Adaptive learning: a broadening of the concept of adaptive management and implications for its implementation.

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Abstract

Increasing attention has been paid to the potential of adaptive management for the management of natural resource systems under uncertainty, due to the capacity such an approach to provide information about the system being managed. The more successful cases of implementation to date appear to have occurred in less complex institutional environments, where there is more control over resource use and where the aim has been to reduce technical uncertainties associated with management. Adaptive management is increasingly suggested as an approach in more complex institutional environments where managers have less control. In such cases, it is suggested that the approach should aim to reduce the institutional as well as the technical uncertainties associated with the resource system. To do this, it is suggested that the concept of the resource system and of adaptive management should be broadened through the use of Institutional analysis and development (IAD) frameworks. Broadening of the adaptive management concept shifts the focus from managing the resource system towards learning about the system in order to improve the outcomes of management actions. Such an adaptive learning approach has implications for the process of implementation. The implementation process should become more participatory, reducing uncertainties through local knowledge, gaining information about the institutional environment and involving stakeholders in learning about the resource system. Participation is also required for adaptive approaches because such approaches require flexibility and possible changes in management actions and regulations over time. Participation can also assist in the monitoring of the resource system and management process.

Introduction

The issue of how natural renewable resources (such as fisheries, forests, wildlife etc) can be managed so as to generate benefit for current and future generations of resource users is problematic and has been the subject of practical and academic debate for many years. The effectiveness of many natural resource management regimes in achieving such sustainable use has been questioned (Stephenson and Lane, 1995, Ludwig et al., 1993), and some explicitly link this to the fact that there is still so much uncertainty associated with natural resource systems and the management process (Ludwig et al., 1993). Uncertainty results from a number of factors. Firstly, such systems are extremely complex, involving dynamic interactions within and between the characteristics of the resource and the people who utilise or manage them. Many of these interactions are only partly understood, if at all. In addition, such resource systems show immense local variability in their physical, biological, technical and institutional characteristics and in the needs and objectives of those utilising and managing them. This tends to lead to difficulties in making predictions about the resource system, to difficulties in planning and also it makes generalisation about effective management strategies difficult.

The majority of renewable resources can be considered as common pool resources as defined by Ostrom et al., 1994). Common pool resources, whether forests, fisheries or grazing area, share two key characteristics. Firstly, the exclusion of potential appropriators, or limiting appropriation rights of existing users, is a non-trivial problem, and secondly, the yield of the resource system is subtractable (Ostrom et al., 1994). It has become increasingly recognised by some within the areas of social sciences and natural sciences that the use of generalised solutions for natural resource system management, often implemented as a blueprint for successful management, have not always been successful (Pretty, 1995, Rondinelli, 1993). For example, Ostrom (1999) notes that “national government agencies are frequently unsuccessful in their efforts to design effective and uniform sets of rules to regulate important common pool resources across a broad domain”. The blueprint approach to management has also been criticised due to its tendency to involve only limited consideration of the conditions and perceptions of the various stakeholders (e.g. Rondinelli, 1993). As a result of this lack of consideration of local conditions and objectives, generalised solutions are introduced to diverse, complex and uncertain environments, often without modification, and tend to fail (IIED, 1994, Pretty and Chambers, 1994, Scoones, 1995, Rondinelli, 1993). These criticisms have led to increased recognition of the need for more location specific solutions. However, location specific solutions can be difficult to establish and adaptive management may be a useful approach in this respect, avoiding generalised solutions and instead resulting in more location specific solutions for natural resource system management.

Adaptive management has been suggested as an approach to managing natural resource systems where knowledge of the system is limited and there is a great deal of uncertainty due to its complexity and dynamics. It has been suggested as an approach for the management of a wide range of natural resource systems including agriculture,

forestry, fisheries, wildlife and large scale ecosystems (Walters, 1997, Nichols et al., 1995, Lorenzen et al., 1998). Adaptive management has been suggested as particularly useful in situations where management of complex systems must proceed despite uncertainty and difficulties in predicting the results of actions (Walters, 1986). The approach treats management as an experiment with uncertainties identified and management actions developed in order to test alternative hypotheses relating to these uncertainties. In this way management can be used to learn more about the resource system with management actions subsequently refined based on this learning. Despite the attractiveness of adaptive management as a concept there have been problems with its implementation (McLain and Lee, 1996, Halbert, 1993, Walters, 1997). Amongst the reasons that adaptive management has not been successful in a number of cases has been that adaptive management has concentrated on the technical, bio-physical aspects of the resource system and the uncertainties associated with these. Less consideration has been given to firstly, the social and institutional factors that impact on the biophysical nature of the resource system and secondly, the institutions and mechanisms through which new approaches can be integrated into existing procedures.

