al. 2003), and to manage “people’s activities in a manner that promotes sustainable development (improving livelihoods without disrupting the water cycle)” (Jonker 2002). Much like the concept of sustainability, IWRM is not an end state to be achieved, it is a continuous process of balancing and making trade-offs between different goals and views in an informed way.

The broadening of the range of actors involved in producing water resource management knowledge under IWRM resonates with the notion of the extended peer community proposed by Funtowicz and Ravetz (1994) and also with the notion of socially robust mode 2 science (science done in the context of application in problem-oriented communities) developed by Nowotony et al. (2001). Essentially, IWRM claims that, to be effective, management knowledge should be produced by a range of actors in order to adequately reflect the complex web of relationships between water and land processes and their governance systems. However, it should be noted that the GWP, as prime proponents of IWRM, have added a caveat stating that different nation states will find different ways of implementing the IWRM process, be at different development stages, and therefore, will derive different benefits (GWP-TAC 2000). Although honest, such coyness could be viewed as weakening the claims made about IWRM by essentially providing a means of explaining away any failure to deliver anticipated benefits from an IWRM program as a consequence of "local conditions."

Distilled as a set of statements about how knowledge production and use should be organized and a set of testable claims about the resultant beneficial outcomes, IWRM can be described as follows.

Knowledge production and use should:

- be coordinated across water and land resources;
- involve multiple stakeholders (those responsible for and affected by management intervention);
- integrate across spatial and temporal scales;
- integrate disciplinary perspectives; and
- be holistic in character.

Integrated water resource management will:

- constitute a sustainable approach to managing water resources;
- enhance water resource sustainability;
- produce a better understanding of human–ecosystem interactions;
- maximize social and economic welfare generated from water and land resources; and
- reduce disruption to the water cycle and to aquatically dependent ecosystems.

How Are the Goals of IWRM to Be Achieved?

Within the IWRM framework, there is recognition of the wide range of interacting environmental and human processes spread across a range of scales and institutions of relevance to water management (Everard and Powell 2002). There is also a recognition that sustainable use of water resources will require more than the individual or separate management of these processes. At a practical level, how is knowledge to be produced and used in such a way as to properly acknowledge the holistic, interconnected nature of water resource and use processes involved? Contemporary information about the current state of the IWRM concept and its implementation as understood by the GWP can be found in the Technical Advisory Committee (TAC) Background Paper No. 10 (GWP-TAC 2004). This document describes the "Why, What and How" of the IWRM planning processes to provide guidance on implementing IWRM. Successful implementation is seen to rely on three components (GWP-TAC 2004):

- an enabling legislative and policy environment that sets up and empowers;
- an appropriate institutional framework composed of a mixture of central—local, river-basin-specific, and public—private organizations that provides the governance arrangements for administering; and
- a set of management instruments for gathering data and information, assessing resource levels and needs, and allocating resources for use.

These three components constitute a statement of the necessary governance conditions for the successful implementation of IWRM, but in themselves, are not sufficiently detailed or prescriptive to fully specify how to realize the claims of the framework. It could even be argued that the three components constitute a generic statement of the necessary governance conditions for implementing any natural resource management framework.

The GWP provide more detail on implementation in the form of a toolbox of good practice. Implementation of IWRM is viewed as a cyclical process often referred to as the "Integrated Water

Resources Management Cycle" (GWP-TAC 2004). This cycle has been described in great detail elsewhere, but in summary, follows these steps:

1. recognizing the need to change by establishing the status of water resources and building commitment to reform current management practices, then;

2. assessing the gaps between current management practices and those needed to resolve water resource issues, then;

3. preparing a management strategy and action plan that complete the three pillars for successful IWRM implementation, and building commitment to actions, then;

4. implementing the plan and monitoring and evaluating progress toward achieving goals.

