ECOLOGY AND SOCIETY

E&S





The following is the established format for referencing this article:
Lal, P., H. Lim-Applegate, and M. Scoccimarro. 2001. The adaptive decision-making process as a tool for integrated natural resource management: focus, attitudes, and approach. Conservation Ecology **5**(2): 11. [online] URL: http://www.consecol.org/vol5/iss2/art11/

---

A version of this article in which text, figures, tables, and appendices are separate files may be found by following this link.

---

***Insight***, part of Special Feature on Integrated Natural Resource Management

# The Adaptive Decision-Making Process as a Tool for Integrated Natural Resource Management: Focus, Attitudes, and Approach

*Padma Lal*, *Hazel Lim-Applegate*, *and Michelle Scoccimarro*

---

***Australian National University***

---



---

## ABSTRACT

Integrated natural resource management (INRM) and its many closely related approaches are generally considered to be more effective than single-disciplinary approaches for managing the complex resource issues currently facing many countries. INRM approaches aim to integrate several disciplines and involve different stakeholders operating in their own subsystems across different spatial and temporal scales. These approaches focus on identifying management strategies for sustaining natural resource stocks and flows of goods and services as well as their underlying ecological processes. Changes in the behavior of consumers and producers and in the allocation of resources among uses, users, time, and space will be necessary to achieve sustainable development. To accomplish this, changes in focus, attitudes, and approaches to research and management will also be necessary. This paper argues that the key focus of INRM should not be the natural resource itself, but rather the interactions of humans with each other and with their natural environment, and the decisions they make about using and managing resources. Such decision-making processes aim to identify and implement action-oriented strategies and to apply economic and noneconomic instruments that motivate behavioral changes, allowing for different responses to various economic imperatives. This process should be guided by constructivist philosophy and supported by rigorous cross-disciplinary research and active stakeholder participation. It must be compatible with dialectic decision making to reflect the different views and objectives of the stakeholders, the presence of incomplete information, and, at times, the fact that researchers have only a poor understanding of the dynamics of subsystems and their interactions. There must also be iterative, regular monitoring and fine-tuning of the management strategies chosen. We prefer to call the entire process an adaptive decision-making process (ADMP). Here we propose a four-phase ADMP illustrated by projects in Fiji and Thailand, both of which are supported by the Australian Centre for International Agricultural Research. The role of research, researchers, and other stakeholders in the ADMP is also discussed.

**KEY WORDS:** adaptive decision-making process, bioeconomic models, commodity research, decision support system, integrated natural resource management.

*Published: December 20, 2001*

---

# INTRODUCTION

Traditional resource management policies and strategies are commonly based on reductionist approaches within the paradigm of a single discipline. Management strategies of this type are largely " ... reactive, disjointed, and for narrow or limited purposes ... " with " ... ineffectual or unsatisfactory, often undesired, management outcomes ... " (Born and Sonzogni 1995:168). These methods are generally ineffective in explaining real life with its complex interactions and uncertainties. Researchers practicing such strategies tend to regard current global resource and environmental issues as "wicked problems" that are impossible to formulate in a definitive manner (Rittel and Webber 1973, Margerum and Born 1995, Bellamy and Johnson 2000).

There is an increasing consensus about the need to find an approach to resource management that encourages environmentally friendly economic development by treating economic growth and environmental management protection as a continuum that crosses the boundaries of various scientific disciplines. The need to develop a process for formulating and implementing a course of action that explicitly takes into account social, political, economic, and institutional factors is also acknowledged. Such a process must be inclusive and fully address the scale and scope of environmental and human issues and their consequences (Dixon and Easter 1986, Cairns 1991, Born and Margerum 1993, Born and Sonzogni 1995).

Such realizations have led to a gradual but fundamental shift in the resource use and management paradigm. Integrated approaches to resource management have been advocated in many fields, such as river basin management, regional planning and ecosystem management (reviewed by Born and Sonzogni 1995), coastal zone management (Cicin-Sain 1993), wetlands management, and oceans management (Costanza et al. 1999). This emerging management concept has been known by at least 36 alternative terms (Downs and Gregory 1991), including "integrated catchment management," "integrated environmental management," "ecosystem management," and "systems analysis." In this paper, we use the term "integrated natural resource management" (INRM).

Although INRM has been heralded as *the* approach to addressing resource use and management, adopted by agencies and communities in developed countries, and advocated by many international development donor agencies, it does not yet have a systematic methodology. As part of the conceptual development of and based on their experience with INRM, theoreticians and practitioners alike have outlined elements and principles that are integral to the process. It is generally accepted that any systems approach adopted should:

- integrate multiple disciplines,
- span spatial and temporal scales, and
- involve multiple stakeholders in planning and implementation.

However, the application of INRM still poses significant problems even when all of the key elements are in place (Gunderson et al. 1995, Bellamy and Johnson 2000). These problems are related mainly to the predispositions of stakeholders, researchers, and technical experts as well as managers, farmers, and other end users (Resource Assessment Commission 1993).