In this paper we categorise uncertainties in to two broad areas, “technical” uncertainties and “institutional” uncertainties. Technical uncertainties are those associated with natural resource system processes and the modelling of them, while institutional uncertainties are those connected with the interaction of actors (resource users and stakeholders) in the management process. It is important to clarify here that the term “institution” is used to refer to, as defined by Ostrom (1991), “the set of rules used to determine the decision making arrangements in a particular setting, including who can participate in decision making, procedures to be followed and what actions are allowable.

Both types of uncertainty are relevant to common pool resources due to the characteristics of subtractability and excludability. This requires that any management, if it is to be successful, addresses both technical and institutional issues. Firstly, renewable resources are subtractable in that one person’s use of the resource subtracts from another person’s use. Given that the aim of any sustainable management is to utilise the flow of resource units whilst maintaining the stock, it is important to know what can be used, how much can be used and when it can be used. There are many technical uncertainties associated with this. The second key characteristic of common pool resources is that the exclusion of potential users is a non-trivial problem. This is due to factors such as the location or size of the resource, the nature of the resource units themselves or the fact that the resources are open to multiple use. The management of natural resources is therefore not carried out in a completely controllable or predictable human environment.

Management needs to take in to consideration how individuals are to be excluded. Given that the resource is also subtractable, how the resource units are to be allocated to those not excluded in a way that is acceptable, or at least enforceable, is also relevant. This is commonly achieved through rules that create incentives or disincentives for certain types of action. However there is still much uncertainty about

the effects of different types of rules in different physical, social and economic environments on different courses of action. Such uncertainties are considered here as institutional uncertainties. These uncertainties have been subject to less research in the field of natural resource management than the technical uncertainties, but their relevance is increasingly being recognised.

The technical aspects of the resource system cannot be understood without reference to the social and institutional arrangements, and unless thought is given to how adaptive approaches can be made operational, such approaches are of little worth. In this paper, in order to address these issues, we shall re-examine the concept of adaptive management and the process of implementation. We suggest that the concept of adaptive management for natural resources management should be broadened to include a wider definition of natural resource systems and secondly that stakeholder participation should become a key part of the process of implementation. While participation in the process could be argued for management approaches generally, we shall go on to show why it is particularly relevant in the case of adaptive management.

Rationale for adaptive management for natural resource system management

The origins of adaptive management approaches for natural resource system management were scientists at the University of British Columbia who developed the approach in the 1970's in order to assist environmental decision makers and resource system managers (McLain and Lee, 1996). Adaptive management was developed as a response to management approaches such as comprehensive rational planning and conservative management approaches, such as the precautionary approach, that have been used for resource system management and have not appeared to meet management objectives. These approaches either have not taken uncertainty into account or else have not sought to reduce it.

In a comprehensive rational planning approach, as applied to resource system management, it is generally considered that uncertainties can be reduced through scientific research, often independent from decision makers, and that research results can be used to provide best estimates that can then be used by resource managers. This has led to quite detailed plans that were sent out across the board. Because the problems faced have become more complex and uncertain, both technically and institutionally, the detail required and rigidity have increased. Managers have found that they have needed to implement actions that have been beyond the constraints of the imposed procedure, leading to change in the management policy through trial and error. However, because there is generally no acceptance that deviation from the resulting plan is possible, there is no mechanism for ensuring either that management actions are informative or that the organisation is able to learn from the experience of such deviations (Rondinelli, 1993). This is not a problem where uncertainty is low because implementation in such cases is more likely to conform to the plan. However, where uncertainty is high, this approach can be less effective. Indeed Young (1998) suggests that where considerable uncertainty exists, believing uncertainty has been eliminated

and that decisions can be made with complete confidence is likely to result in an arrangement that may be vulnerable to disruptions.