The cycle can be viewed as a modified version of a standard decision-making process model of problem formulation—option generation and selection—implementation—monitoring and evaluation, tailored to suit the IWRM context. As such, it is a interorganizational (i.e., governance) scale version of a learning process similar to the Kolb cycle (Kolb 1984) although stakeholder involvement may result in certain phases and steps in the process having to be repeated, so the steps are not necessarily sequential.

Evidence from IWRM Experiences

Despite IWRM being promoted as an attractive framework by many supranational as well as national organzations, and several inquiring contributions as to the realized effectiveness of the approach (Geldof 1997, Jewitt 2002), case evidence from implementation does not yet clearly demonstrate achievement of any of the claimed beneficial outcomes (as recently noted by Varis et al. 2006), and indeed highlights a number of challenges. The following paragraphs extend Walther's (1987) assessment of IWRM by discussing implementation challenges divided into three key areas: definition, evidence, and capacity.

An agreed definition has never been established for IWRM, and the question of how it should be implemented has never been fully addressed (Odendaal 2002). Indeed, although the GWP recently called for clarification of the essential elements of IWRM to help policy makers understand the issues that need to be focused on (GWP-TAC 2000), the concept remains elusive and fuzzy (van der Zaag 2005). Going further, Jønch-Clausen and Fugl (2001) have suggested that IWRM has degenerated into a buzzword with different meanings.

But is this a problem? After all, one might expect the variety of water resource management contexts and the recognized complexity of water management issues to resist the creation of a single, usable definition for IWRM. We would argue that lack of a sufficiently unambiguous meaning is a problem. If IWRM is to be anything more than a non-specific (and, therefore, untestable) set of claims that more coordination and integration in knowledge production and use will be better for water resource management, IWRM must state what kind of coordination and integration in knowledge production and use, undertaken by what kind of institutions, when, and for what purpose should take place. It must be able to say something about the governance configurations and processes that are most suitable for integrated knowledge production and use, and therefore, the most beneficial for water management.

The fact that there is ambiguity about the IWRM concept may itself be a barrier to implementation—why should there be an institutional change in water resource management if the form and benefits of integration cannot be unambiguously articulated and compared? Indeed, it remains to be seen whether it is possible for a single water management framework to be universally useful across different physical, economic, social, cultural, and legal conditions (Biswas 2004). The necessity to adapt the IWRM concept to suit different local contexts makes it very difficult to develop a generic and overall description of strategies and techniques (Jeffrey and Geary 2006), casting further doubt on the adequacy of the causal understanding of the relationships between knowledge production and water resource management outcomes covered by IWRM. Furthermore, the cross-sector, multi-stakeholder approach advocated by IWRM creates significant challenges that need to be met (Ohlson 1999) including, among other things, ambiguous boundaries and complex links; difficulties with objectives, alternatives, and consequences; pervasive uncertainty, and; multiple stakeholder conflict.

On evidence, Jeffrey and Gearey (2006) argue that empirical evidence of unambiguously demonstrated benefits of IWRM is either missing or poorly reported. However, despite the difficulties of untangling the relative impact of IWRM over other aspects of implementation context, Walther (1987) analyzed three Canadian case studies to assess the success of IWRM. He concluded that the success and performance of IWRM, measured in terms of output such as formal decisions or plans, is primarily a function of the historical situation into which a project is placed, and only secondarily of its professional design. This is perhaps expected given scientific knowledge about the historically contingent nature of complex systems.

One of the main supposed benefits of using IWRM as a framework is its focus on the blending of viewpoints (Grigg 1999). In other words, IWRM provides a holistic framework to combine the contributions of users, planners, sciences, and policy makers. In a sense, however, IWRM is not holistic as it considers water to be very important, if not the most important resource. Integrated management of only one resource is, by definition, not possible because of interconnections with other resources and aspects of human activity from land-use planning through transport to regional economic development. However, managing all resources and activities in an integrated and holistic manner would seem to be a recipe for large, unmanageable, and counterproductive governance systems. To avoid this, Biswas (2004) suggests that the aim should not be to institutionally integrate the management of multiple resources, but to create collaboration, cooperation, and coordination between the existing institutions. Again, whether or not such ambitions result in benefits remains largely to be seen, but problems that can occur through a lack of integration between water and other policy sectors are recognized (see Samuels et al. 2006).