Because of these problems, many researchers are attempting to further their understanding of INRM, with peer-reviewed publications as a measure of their success. They identify important research problems viewed from within the paradigms that they themselves use to structure research (Kuhn 1970), and based on a positivist philosophy (see Guba 1990). The researcher/inquirer adopts a noninteractive position, and analysis is regarded as value-free. Methodologically, the researcher states a hypothesis and sets out to test (falsify) it empirically. However, achieving practical outcomes is rarely the goal of researchers, which creates a problem when research results are linearly transferred to end users. Managers who have narrow, legislatively mandated terms of reference, duplicate each other's roles, and act inconsistently represent a different set of problems (Resource Assessment Commission 1993). End users are also reluctant to alter their behavior without incentives compelling enough to bring about changes in their fundamental decision making.

To address these problems effectively, all the stakeholders, including users, researchers, and managers whose decisions and/or activities influence actual outcomes, would have to make significant changes in their behavior, and probably in their attitudes as well. Furthermore, changes are required in the scale of analysis and action, which could be at the level of the plot, the farm, the community, the region, or even the nation—whatever works. These modifications can be developed by farmers (farmer experimentation), scientists, and/or the private sector. All the stakeholders, including researchers, must be involved in developing strategies for change. These strategies will also require changes in the way research is identified, developed, and conducted as well as in the behavior of managers. The types of strategies that lead to alterations in end-user behavior would also need to be reviewed, so that individuals are given incentives, rather than directed, to change.

In this paper we argue that, to adequately reflect these concerns, INRM should be seen as an iterative and adaptive decision-making process guided by constructivist philosophy. Decision makers should be encouraged to make dialectic choices from among management strategies that focus on changing people's behavior to achieve specific outcomes, rather than relying on the specific inputs required for traditional resource management.

The objectives of this paper are:

- to provide a practical adaptive decision-making process (ADMP) and
- to illustrate its application using two case studies in which the ADMP framework was used to identify research issues and to implement participatory research in support of stakeholder-based decision making.

---

## THE ADAPTIVE DECISION-MAKING PROCESS (ADMP)

The adaptive decision-making process (ADMP) is a problem-focused, action-oriented participatory process aimed at producing use and management strategies that stakeholders agree with and feel like they "own." This process recognizes multiple stakeholders who have different values and knowledge systems and use multiple paradigms. It acknowledges the need for a dialectic decision-making process supported by rigorous single- and multidisciplinary research. Consequently, there are three themes inherent in the ADMP: (1) participatory action research, (2) the use of a user-friendly decision support system (DSS), and (3) dialectic, stakeholder-based decision making underpinned by analytical rigor.

### Constructivist philosophy

In constructivist philsophy, " ... realities exist in the form of multiple constructions, socially and experimentally based, local and specific, dependent for their form and content on the persons who hold them ... " (Guba 1990:27). Thus, any inquiry is value-bound, and these values influence a researcher's choice of problem and interpretation (Tacconi 2000). The recognition of different realities suggests that no one understanding is complete, and that no one solution can be optimal. This is particularly true when there is a great degree of uncertainty, and when decisions need to be made despite inadequate information. To achieve this, stakeholders need to embrace a collaborative dialectic process of interaction, investigation, and testing. The real challenge is to use this approach for effective resource management.

### Participatory action research

Participatory action research requires the active involvement of all the stakeholders in the entire research-extension-development process and the acknowledgment of their multiple realities (Okali et al. 1994, Cornwall and Jewkes 1995). Stakeholders learn through their experiences and modify their actions accordingly (Chamala and Keith 1994). Key characteristics of the action-oriented research process include:

- problem-focused research that responds to local priorities;
- a methodology with an interdisciplinary focus that includes every stakeholder's knowledge system;
- the use of more than one methodology;
- triangulated data collected by researchers and stakeholders;
- analyses carried out by researchers from different disciplines using their own theoretical constructs, paradigms, and disciplinary tools;
- results and information that are interpreted through a dialectic process;
- actions that are integral to the process; and
- final results that are shared and owned by all the stakeholders.

### Decision support system (DSS)

A decision support system (DSS) is an integrative analytical tool that describes key processes and spatial and temporal connections within and between human and biophysical subsystems from a systems perspective. It uses a multidisciplinary approach to provide a definitive representation of a system, using mathematical algorithms where relevant. Multiple management objectives are recognized and built into the evaluation framework (Kersten et al. 2000). A DSS comprises data sets, key analytical models, and a user interface, and is central to the dialectic decision-making process.