Conservative management is an alternative approach that accepts decisions still need to be made and knowledge about the resource system is incomplete. In the light of this, its approach is to ensure that decisions are conservative and risk averse. Management policies should be robust under conditions of uncertainty, the degree of conservatism being adjusted according to the level of uncertainty (Caddy and Mahon, 1995). An extension of the conservative management approach is management using the precautionary approach. In this case uncertainty is recognised explicitly, though this has generally been confined to technical uncertainties, and action should only be taken if it can be shown not to harm the resource system. Using the precautionary approach, limits or thresholds are selected that constrain the possible management actions, such as exploitation rate, to levels that are unlikely to do harm (United Nations, 1995).

Conservative and precautionary approaches to management can be criticised because the risk averse nature of the decision-making results in management that does not necessarily make optimal use of the resource system. This can lead to benefits from the resource system falling short of the potential. While conservative management policies have the potential to prevent overexploitation or excessive damage to the resource system, they do not tend to provide information about the system being managed. Implementation of conservative management policies may therefore lead to a loss of benefits in the short term while at the same time avoiding opportunities to increase knowledge about the system (Walters and Holling, 1990). This minimises opportunities to refine the management policy in order to meet the long-term objectives.

Adaptive management, as with the conservative approach, acknowledges that management action may be necessary despite imperfect knowledge. However, unlike the conservative approach, adaptive approaches focus on reducing uncertainty over time in order to achieve more effective management (Hilborn et al., 1995, Walters and Hilborn, 1978). This is achieved through an organised approach to learning from management experience through planned experimentation in a structured process of ‘learning by doing’ that involves learning processes rather than single solutions or control through management. While Ludwig et al. (1993) argued that management of natural resource systems is usually experimental as actions are implemented despite the fact that the outcome is not certain, this should not be considered an adaptive approach as the actions are not planned to yield greater information about resource system processes.

Adaptive management allows alternative management actions to be compared in an experiment to assess their effectiveness (Halbert, 1993). There are two types of adaptive management that can be used, passive adaptive management and active adaptive management, both of which are based on increasing understanding and using the results from actions to adjust management policy

Passive adaptive management.

With passive adaptive management, a model that best describes the natural resource system is developed and management proceeds using this model. Improvements are made to the model and to management policy as and when information about the resource system is gained (Walters and Hilborn, 1978). The actions that are implemented can make use of existing variation in the resource system in order to provide an experiment, with the model and the management policy adjusted in the light of information that is gathered over time. Information will be gained through temporal variation arising from both changing resource assessments and natural variation in the resource system (Walters and Hilborn, 1978). Passive adaptive management, according to Walters and Hilborn (1978), has the greatest potential when applied to resource systems that are likely to provide information as a result of having a high degree of natural variation.

Active adaptive management.

Active adaptive management involves taking management action that, if properly designed, will, in addition to short term benefits, produce better information for the long term management of the resource system (Walters and Hilborn, 1978). In this case the resource system is subjected to some form of deliberate disturbance through actions implemented as an experiment (Hilborn et al., 1995, Walters and Hilborn, 1978). The results of the experimental actions are assessed and used to improve the management policy. Indeed, Walters and Hilborn (1978) believe that the active adaptive management process should be viewed as one of sequential experimental design with the results evaluated and leading to improvement of, and possible changes to, the management policy and future experimental action. In the long term it is expected that the information gained should lead to better management leading to more consistent management success.

The important idea with active adaptive management is that managers should try to ensure that actions are implemented in such a way as to learn and test out conflicting hypotheses relating to the resource system (McLain and Lee, 1996). Management actions are implemented, and monitoring and evaluation is undertaken in order to compare the actual outcomes of the actions with what was expected.

Experiences from implementing adaptive management.

A common feature of adaptive management as proposed by Walters (1986) is that, when implemented, it has tended to concentrate on identifying and reducing the technical uncertainties associated with resource system management without explicitly considering the issues already discussed in the first section. This is exemplified by, for example, Walters (1997) who notes, with reference to the United States, that the knowledge gaps in the understanding of resource systems most often involve biophysical processes and relationships. The institutional setting and any institutional uncertainties that are part of the implementation process have tended not to be

considered. This has been noted by Halbert (1993) who points out that very little analysis has been conducted into the institutional and sociological requirements for the effective implementation of adaptive management.