On capacity, it is acknowledged that effective water governance is necessary for the successful implementation of IWRM plans (Koudstaal et al. 1992). Thus, many of the key implementation challenges involve the establishment of suitable policies and laws, viable political institutions, workable financing arrangements, self-governing and self-supporting local systems, and a variety of other institutional arrangements that will help to mitigate this impending crisis (Grigg 1999, Wallace et al. 2003). In many countries, the principles that underlie the IWRM concept have not been internalized into socioeconomic development policies and systems of governance. There is a lack of planning tools, management strategies, and human, institutional, and systematic capacities to meet local demand for sustainable water services under climate variability and climate change regimes. Transboundary and regional water issues bring about additional complexity in developing appropriate national responses to water resources management (Kashyap 2004).

These implementation capacity issues are attracting increasing attention from authors, many of whom echo Gilbert White's observation that "the problems of accurate analysis of inter-sectoral linkages and of achieving institutional reforms in the planning process are formidable. It would be sanguine to expect early or easy solutions." (White 1998). Perhaps the temptation of the seemingly simple integrationist agenda underlying IWRM, although attractive, should be viewed rather more sceptically.

ADAPTIVE MANAGEMENT

The Goals of the AM Framework

Although the origin of the AM concept lies in many different intellectual and practitioner fields, its initial presentation as a natural resource management paradigm was in the 1970s. It was developed at the International Institute for Applied Systems Analysis in Vienna to support the management of natural resources under uncertainty (Holling 1978, Walters 1986, Walters and Holling 1990, Irwin and Wigley 1993, Parma et al. 1998, Ohlson 1999, Prato 2003). Uncertainty here refers to "the situation in which the information that describes a problem under study is deficient" (Klir and Wierman 1999).

Adaptive management has been described as "an integrated, multidisciplinary and systematic approach to improving management and accommodating change by learning from the outcomes of management policies and practices" (Holling 1978). In other words, AM involves the design and implementation of management programs that offer the possibility to experiment with and compare selected policies and practices. This comparison takes place through evaluation of alternative hypotheses about the system (Holling 1978, Walters 1986, Lee 1999). These hypotheses and assumptions are translated into plans and actions that are evaluated and monitored in order to test their effect on the system. Based on these results, the hypothesis and assumptions will be adapted with the objective of improving the overall management framework. The idea is that this process is repeated to guarantee continuous improvement. In other words, a learning model applied to natural resource management, similar in ambition to good practice recommendations for IWRM implementation. Lee (1993) emphasizes the usefulness of this approach by stating "if human understanding of nature is imperfect, then human interactions with nature should be experimental." Adaptive management can be seen as a management framework that is both anticipatory and adaptive (Kay 1997).

Like IWRM, AM has been around for several decades, and like IWRM, AM has not stopped evolving as a concept. Consequently, different researchers and disciplines have different descriptions for and understandings of the AM framework (Goodin 1996, Pahl-Wostl 2002). Although the management-as-experiment concept is undisputedly at the core of how management knowledge should be produced under the AM framework, it should be noted that other meanings have been ascribed to the framework (Bormann 1998), among which the notion of integration can be found prominently, for example:

- AM integrates environmental with economic and social understanding during the design phase and after implementation (Holling 1978);
- AM is a concerted effort to integrate existing interdisciplinary experience and scientific information into dynamic models that attempt to make predictions about the impacts of alternative policies (Walters 1997);
- AM combines democratic principles, scientific analysis, education, and institutional learning to increase our understanding of ecosystem processes and the consequences of management interventions, and to improve the quality of data upon which decisions must be made (Ecological Society of America 1996).