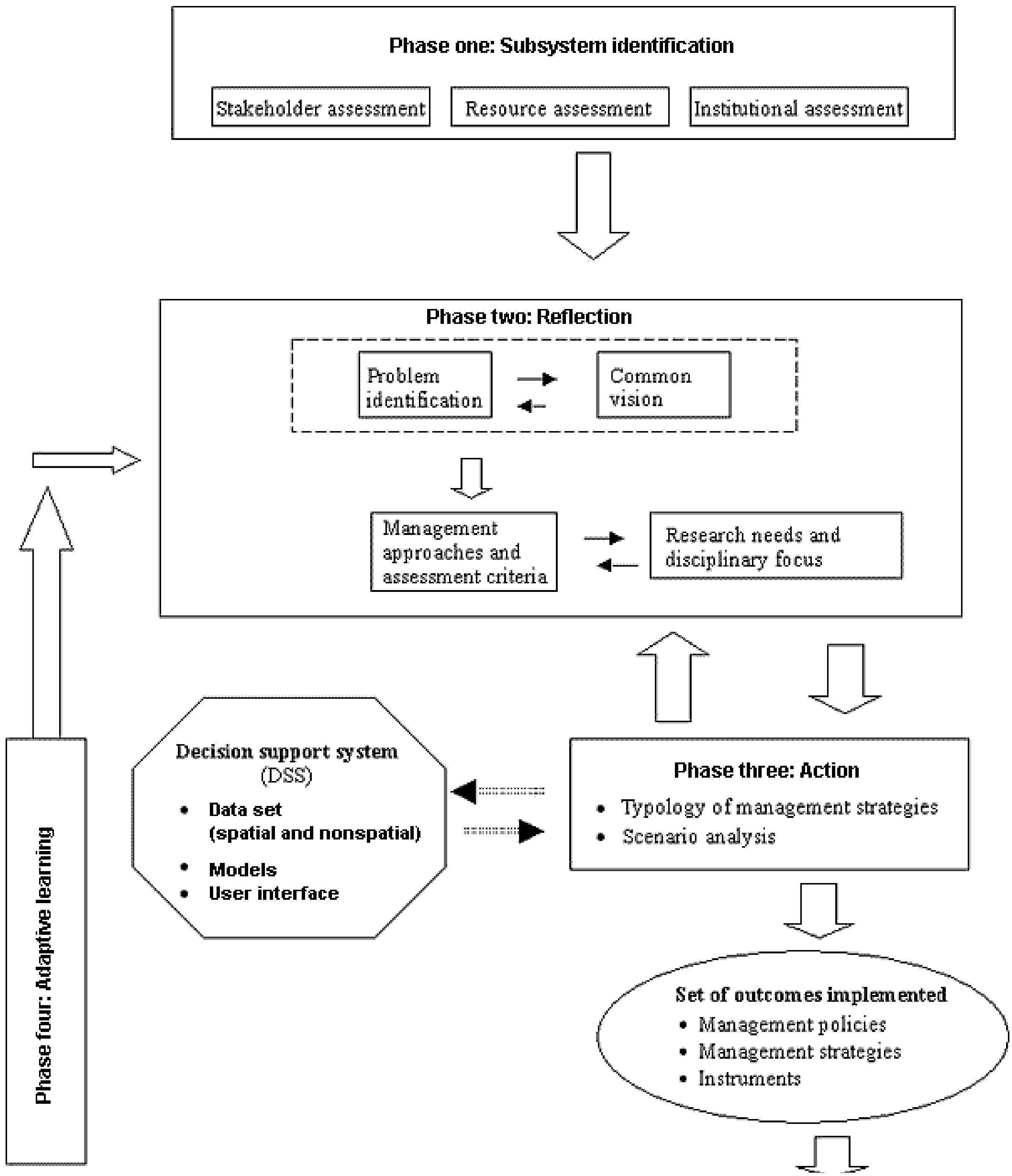
### Dialectic decision-making process

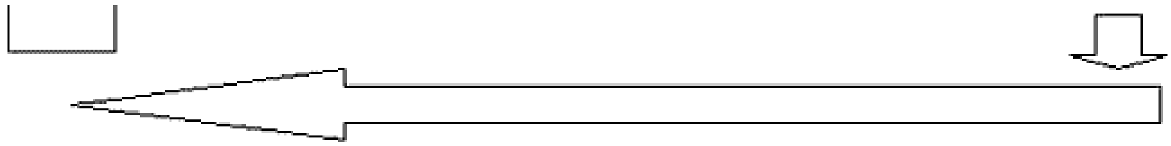
Dialectic decision making assumes that there are many different interpretations based on different scientific paradigms, experiences, and value systems that cannot easily be reconciled. No one interpretation may be complete, and, as a result, many realities are possible. This process thus " ... elicits and refines hermeneutically ... with the aim of generating one (or few) constructions on which there is substantial consensus ... " (Guba 1990:27). Decisions are based on the knowledge systems of all the stakeholders and on sound judgments supported by rigorous analysis. These decisions are achieved through interactions between stakeholders. This type of decision-making process is aided by the use of a DSS.