One reason for the focus on technical uncertainties has been because adaptive management has usually been attempted within an environment where there are well defined legal rights and clear enforcement. Within such environments, where managers have had a high degree of control over the management actions that can be taken and the actions of resource users, there have been a number of successes in reducing technical uncertainties. One of the best known examples is that of the Australian North West Shelf fishery (Sainsbury, 1988) where adaptive management was used to try to distinguish the reason for changes in trap and trawl fishery catch composition. Experimental management strategies involving closing certain management areas to trawl fishing while allowing trap fishing were implemented. In this example there was a fairly stable institutional environment and the managers had a high degree of control. There was also less risk of conflict as, while the trap fishery was domestic, the trawl fishery was largely foreign.

There has recently been a shift towards attempts to implement adaptive management at a larger scale and in more complex institutional settings (Dovers and Mobbs, 1997). In addition it has also been suggested for resource management in developing countries where, for various reasons, managers may have much less control over the actions of resource users. Where adaptive management has been attempted in a more complex institutional environment, it has often proved more problematic to implement. Walters (1997) describes how in cases where management, research and policy has required collaboration between a number of agencies, citing the examples of the Florida Everglades and Columbia River, it has not been possible to implement adaptive management. This may be as a result of leaving the focus on the technical uncertainties without fully accounting for both the institutions involved in implementing new rules and the institutions of users. More recently there has been the recognition that adaptive approaches should take into consideration the institutional setting. This has resulted in attempts to integrate the technically focussed adaptive management approach with participatory approaches that involve stakeholders and aspects of social learning (Dovers and Mobbs, 1997).

Bosch et al. (1996) have described the implementation of an adaptive approach for grassland management on South Island in New Zealand in the form of a participatory adaptive approach that involved land managers in research. This approach centred on a participatory initiative that links research and management as well as using and enhancing the knowledge in the community. Implementation has resulted in increased collective local knowledge and has enabled the community to work towards their objectives for the improvement of the resource system (Bosch et al., 1996, Allen, 1997). Successful outcomes have resulted through increased knowledge relating to the resource system and decision making. Middendorp et al. (1996) have also been able to increase knowledge about oxbow lakes in Bangladesh as a fisheries resource system through a passive adaptive approach that involved resource users. The use of natural

variability between lake systems and their management allowed yield models to be developed with resulting information provided to the resource users allowing them to improve management of these systems.

Broadening the concept of adaptive management

As adaptive management approaches are being suggested for larger scale systems and are to be implemented in more complex social settings, so it is necessary to go beyond reducing technical uncertainties. As Lorenzen and Garaway (1997) have pointed out, technical outcomes of management actions cannot be understood on the basis of technical considerations alone. The actions of people, whether they are resource users or, at a higher level, decision makers will, in combination with the physical aspects of the resource system, determine the outcomes of resource management. The actions of these people are determined by the rules in place that govern their action combined with the physical and cultural world in which they live. Therefore the outcomes and process of implementing management actions in a bio-physical resource system are greatly affected by the institutional environment (Ison et al., 1997, Garaway, 1999, Lorenzen and Garaway, 1997). Because of this, it has been recognised by many authors that there is a need to gain an understanding of the wider social, economic and institutional environment in which management operates (Bosch et al., 1996, Dovers and Mobbs, 1997, Lorenzen and Garaway, 1997, Scoones, 1999). This is the case not just for adaptive management but should be relevant for all management approaches implemented in more complex institutional environments.

While there have been attempts to broaden the concept in practice, as mentioned in the previous section, there is a need to create a broader framework that can account for both the technical and institutional aspects of resource system management. To begin with this would mean broadening the definition of the resource system to include institutional aspects. A useful way to examine these institutional issues is through institutional analysis and design frameworks.