Unlike IWRM, AM may take a multi-organization guise, but more fundamentally, it is concerned with organizational learning whereas IWRM is concerned with transforming governance arrangements. Distilled as a set of statements about how knowledge production and use should be organized and a set of testable claims about the resultant beneficial outcomes, AM can be described as follows.

Knowledge production and use should involve:

- making causal understanding explicit as hypotheses;
- anticipating the effects of management action;
- actively experimenting by treating management action as tests of these hypotheses;
- keeping a record of causal understanding and the outcomes of management action;
- comparing the outcomes of management action with causal understanding to learn and to adapt management action; and
- integrating disciplinary knowledge.

Following McLain and Lee (1996), Wondolleck and Yaffee (2000) and McDaniels and Gregory (2004), AM will:

- increase the pace and frequency at which policy makers and resource managers acquire knowledge about ecological relationships;
- improve the effectiveness of management decisions through the use of iterative hypothesis testing and the quality of data available;
- enhance information flows among policy makers; and
- create a shared understanding among scientists, policy makers, and managers.

How Are the Goals of AM To Be Achieved?

Often people think of AM as "learning by doing," but this simplifies and misses the essential goal of needing to experiment with complex systems to learn from them. In the process of AM, management actions are taken not only to manage, but also explicitly to learn about the processes governing the system (Shea et al. 1998). Adaptive management theory can be split into two streams: passive AM and active AM. Passive AM "formulates predictive models of ecosystem responses to management actions, bases management decisions on model predictions, and uses monitoring data to revise model parameters" (Walters and Hilborn 1978). This form of AM is non-experimental, which makes it rather simple and inexpensive to implement. However, Hurlbert (1984) and Wilhere (2002) are of the opinion that this form of AM lacks statistical validity and does not provide reliable information for decision making. Through time, the AM framework has slowly evolved from this passive form into an active form of AM, whereby experimentation is a key element for the development and evaluation of management decisions and actions (Halbert 1993). These experiments and the outcome of their implementation form a basis for determining whether a particular intervention has achieved a desired outcome. In comparison to passive AM, the active form of AM claims to provide reliable information for decision making, because experiments include replication and randomization of management actions (Lee 1993).

Active AM is supposed to offer a framework to integrate research, policy, and local practice to increase the adaptive capacity of river basins through a cyclical learning process that encompasses policy formulation, implementation, and evaluation, as well as the modification of conceptualizations based on the outcome of the policy evaluation (Holling 1978, Walters 1986, Gunderson et al. 1995, Gunderson and Holling 2001). From both institutional and ecosystem management perspectives, continuous and deliberate learning emerges as a result of this experience–knowledge–action cycle. Many researchers have emphasized the importance of stakeholder involvement throughout this process for improving the quality and perception of decisions made at each step (Dovers and Mobbs 1997, Shindler and Cheek 1999).

Various procedural descriptions of AM can be found in the literature (e.g., Bormann et al. 1993, National Research Council 2004). McLain and Lee (1996) provide a detailed procedural definition of AM as involving: identification of problems, collaborative brainstorming, model development, hypothesis testing, planning, experimentation, monitoring, evaluation, and behavioral (management action) adjustments.

Evidence from AM Experiences

Despite the appealing experimental logic of the AM approach as a tool to aid decision making in complex natural resource management domains, a number of researchers have identified different obstacles that have prevented successful implementation and limited the realization of the benefits claimed to stem from AM. Based on evidence from three case studies of AM, McLain and Lee (1996) conclude that the proposed advantages have not always been achieved. Walters (1997) goes further noting that out of the 25 major planning exercises for AM that he has participated in, only two could be considered well planned. Other initiatives have either "vanished with no visible product" or become "trapped in an apparently endless process of model development and refinement." There are clearly major difficulties in demonstrating value from AM approaches and this is reflected in the style of reporting. For example, Habron (2003) provides an engaging and information-rich account of AM experiences from a watershed in the Pacific Northwest, comparing observed challenges with those reported in other locations, but is limited to commenting on process rather than outcomes. The paucity of post-intervention evaluations of AM initiatives could be excused in the short term by the time scales involved. However, with increasing emphasis on evaluating intervention outcomes, recent years have seen several major attempts to conduct cohort studies of project experiences and results. Disappointingly, the largest of these to date (by O'Donnell and Galat [2008] on river enhancement initiatives) reports low levels of support for the AM management cycle with poor monitoring, poor use of science in practice, and poor communication of experiences characterizing the assessed schemes.