Operationally, the ADMP comprises four phases: (1) subsystem identification, (2) reflection, (3) action, and (4) adaptive learning (Fig. 1). Although a four-phase ADMP is recommended, the boundary between one phase and the next is flexible, and more than one phase may be undertaken at the same time.

---

**Fig. 1.** The adaptive decision-making process (ADMP).





## The phases of the ADMP

*Phase one: Subsystem identification.* The following three assessments are carried out in this phase:

- a stakeholder assessment, which identifies key resource owners, users, and managers at all levels of government, existing patterns of decision making, and the contexts in which stakeholders interact;
- an institutional assessment of the rules and regulations that govern activities within the ecosystem and of other institutions that may indirectly affect the system. This stage also identifies traditional institutions that may be relevant, as well as the management instruments used by the different agencies involved, including indigenous communities; and
- a resource assessment that uses traditional science and indigenous knowledge to provide a preliminary inventory of relevant biophysical and ecological flora and fauna. It also considers the dynamics of the natural processes that contributed to the current status of the environment as well as the functional processes and interactions between key components of the natural system.

*Phase two: Reflection.* The aim of this phase is to identify priority problems and establish a common vision, select the overall management approach and assessment frameworks to be adopted, and determine the research needs and disciplinary focus by means of participatory action research and dialectic decision-making processes. Researchers play an active role in this process by working with other stakeholders and using their technical and analytical skills to help them understand the effects of human activities on natural dynamics within the legal and institutional contexts of observed reality. The agreements reached during this phase and the data gathered and analyzed are included in the design of the DSS, which is built as part of the action phase.

As mentioned above, the initial goals of this phase are to identify problems and establish a common vision. A clear understanding of the underlying management issues and general agreement on the desired outcome are critical to any decision-making process that attempts to choose a path for development and management. The stakeholders, with their different perspectives, will together define the problem statement, arrive at a common vision about the desired outcome, and identify the appropriate management approaches and the set of management criteria that will be used to choose from among alternative policy options and/or management strategies. Information generated by individual disciplines and across disciplines, as well as indigenous knowledge, should be integrated into the process to develop detailed descriptive and causative inferences about the:

- nature and scope of the specific problems, issues, or concerns;
- existing value systems and patterns of interaction between owners/custodians, users, and managers;
- interactions between existing natural, economic, and social systems and possible cause-and-effect relationships and linkages between human activities and ecological functions and processes; and
- spatial and vertical boundaries of relevant interactions, based on ecological and/or economic considerations.

If complete information is available on the effects of human activities on ecological processes and economic values, and if the integrity of the underlying ecological processes is not threatened, then market mechanisms can be used to encourage an optimal allocation between competing uses during this phase. This assumes that market values reflect all the costs and benefits of the system, and that all the necessary information is freely available.

However, this is often not the case. Resources may exist for which property rights cannot be assigned, which leads to "missing markets." In these situations, market-based mechanisms cannot reliably encourage efficient or ecologically sound outcomes. Under such circumstances, it is useful to develop an evaluative framework to help the stakeholders agree on some way to objectively assess the impact of their activities on the ecological system.

The management approaches and evaluation frameworks chosen help to determine the research needs. The problem or issue itself will dictate the types of single- or interdisciplinary analyses and skills required. Depending on the research subobjectives (exploration, description, understanding, explanation, prediction, evaluation, and/or assessment), then inductive, deductive, retroductive, and/or abductive strategies may be used (see Blaikie 2000:100−127 for details). The research team should be drawn from appropriate disciplines and should normally include at least a biophysical scientist, a social anthropologist or community specialist, and an economist with experience in natural resources, agriculture, or environmental issues.

*Phase three: Action.* In this phase, the stakeholders agree on the management strategies they will use to resolve the resource problem based on their knowledge of what motivates and influences the actions of individual decision makers. Management instruments may include legislation, agreements, market-based strategies, institutional changes, and/or education (Panayotou 1998, Dover 1999). These instruments may meet a specific target and/or self-regulate. The strategies identified by the ADMP should always incorporate incentive mechanisms for change. This allows the stakeholders to adopt strategies for which the benefits outweigh the costs and the risks remain within agreed-upon safe, minimum environmental and social constraints. To guide the stakeholders, a DSS is built, and the researchers use it to help develop scenario analyses.

A DSS generally consists of:

- a set of biophysical, social, and economic data;
- a set of integrated analytical, simulation, and/or optimization models derived from individual disciplines;
- an output module for the spatial and/or nonspatial depiction of expected future outcomes; and
- a user-friendly interface that enables relevant stakeholders to perform "what if" scenario analyses.

The DSS serves three purposes: (1) stakeholders gain a better understanding of the problem in a way that attempts to detach them from their previous inclinations; (2) decision makers may objectively compare the effects of different value systems, different world views, and a range of possibilities based on sound analysis; and (3) the DSS may increase the chance of finding a shared vision or acceptable solution (Kersten et al. 2000). Different scenario analyses represent different management strategies, policy options, and/or institutional settings aimed at changing decision-maker behavior to meet the desired goal. Each scenario can be considered a unique depiction of a future strategy and may be analyzed using the DSS. This type of scenario analysis can also contribute to conflict resolution.