Institutional analysis and development (IAD) frameworks, for example Oakerson (1992), Ostrom et al. (1994) and Ostrom (1994) have been developed for organising enquiry into how institutions (sets of rules) affect, and are affected by, the outcomes of resource management in combination with any given physical and cultural environment. An example of such a framework , adapted from that developed by Garaway (1999), is shown in Figure 1.

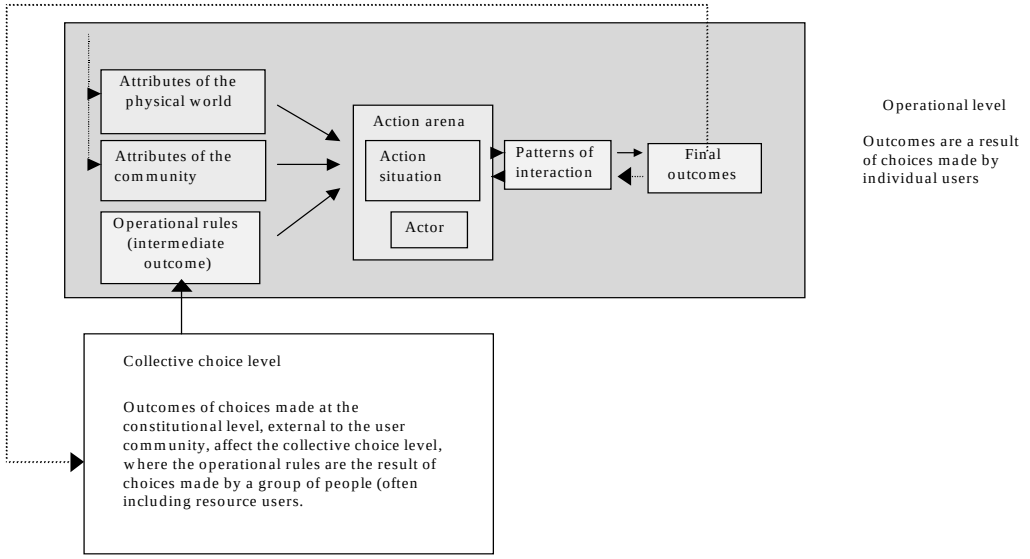

Figure 1. Framework for institutional analysis (adapted from Garaway, 1999).

Such frameworks are extremely useful as a heuristic tool for thinking through the logic of a situation and for breaking down complex situations into their key structural elements. At the centre of all these frameworks is the ‘action arena’, comprising the stakeholder (of which there may be many) and the choices open to them given the situation in which they find themselves. The resultant actions of all stakeholders (patterns of interaction) are seen to be the ultimate determinants of the outcomes of any resource management. The action arena is also affected by the physical characteristics of the resource, the social and cultural environment and the nature of the rules in place that attempt to shape human action. In the framework shown, three levels of choice are recognised, each with an action arena. The levels comprise the Constitutional level, a group external to the resource users, the Collective level, which is a group of people that can often include resource users, and the Operational level where decisions are made by individual users. For clarity only the Operational level is shown here, with the operational rules being the result of choices made at the Collective level, as affected by choices made at the Constitutional level. This is a dynamic framework in that new information about outcomes, and other changes in the system can change the action arena of stakeholders at all levels (Garaway, 1999). As Garaway (1999) explains, new information may lead to people at the Constitutional level to consider changes to the

rules regarding what local decision makers at the Collective levels can do and how. At the Collective level, new information may lead to changes in the operational rules within the existing collective choice rules imposed by the Constitutional level. Finally, resource users may change their actions within the confines of the original operational rules or, if these have changed, consider their actions in the light of the new rules.

Ostrom et al. (1994) identified seven key components of the action arena that, when combined, will generate the set of incentives on the basis of which individuals will act in any given physical and social environment. All these components can “take multiple values and combine to produce an incredible variety of action situations” (Ostrom, 1999). This variety and complexity generates much uncertainty, about the specific make up of any one situation (uncertainty due to a lack of information) and also about how the components affect one another (uncertainty concerning the underlying processes at work). Examples of the types of institutional uncertainty that might exist include uncertainty regarding the characteristics of the participants and their number, uncertainty regarding the roles of the participants and the associated actions they are authorised to take, and outcomes that participants can potentially affect through their actions. To fully understand an action situation (and therefore predict outcomes) it would be necessary to have complete information about all components, a situation that never exists. Ostrom (1999) has noted with regard to complex common pool resource systems that it is not possible to completely analyse and understand the system before action is taken. In order to reduce the institutional uncertainty associated with a particular situation, it may be necessary to both collect information relating to the components of the action arena and to learn about the underlying processes by implementing management actions and monitoring the outcomes. In order to learn about the processes, Ostrom (1999), like Rondinelli (1993), has argued that given the complexity of many resource management settings, policy proposals should be considered as experiments.