Walters (1997) made an assessment of the AM framework, in which he describes several limiting factors that have affected the implementation of AM:

1. a focus on perfecting models rather than field testing them;
2. the expense and risk of undertaking large-scale experiments;
3. fear among research and management organizations that AM may undermine their credibility; and
4. fundamental conflicts among diverse stakeholders about ecological values.

Walters' (1997) assessment resonates with the conclusions of Lee (1993) who found that the following factors inhibited implementation and realization of claimed AM benefits:

1. the high costs of information gathering and monitoring;
2. resistance from managers who fear increased transparency;
3. political risk due to the uncertainty of future benefits;
4. difficulties in acquiring stable funding for experiments; and
5. fear of failure.

The factors identified by both Walters (1997) and Lee (1993) are largely related to the capacity and willingness of organizations to implement AM rather than their fundamental ability to do so. A significant element of organizational reticence to implement AM appears to be related to the support of other stakeholders. Learning is information and resource intensive, and requires the active participation of many stakeholders who need to maintain a commitment to the learning process throughout (Margoluis and Salafsky 1998, Lee 1999). Stakeholders may view AM and its experiments as too time consuming, complex, costly, and ecologically and economically risky, and therefore, be unwilling to accept experiments (and their financial cost) without understanding the consequences.

In addition, long-term sources of funding are crucial for the AM approach. Although Holling (1978) is of the opinion that the AM concept will support management even if there is a lack of sound scientific knowledge for action, other authors disagree, stating that implementing AM requires major investment in research, monitoring, and modeling to test alternative hypotheses about sustainable use and management of the natural resources (Smith and Walters 1981, Hilborn et al. 1995, Walters and Green 1997, Prato 2003). Some evidence for the utility associated with such longer-term effort is forthcoming from New Zealand where a successful species recovery program has been closely linked with an AM approach (Armstrong et al. 2007).

Beyond the institutional, AM implementation has also faced a number of technical challenges including a limited understanding of how to apply AM and difficulties in translating results from site-level projects to whole river systems (Levine 2004). And even where AM has been implemented, the transition from model development to experimentation has been found to be difficult (Walters and Green 1997). Although it is important to have a clear vision or model of the system during implementation of an AM procedure (Walters 1986), Lee (1999) has argued that the objective for AM should be the learning itself and not so much the development of tools that can help to support this learning process. The failure to strive for and implement actively adaptive experiments by resource management organizations has been noted and attributed to a number of reasons including there being (1) little or no flexibility in the institutional system, (2) little or no resilience in key components of the ecological system, and (3) technical challenges with designing experiments (Gunderson 1999).

So, there appear to be a number of largely institutional and organizational reasons why the AM framework has not been universally successfully translated from research into practice and we would emphasize that comment on the relatively small number of reported successful applications is not restricted to this contribution (see, for example, Gregory et al. 2006). Other recent critiques have suggested that the promise of AM cannot be realized unless the approach is recognized as a radical departure from established ways of managing natural resources (Allan et al. 2008). In this regard, AM shares much with IWRM—is there something in common with the nature of management frameworks as testable theories developed within the (largely academic) research community that might explain these common difficulties?

DISCUSSION AND CONCLUSIONS

Before trying to determine whether there are common causes behind the research–practice gap of both approaches, it will be useful to compare and contrast the two approaches. Table 1 describes IWRM and AM in terms of the types of problems they address, the nature of their approach, who is primarily involved in each, how their goals are to be realized, what they generate, and what characterizes good practice for each.