In any multidisciplinary environment, a conflict of interests, values, and approaches is inevitable. This can occur despite good intentions and agreement about desired outcomes, the management approach, and the evaluation framework. Conflicts and disagreements are often unavoidable and must be resolved. Differences may arise because:

- many different activities may be contributing to the observed problem,
- a single activity can have many different impacts,
- there are connections within and between land-based and aquatic components of the ecosystem,
- activities may have indirect and synergistic or cumulative effects, and
- relationships may be nonlinear (Antunes and Santos 1999).

In the face of uncertainty, incomplete understanding, and different value systems, stakeholders should pool their knowledge and be flexible and willing to arrive at a consensus, or at least recognize these differences, which can then be analyzed using dialectic processes to reach some form of agreement. Many different models of conflict resolution are available. However, bargaining and dialogue are superior to authoritarian decision making for complex problems involving uncertainty and competing interests. Buckles and Rusnak (1999) also argue that conciliation, negotiation, and mediation are more likely to produce a "win-win" solution. A DSS may help in the resolution of conflicts, particularly those involving values, management approaches, and strategies.

*Phase four: Adaptive learning.* It is important to treat the process of examining prospective management strategies as a series of management policy experiments. This emphasizes the element of surprise in the search for sustainable development (Janssen and Goldsworthy 1996, Holling et al. 1998, Lee 1999). The management strategies selected in the action phase are now implemented and monitored in an iterative manner (Fig. 1). The results of these experiments indicate the extent to which these problems are manageable, and which strategies are useful. Regardless of how the results are interpreted, this phase becomes one of adaptive (or experimental) learning.

This learning process is central to the ADMP. May (1992) describes three types of learning:

- instrumental policy learning about the viability of specific instruments or programs;
- social policy learning about social constructions of policy problems, the scope of policy, or policy goals; and
- political learning, during which stakeholders become more knowledgeable about policy process and negotiating skills.

Users of the resource are also key learners. They learn by observing the results of their actions and analyzing cause-and-effect relationships based on their newly acquired knowledge; their findings are then fed back into the decision-making process.

---

## APPLICATION OF THE ADMP: ACIAR CASE STUDIES

Two projects are presented to illustrate the lessons learned by applying the ADMP. The first assesses the effects of reforms in the international sugar market and defines appropriate responses for the Fiji sugar industry. The second concerns a framework for integrated water resources assessment and management in the upper Chao Phraya in Thailand. These two projects were chosen to emphasize that the ADMP is relevant whether the underlying research is commodity-based or concerns natural resource management per se. These projects also demonstrate that the ADMP can be applied when stakeholders need to make decisions about either sociocultural or institutional constraints, as in the Fijian case, or biophysical or ecological limitations, as in the Thai case. These two case studies make it clear that this artificial distinction is part of the problem that needs to be considered in INRM research and development.

Although in neither of these projects have all the phases of the ADMP been completed, the Fiji sugar project illustrates how the process was implemented in its early stages, whereas the later phases of the ADMP are best illustrated using the Thai context. The action learning phase has not been completed in either of these case studies.

### The Fiji sugar project

Phases one and two of the ADMP were carried out simultaneously. Preliminary discussion and literature reviews revealed many stakeholder groups in the sugar industry who had a direct interest in and/or whose decisions were likely to influence industry outcomes. Internationally, the World Trade Organization and developments in the European Union Common Agricultural Policy have a direct impact on the Fiji sugar industry. The Sugar Protocol of the European Union has guaranteed Fiji specific levels of exports and prices that are often two to three times the world price. This, together with a productivity decline over the last decade, provided the overall institutional context for research and the scenario analysis.

Domestically, the stakeholders include owners of native lands, which account for more than 70% of all Fijian land under sugarcane; sugarcane growers, predominantly of Indo-Fijian origin, who grow sugarcane on leased land regulated by legislation; a milling company monopoly that owns all four mills; and the sugarcane harvesting groups (Table 1). In addition, the Ministry of Planning, the Ministry of Agriculture, Forestry and Fisheries (MAFF), and, more recently, the Ministry of Sugar are involved in the industry.