A framework for implementing an adaptive learning approach has been suggested by Lorenzen and Garaway (1997) and is shown in Figure 2. According to these authors, this approach begins with the definition of the wider objectives. A broad-based diagnosis of the resource system, involving resource users and stakeholders, is undertaken to gain information on all the system attributes and processes. This should include both the technical and institutional aspects of the system and consider historical outcomes and variation over time. This reduces the uncertainties due to lack of information. Together with stakeholders, the immediate objectives of management are then identified together with possible courses of action. The likely outcomes from these courses of action and the level of dynamic uncertainty, that related to a lack of understanding about both the bio-physical and institutional processes associated with each action, are predicted. Where uncertainty is high, an adaptive approach can be taken to implement actions, based on sound experimental design, that can reduce uncertainties. As mentioned, the adaptive approach taken can be either passive or active. The outcomes of an adaptive approach can be used to inform future management and perhaps lead to further experimentation to reduce identified uncertainties.

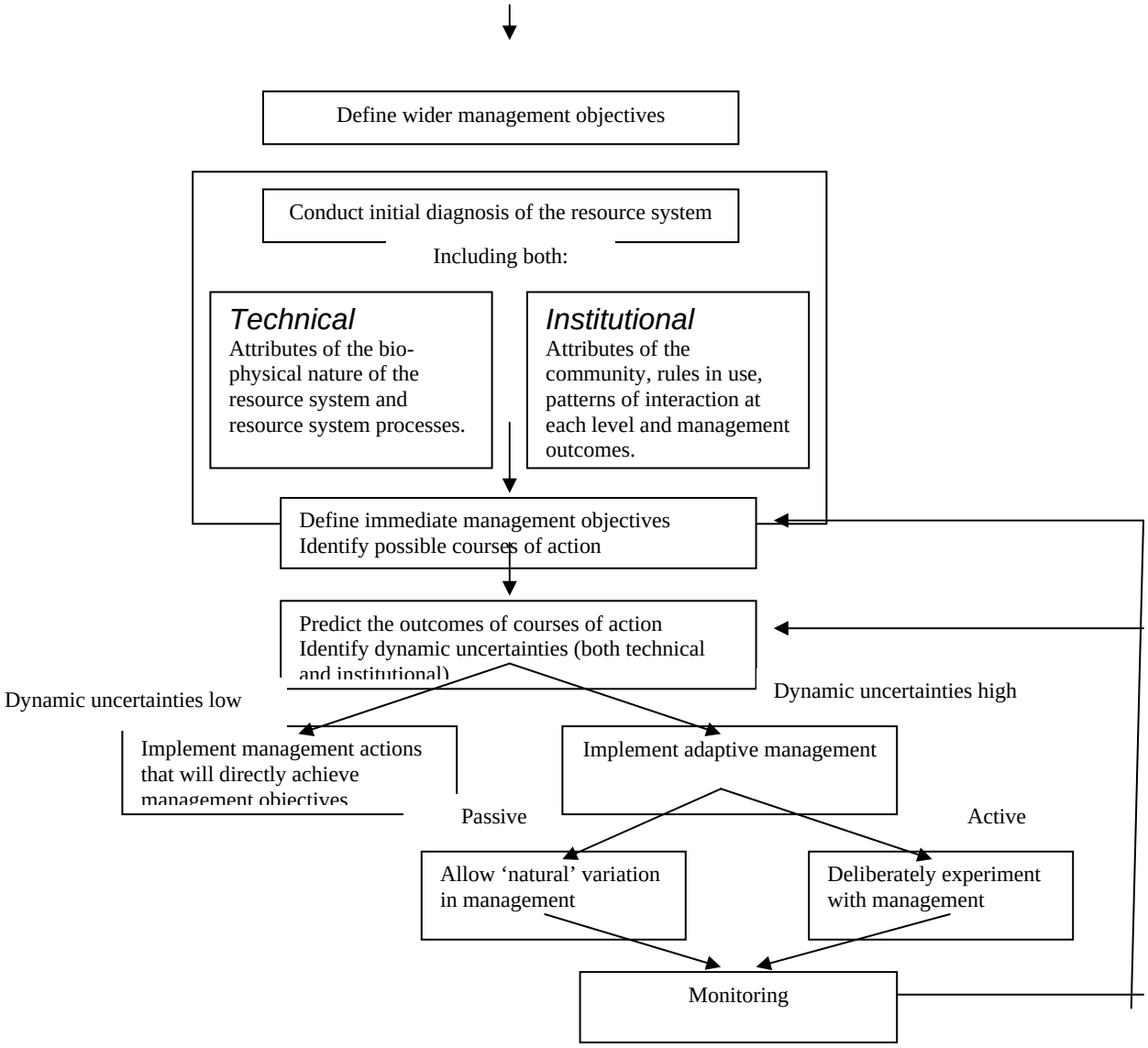

Figure 2. Framework for an adaptive learning approach for management under uncertainty. Adapted from Lorenzen and Garaway (1997).

Implications of a broader concept for the process of implementation

Broadening the concept of adaptive management to include social and institutional aspects and the reduction of institutional uncertainties will require modification of the implementation process. In order to learn about the institutional arrangements and processes, it will be important to involve resource users and stakeholders in the management process. One of the major criticisms of the traditional approach to adaptive management made by McLain and Lee (1996) is that stakeholders have not

been sufficiently involved in the process. This view is shared by Smith et al. (1998) who note that both their review of adaptive management in the US, and that of Gunderson et al. (1995) suggested that there is insufficient stakeholder involvement. Participatory methodologies can be used to gain more information about the existing situation, institutional, technical and bio-physical attributes, and help gain a greater understanding about the processes at work. This can help to more fully understand the particular action situation and can therefore assist in predicting outcomes of management action. A second important aspect of an adaptive approach is that it will require increased flexibility, there may be a need for changes in rules which may occur at short notice and that, in turn, would require the involvement and commitment of resource users and stakeholders. In addition, by involving resource users and stakeholders, there is an increased ability by all to learn from the experience of implementing management actions. This learning will be occurring where it is most important, that is, by resource users in many cases.