Integrated water resource management is primarily concerned with reform of water governance arrangements whereas AM is primarily concerned with the reform of responsible authorities, although this may involve stakeholder participation or coordination with other agencies. Integrated water resource management is concerned with changing the way in which water is managed by, in one sense, reformulating the problem or re-bounding the "system" of concern. Adaptive management is concerned with changing the way in which responsible authorities view and undertake management action to focus on learning as a key way of combatting uncertainty and promoting adaptivity. In this regard, IWRM and AM are both focused on and require some degree of institutional reform—from changing some management processes to potentially establishing entirely new organizations.

Each approach could inform change agendas at different scales, but there is also a difference with regard to their degree of prescription. As a call for reform of governance, IWRM is less detailed in its prescription than AM, which is a call for reform of organizational process. Reforming entire governance systems is a significant and costly task and one that requires as necessary preconditions a robust statement of failure in existing arrangements and an as-yet unknown causal theory of governance arrangements and natural resource management outcomes. It is not clear from the literature that sufficient "failures analysis" has been undertaken to show that existing water resource issues are a direct consequence of the way in which current governance operates. Such a lack of a sound case for reform could well be an underlying barrier to implementation. After all, why should governance be reformed if no sound case has been made? Such a case would need to be made on a country-by-country, possibly even region-by-region, basis.

Reforming organizational processes is also a significant and costly task for the organization(s) concerned, but on a lesser scale compared with the reforms called for by IWRM. The implementation challenges here are related to a combination of additional cost, a lack of failures analysis, and political risk. Organizations operating an AM regime may be less cost effective over the short and medium terms than they would be otherwise. To the authors' knowledge, no cost data have been published for organizations to assess the implications of moving to an AM regime, or whether AM is still shown to be as equally attractive once the cost of implementation is factored in.

In addition, as with governance reform there is a lack of rigorous analysis showing that current (management) processes are a cause of water resource problems. It is difficult to untangle the causes of water resource management problems, but part of the claim made by proponents of AM is that management would be improved (i.e., issues prevented or solved) if an AM approach was adopted. This claim implies that current management processes are at least partly to blame. But, as with IWRM, no robust analysis of this claimed failure has been undertaken at a sufficiently detailed (i.e., organization-specific) level. Combine this lack of a sufficiently robust critique of incumbent governance arrangements with the inherent political risks involved in explicitly making management "experiments" and the implementation challenges for AM become easier to understand.

We conclude that both IWRM and AM face many hurdles to their successful transfer from premise into practice. Table 2 expounds four types of barriers common to both approaches.

The fact that both approaches share a common set of barriers is not, we argue, the result of a serendipitous alignment of contemporary processes or phenomena that serve to resist change. There is perhaps a wider, underlying problem: that of translating generic, science-based management concepts and frameworks into practice. Evidence from other management stables not allied with the field of natural resources management provides no small measure of confirmation for this position. For

Table 1. Comparison of IWRM and AM approaches to water resource management

	Addresses problems that ...	Is a ...	Involves ...	Is achieved by ...	Generates ...	Good examples are characterized by ...
IWRM	... are seen to be the fault of fractured planning and a lack of appreciation for the connectivity of processes	.... call for joint governance	... multiple organizations and stakeholders operating across sectors and scales	... reform of the existing governance system (planning, management, and communication processes)	... coordinated and integrated sets of resource management plans and actions	... strong political commitment to reform and to inter-organizational, cross-sectoral management
AM	... “Big Science” and “Command and Control” approaches have failed to effectively solve, and that determinism does not adequately describe	.. theory about effective management of natural resources, and a process for organizational learning	... responsible authorities with support from different stakeholders	... engaging in a program of active learning about natural resource dynamics and use	... a style of management that emphasizes exploration and learning	... a combination of hypothesis formulation, action, and analytical reflection on the outcomes of management with the emphasis on learning