**Table 1.** Institutional arrangements affecting the Fiji sugar industry.

| | |
|---|---|
| Agricultural Landlord and Tenant's Act | provides for a maximum 30-yr, nonrenewable tenure arrangement on native land; most of these leases will expire between 1997 and 2005 |
| Crown Lands Act | sets forth the conditions for leasing crown land |
| Sugar Industry Master Award | formalizes the relationship between growers, sugarcane cutters, transporters, and millers<br>regulates the distribution of sugar proceeds between growers and millers<br>stipulates payment rates for transportation, sugarcane harvesting, etc. |
| Sugar Industry Tribunal Act | covers industry disputes, including arrangements for sugarcane harvesting and transportation |

To initiate a participatory process, it was crucial to obtain the endorsement of the most influential government official, the Permanent Secretary of the Ministry of Planning, who was also the Secretary of the Sugar Commission of Fiji. Discussions later included MAFF, the Fiji Sugar Cane Growers Council (which represents all those involved in sugarcane production), and the Fiji Sugar Corporation (the sole sugar miller). After the project implementation meeting, efforts were made to keep the Native Land Trust Board (the custodians of indigenous land) informed, with the hope of involving it more actively at a later date. One year after the project began, the Land Trust's full cooperation had still not been secured, and this may take some time because of recent political events. The Native Land Trust Board finally agreed to share some of its data late in 2001, well over 5 yr since the project idea was first mooted!

Discussion with the stakeholders identified the management issues that required analysis. Given the huge challenges facing the industry, it was not difficult to arrive at a broad consensus on priority issues. There was general agreement that impending trade negotiations with the European Union were the major concern and that land tenure was the most critical domestic issue. More than 95% of all land leases are due to expire by 2005. If these leases are not renewed, as has been threatened, and the land reverts to the indigenous landowners, the sugar industry will be further jeopardized due to the lower productivity of farms that are managed by indigenous Fijians.

There were, however, different opinions about how to address these issues. Before the ADMP concept was introduced, the Sugar Corporation had concentrated on improving the efficiency of transportation and milling. In contrast, research at the Fiji Sugarcane Research Centre was focused on farm-based fertilizer and pesticide trials, farm management trials, and breeding varieties to suit different soil conditions. Researchers from MAFF were interested in assessing sugarcane land-use capabilities, whereas the Lands Department was developing land information systems based on geographical information systems (GIS). These different stakeholder groups did not interact, and thus did not achieve the synergistic benefit of an integrated approach.

Following discussions that lasted almost 12 months, the key stakeholders endorsed the use of the ADMP approach. They acknowledged the value of integrated research, using a nested scale of analysis (Fig. 2) to address the problems facing the sugarcane industry. Staff from the Fiji Sugarcane Research Centre agreed that there was a need for integrated bioeconomic research. MAFF acknowledged the merits of combining their work with that of the Lands Department, and agreed to join the research team, thus bringing together a land-use specialist, a crop scientist, an agricultural and resource economist, and a trade economist. The Sugar Corporation, on the other hand, became involved only after the merits of the project were no longer in dispute; the corporation also needed to be reassured that the project leader was apolitical at a time when the country was divided along ethnic and political lines.

---

**Fig. 2.** Nested scales of analysis.

| **Scale** | IMPACTS / FEEDBACK | **Analysis [tools]** |
| --- | --- | --- |
| INTERNATIONAL | | International trade [ trade model, political economics] |
| NATIONAL | | Economy/industry wide impact assessment [CGE model, regional GE submodels] |
| REGIONAL<br>• Economic region<br>• Biophysical catchment | | Land use suitability [crop suitability models, land use models, bioeconomic model]; spatial variability [GIS] |
| LOCAL<br>• Farm household system | | Household profitability (on-farm and off-farm activities) [household income and expenditure model] |
| • Agricultural activities of households | | Farm activity model [farm model] |
| • Specific crop | | Biophysical crop-specific/crop model |

---

Not all issues were resolved easily; some required extensive dialogues over long periods of time, and others are still unresolved. For example, because the Lands Department and MAFF operate on different scales, it has still not been possible to reconcile their outputs. Issues related to the scale of analysis and the appropriate degree of accuracy must still be addressed, as must some issues between the bioeconomist and the land-use specialist; discussions of these subjects are continuing. It may be possible to resolve these problems once the users of the research clearly indicate the scale at which they want the analysis and results to be expressed.

Only when the recently appointed Chief Executive Officer of the Cane Growers Council fully endorsed the ADMP project did researchers gain access to Council data and information. The new CEO is working closely with the research team and has asked to see the results of key analyses of the expected effects of expiring land leases on landowners, sugarcane growers, and the sugar industry as a whole. The Minister for the Sugar Industry has also sought similar information.

The results of the analysis of land tenure options have been made available to the bipartisan Agricultural Landlord and Tenant Act Task Force, the key forum for the land tenure issue. The research team is continuing its discussions with the Sugar Commission, the Growers Council, and the Minister for the Sugar Industry, and there have been requests from these bodies for additional scenario analyses of alternatives for land tenure reform. However, negotiations over the renewal of leases have stalled because of recent political events in Fiji.

Stakeholders will be able to undertake scenario analyses using the DSS with minimal input from technical staff. The key components of the DSS design are currently being developed. To guide this development, potential users, including key government agencies, the Growers Council, members of the Sugar Commission, and the Fiji Sugarcane Research Centre have been asked to identify the issues they would like to address in the near future.