Participatory methods that include resource users and other stakeholders in the management process have often been used in agricultural development, and the methodologies used tend to differ mainly in the extent to which the farmers and rural community are able to participate in the development process. There have been a number of methodologies developed where learning and action by resource users is important. These methodologies can be distinguished as they have the aim of combining research and decision making so that farmers and rural communities become analysts and decision makers, with support from external specialists where appropriate. Such methodologies have been developed for complex situations, predominantly in developing countries, where there may be differing views amongst stakeholders about the nature of particular problems. Such methods seek to involve the people who are the focus of the research and development in the identification of problems and potential solutions. Involving users in the development of agricultural technologies has been claimed to provide for solutions that are better adapted to local environmental and socio-economic conditions (Röling, 1989 (in Martin and Sherington, 1997)). It is important for an adaptive learning approach that participation would facilitate learning by stakeholders rather than primarily to extract information for external decision making. Describing in particular aquatic resource systems, Townsley (1998) believes that community level intervention can help to reduce uncertainty and overcome problems with user conflict. This is an important point as value conflicts amongst stakeholders concerning the objectives of management have been suggested by Walters (1997) as a reason for the failure to implement adaptive management approaches.

Within the proposed adaptive learning approach, stakeholders should be involved at an early stage to define objectives and to provide information on the resource system and institutional arrangements. They should be involved in the choice of management action to be implemented and if possible should have some input in the analysis and evaluation of the outcomes of the management action. In this way the stakeholders are actively participating in the management process, learning about the resource system

and helping towards management that results in acceptable locally relevant solutions for natural resource system management.