example, in his 1984 assessment of the state of organizational science, John Miner found little evidence of a correlation between organizational scholars’ ratings of the importance of a theory, its use, and its estimated validity (Miner 1984). A more recent revision of the field has noted little progress in the translation of theory into practice and identified “paradigmatic fragmentation” as a contributing factor (Schwartz et al. 2007). The operational research (OR) profession also engages in regular deliberation on the epistemological status, practical use, and perceived utility of its contributions. Indeed, there are strong parallels in the nature of debates within the OR and IWRM/AM communities; negotiating an underpinning rationale for the utility of models, theories, and approaches (see Holling (1998) and Baumann (2000) for an example from AM and Connell (2001) and Ormerod (2001) for OR).

The gap between concept, claim, and reality may be too wide for implementation to bridge at least with regard to the way in which such concepts are currently formulated and pushed out toward practice. Scientific management frameworks perhaps ought to be viewed as theories, subject to normal processes and standards of empirical and conceptual scrutiny. They should not be left viewed as they currently are—partially supported sets of claims about the relationships between organizational and governance arrangements for producing and using knowledge, and desirable resource management outcomes.

Certainly the barriers relating to institutional reform should not be underestimated. Integrating land and water planning is an agenda also pursued separately within the explicit IWRM and AM literature (Geerlings and Stead 2003, Slater et al. 2004, Carter et al. 2005). In a recent detailed analysis of the process and institutional issues involved in better integrating land-use and water-supply planning in the United Kingdom, Samuels et al. (2006) identify a series of problems to be overcome. These include difficulties associated with the sheer number and range of stakeholders involved; a lack of established and integrated planning processes within and between sectors; differences in planning and regulatory process time scales, and; high levels of uncertainty within and between different planning and regulatory processes. Although they provide a series of recommendations for land-use planners to

Table 2. Major barriers to the implementation of IWRM and AM concepts

Barrier	IWRM	AM	Research agenda
Institu-tional	Effective water governance is crucial for the implementation of IWRM plans. Problems in management and governance go beyond mere technical challenges; in the case of IWRM, institutional reform is needed: correct policies, viable political institutions, workable financing arrangements, self-governing and self-supporting local systems, etc. Institutions are rooted in a centralized structure with fragmented subsectoral approaches to water management, and often local institutions lack the capacity. Awareness and priority of water issues at the political level is, in many cases, limited. Also information and data to support sound management of water are generally lacking.	It is said that institutional challenges may be the key barriers to implementation of AM, and that AM may be a tool for enhancing institutional effectiveness. Social dynamics and institutional rigidity may complicate the implementation of the AM approach. Learning is information intensive and requires the active participation of many stakeholders, who need to maintain a commitment to the learning process throughout. Sound adaptive water management relies on functioning institutions that are designed to accommodate changes and new information. This institutional base is crucial for sustainable water resources management and development. Also, a long-term source of funding is crucial for the AM approach, which should include all steps of the process.	What institutional and governance structures and processes are needed to successfully implement IWRM or AM? Are they practically feasible? What would be required to change from existing structures and processes? And, importantly, why should political leaders embark upon a potentially radical overhaul of management practices?
Evide-nce of success	The necessity of adapting the IWRM concept to suit different local contexts does not allow for a generic, complete description of strategies and techniques. In practice, the IWRM concept has not structurally demonstrated its ability to increase the sustainability of water resources management. Empirical evidence is either missing or poorly reported. It will be important to identify the essential elements for IWRM, while avoiding rigid prescriptions and allowing for vast differences among countries.	AM is a form of systems analysis that includes and performs many feedbacks between sectors, rather than narrow technical analysis, and uses conceptual qualitative modeling rather than formal quantitative modeling. The drawback of this soft approach is that it is not easily reportable or demonstrable because it does not provide quantitative results. Also, the AM approach has merged into a more generic process, which could jeopardize the intended flexibility of the approach. It is important here to identify short-term strategies in the face of long-term uncertainty.	How can evidence be gathered to show that management frameworks like IWRM or AM are successful? Gathering evidence to show the value of implementing these approaches may be a necessary prerequisite to convincing political leaders to instigate institutional and governance reform. However, existing evidence is not
Ambi-guity of definit-ion	The most used definition of IWRM by the GWP gives very limited practical guidance to present and future water management practices. Besides the GWP definition, there are several other definitions that all differ from each other in one or more facets or dimensions. Ambiguity of definition further compounds difficulties in demonstrating success.	A reason for failure to achieve widespread adoptation and a rather modest success when adopted is the failure to define what exactly is meant by AM, and how it should be implemented. The AM concept has multiple and often ambiguous definitions. Resource managers may not understand what AM is and how they can apply it in practice.	What exactly is IWRM? What exactly is AM? The literature contains incomplete, ambiguous, and sometimes even contradictory definitions, partly because of the thrust for genericity behind both approaches. Is such diversity of understanding a strength, a weakness, or a necessity given the wide range of social, economic, and environmental contexts that IWRM and AM are supposed to benefit?