### The Thai project

At first, the Thai project did not fully embrace the ADMP process. The project began as a catchment management project, with a greater focus on the scientific challenges to individual disciplines. It was not until late in the first phase and early in the second that it became outcome-oriented and incorporated decision makers into the process. Researchers from different disciplines were almost halfway into the project when they finally started to see the linkages and appreciate the synergy that would result from bridging the disciplinary divide. This project has completed three of the four phases of the ADMP.

Phases one and two were undertaken concurrently because of difficulties related to the diversity of stakeholders in Thailand. After a preliminary literature review and stakeholder discussions, it became apparent that the key issues involved land and water resource allocation, together with the effects of government policies and management strategies. Three government agencies are actively involved in management within the catchment area. The Department of Land Development is responsible for developing catchment management plans, the Royal Forestry Department implements forest conservation strategies, and the Royal Project Foundation has an active role in agricultural extension. These agencies are represented at national, provincial, and local levels. A number of environmental nongovernment organizations, activist academics from Thailand, farmers, and farmer organizations are also involved in resource management.

However, not all stakeholders were interested in the ADMP project because of their experiences with earlier academic projects, which did not produce useful results. For this reason, the Department of Land Development was deliberately chosen as the key government stakeholder, because it expressed the most interest. The challenges were then to implement the ADMP and design a DSS-based process that could meet the needs of the Land Department without limiting the future involvement of other stakeholders. The project team then had discussions with the rural householders who live in the catchment area and are the primary stakeholders. As the project progressed, other stakeholders joined when they saw that the DSS developed as part of the project could be useful in their own efforts to devise suitable management strategies.

Although households are the main decision makers in the catchment when it comes to issues related to the allocation of inputs such as family and hired labor, capital, and land (Walker and Scoccimarro 1999), water is managed communally, as in other regions of northern Thailand. Weir management committees allocate water and organize labor for the maintenance and repair of the weir infrastructure (Tanabe 1994).

It was evident after a number of stakeholder meetings that their priority concerns were not the same as those previously identified by the government. Downstream agricultural communities were worried about the effects of changes in land cover on the availability of water, in particular, about the possibility of flooding and drought caused by upstream forest clearing for agriculture. The Land Department was interested in identifying land uses that suit underlying biophysical conditions and meet socioeconomic criteria. Individual agricultural households were concerned about their livelihoods. The demand for water for dry-season cropping has increased, and there were proposals for new water storage facilities.

Research needs evolved as the project progressed. Consequently, although the project began with a core research team comprising a hydrologist, an economist, and a social anthropologist, it expanded over time to include a crop modeling expert, a land use specialist, a soil erosion expert, and a DSS specialist.

The large number of stakeholders had many different views and objectives. Appreciating their roles in the catchment area and understanding the ways in which other factors affected household decision making were crucial issues for the project team, whose objective was to recognize and incorporate these varied views. For example, farmers were interested in their own financial performance and were not necessarily concerned about downstream implications. National policy makers tended to view the catchment area as a whole; some of them focused on overall land and water use, whereas others were more interested in the distribution of water use by household within the catchment area.

In the third phase, the key objectives were to identify a typology of management strategies, determine the assessment criteria that were important to the different stakeholder groups, develop a DSS, and analyze possible management scenarios.

Much of this phase was implemented by the researchers, who had regular interactions with other stakeholders to validate assumptions, check information, and seek input about management objectives, strategies, and assessment criteria. They also tried to determine how to present the results in the form that would be the most useful to the stakeholders. The researchers used standard discipline-based methodology to collect and analyze data, develop analytical models for scenario analysis, and construct the DSS. A brief overview of the different components is provided to demonstrate and emphasize how the DSS, which is the core of the ADMP, was built using the most rigorous single- and interdisciplinary methodologies, models, and tools.

In the upper Chao Phraya catchment area, a number of management approaches have been used, including command and control regulation of particular activities, market intervention to promote alternative crops or subsidize input use, interventions in capital markets, and public investment in irrigation infrastructure. These policies, implemented by a variety of agencies with specific objectives, have had both intended and unintended consequences for the socioeconomic and biophysical systems.

As part of the process of determining the various objectives of natural resource management in the catchment area, stakeholders have identified assessment criteria that reflect their own interests and goals. These criteria include household performance, variations in household performance among different farming systems, the distribution of resource use among communities within the catchment area, and land cover and its associated effects on the hydrological regime. Having a range of indicators that reflect biophysical and socioeconomic processes in the catchment area makes users confront the consequences of policy intervention for both human and natural systems.

The Thai DSS recognized the nested operational scales of stakeholders and made it possible to feed production decisions from the local level to the wider regional and national scales (Fig. 2). In turn, the human and natural resource systems of these wider scales affect the local level, commonly through changes in commodity prices or environmental conditions. Given the links between these scales, different analytical tools are used to accommodate the precision required at each scale; these tools range from crop simulation models and household bioeconomic models to catchment-level, physico-bioeconomic models that link hydrological and household-based bioeconomic models. It is important to note that this integration of disciplines and interests is immensely complex. To address this, the DSS integrated various components heuristically in such a way that those components and interrelationships deemed most likely to underlie the cause of a problem could be explored first.