In addition to participation being an important component of the adaptive learning process because of the broader definition of the resource system used in the concept of adaptive learning, it is also crucial because of two particular requirements of adaptive approaches. Participation is required firstly because of the increased flexibility that is required with an adaptive approach and secondly, because it can assist in the monitoring of the process and the outcomes. In addition, participation will be crucial for the implementation of adaptive approaches in environments where the management decisions are made by the stakeholders rather than an external body.

If active adaptive approaches are considered, it is important to bear in mind that implementing experimental actions involves risks and often incur costs, both direct and also through lost income. Whether adaptive approaches are considered will depend very much on the values of stakeholders and their attitude towards risk. Because the resource users and stakeholders may be involved in a dynamic management environment as a result of implementing an adaptive approach, it is important that they understand the potential risks and benefits and the reasons for any changes in regulations. For this reason, particularly associated with adaptive approaches, it is important to involve stakeholders in the process.

Participation in the management process is believed by Jentoft et al. (1998) to “enhance the legitimacy of the regulatory regime”. They believe that a lack of acceptance of command and control regimes by resource users may be increased where the regime being imposed does not match with how the users view their problems and view the resource system. With greater involvement there may be more understanding and acceptance of an experimental adaptive approach which might, as experimental management often is, be controversial (e.g. Mapstone et al., 1996). Communities are interested in the results of management actions and their implications when they have been involved in the management and they have a sense of ownership of the information (Campbell, 1994). Involving resource users and stakeholders in the process and ensuring that there is understanding and learning could have benefits for adaptive approaches in the form of the willingness to take risks. It has been noted by Pretty (1995) that groups will tend to agree to less risk averse decisions than the individuals would have had they been working independently.

Participation of resource users and stakeholders is also important for the monitoring of management actions. This can enhance the monitoring of the bio-physical aspects and is crucial for the understanding of institutional processes. There is therefore a need for stakeholders and those involved in managing the resource system to develop skills to monitor and analyse the results of management actions on the bio-physical and institutional aspects of the resource system and be able to adapt their practices accordingly. Within an adaptive learning approach, participatory monitoring and evaluation processes involving resource users and stakeholders will enhance the process. Where possible, the indicators chosen to measure change or effect should be

locally relevant and easily measured. This will enhance the information that can be gathered, increase the ability of stakeholders to monitor their system and help them learn about the resource system and gain greater understanding. Resource users can then build on collective local knowledge, add scientific analysis of their system, gain confidence and potentially ensure the continuation of the process (Bosch et al., 1996).

Summary

Adaptive management has strongly emerged as an option for the management of natural resource systems under uncertainty. While conservative management policies can prevent overexploitation or damage to the resource system, they do not have the same capacity to provide information about the system being managed.

In examining the implementation of adaptive management approaches, it appeared that the more successful cases have been implemented in less complex institutional environments, where there is more control over resource use, with the aim of reducing the technical uncertainties associated with the resource system management. Indeed, the focus of adaptive management in much of the literature has been on reducing the technical uncertainties associated with the management process. However, adaptive management is increasingly being suggested for use in more complex institutional environments where managers have less control and both the socio-economic and natural environments are constantly changing. The success in these cases has been more limited. It has been suggested that an adaptive approach could potentially be made more effective if institutional as well as technical uncertainties associated with the resource system are reduced. The focus should be shifted from adaptive management of the resource system to adaptive learning for improved outcomes. It is therefore proposed that the concept of the resource system and adaptive management should be broadened to include institutional aspects of the resource system and explicitly account for both technical and institutional uncertainties. The IAD framework is suggested as a suitable starting point to frame enquiry.

This broadening of the concept, to more of an adaptive learning approach, has implications for the process of implementation. The process of implementation should become more participatory, utilising local knowledge, gaining information about the institutional environment and involving resource users and other stakeholders in learning about the broad resource system. The participation of stakeholders is required in the implementation of such an adaptive approach in order to reduce both the technical and institutional uncertainties. Additionally, it is believed that adaptive approaches in particular require the participation of resource users and stakeholders for two key reasons. The first is because of the requirement for flexibility and possibility of requiring changes in management actions and the corresponding regulations over time. The second is that participation allows the effective monitoring of institutional processes and also can enhance the collection of bio-physical information.

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