(con'd)

Complexity, cost, and risk	IWRM takes into account relationships and dynamic interactions between human and natural systems, land and water systems, and key stakeholder agencies and groups. This interconnectedness on different scales and levels makes it very complex to translate the IWRM concept into practice. Management problems end up with ambiguous boundaries and complex links with other problems; goals, alternatives, and consequences that are not well defined or understood; pervasive uncertainty that may not be quantifiable; and iterative management that involves conflict and negotiation among multiple stakeholders with divergent interests and values.	Stakeholders may view experimental management as too time consuming, complex, and costly, and more ecologically and economically risky. They may be unwilling to accept experiments without knowing the consequences. AM is considered difficult to initiate and sustain, and unlikely to be affordable in many instances. AM is likely to be costly and slow in many situations, so those involved in stewardship should thoroughly consider whether this approach is worthwhile in all cases. New information must be collected and processed by management actors to draw meaningful conclusions and implement appropriate action. Providing such information is a difficult, costly task.	How are the lessons of complexity science to be communicated to stakeholders, and how do we formulate convincing arguments about the roles of uncertainty, sub-optimality, and diversity. What kinds of financial, administrative, and social relationships best support IWRM and AM approaches.

better take water (resources and networked supply) and wastewater issues into account and vice versa, the scale of institutional reform required for integration to be implemented is significant.

If IWRM and AM are to be implemented successfully, we believe the road will be long and difficult and must start with constructing a clear case for reform. This cannot be achieved through positing a general argument that emphasizes the benefits of either approach—specific failures and problems must be identified, and relative costs and benefits of comparable alternative approaches to the various stakeholders involved assessed. Frameworks must themselves become viewed as testable theories and revised or abandoned as evidence dictates. Such a challenge is clearly problematic in the case of AM where the testing of theories is itself an integral element of the approach, raising the specter of viewing theory testing as (one component of) a theory to be tested: a recursive dilemma or an invitation to expound and strengthen the AM framework?

We must not, however, fall into the trap of thinking that a lack of extensive evidence for success is, of itself, indicative of failure. Those engaged through IWRM processes recognize the potential value of inter-institutional and cross-sectoral assessment and planning, whereas those engaged through AM processes clearly welcome wider stakeholder involvement and the liberty that results from being able to explore rather than optimize. These are positive features of practice that are perhaps poorly described by theory. However, we would suggest that, as these frameworks move from infancy into adolescence, they will encounter a more inquisitive and skeptical community of practitioners, less willing to pursue promise and more eager to demand evidence. Innovative, cost-effective, and long-term evaluation studies are urgently needed in this context and the research community should perhaps be more active in lobbying research funders to commit longer-term support to groups wishing to appraise the comparative value of strategic water management approaches.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/vol13/iss2/art29/responses/

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