Biophysical and socioeconomic data sets collected from different sources, including indigenous knowledge, formed part of the data module in the DSS and were used for three purposes: (1) as data for the modeling tools, (2) to provide information to users, and (3) to produce model outputs in spatial and nonspatial forms. Spatial data layers in the DSS included soil maps, catchment and administrative boundaries, digital elevation models, and land cover and zoning maps. These data layers were overlaid in various scenario analyses.

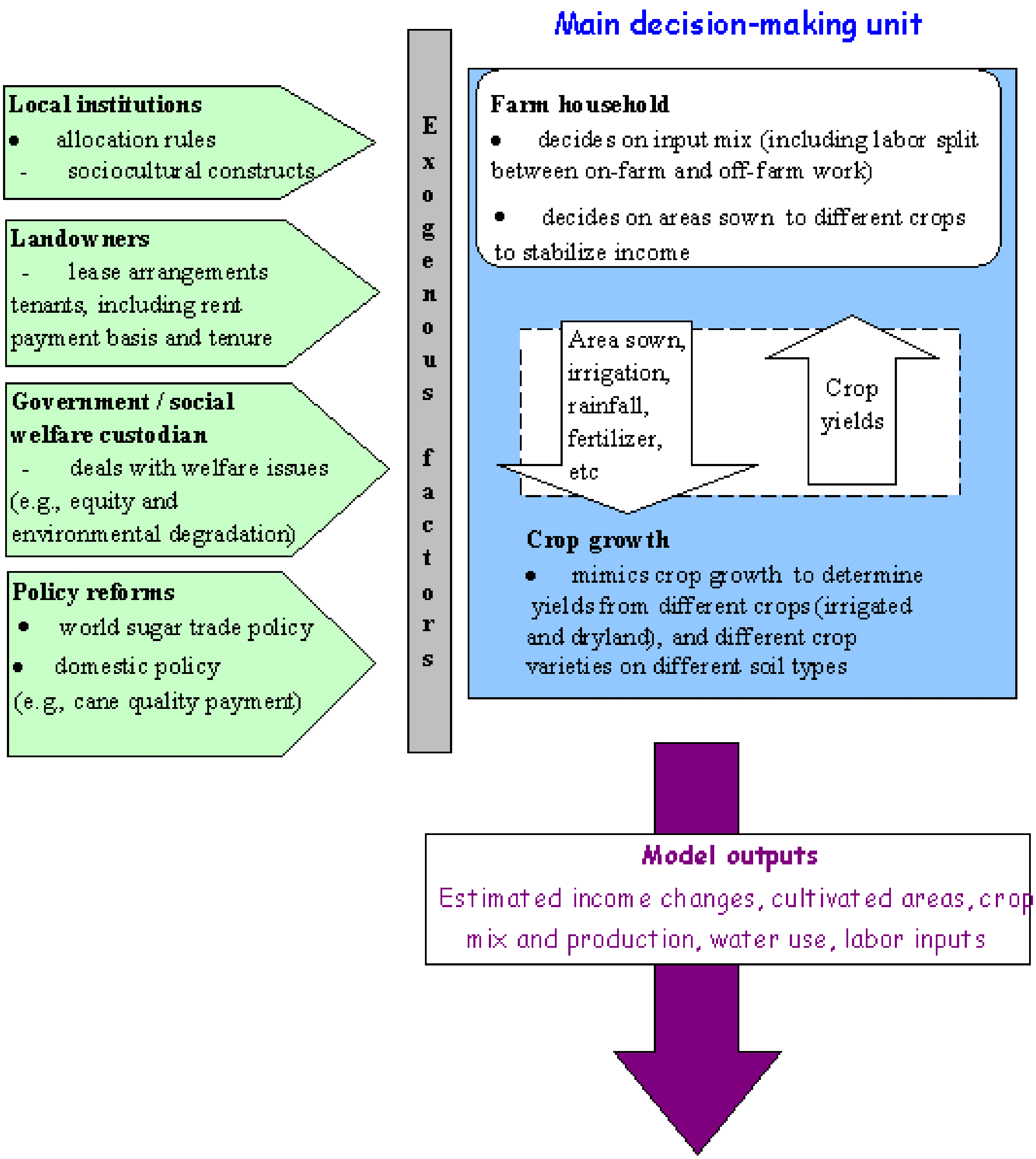
The design of the DSS was not easy, because methods for integrating data (particularly spatial data) and modeling tools are in their infancy. Although off-the-shelf software exists for spatial data manipulation and modeling, few packages incorporate both. As a result, software had to be designed especially for the DSS application.

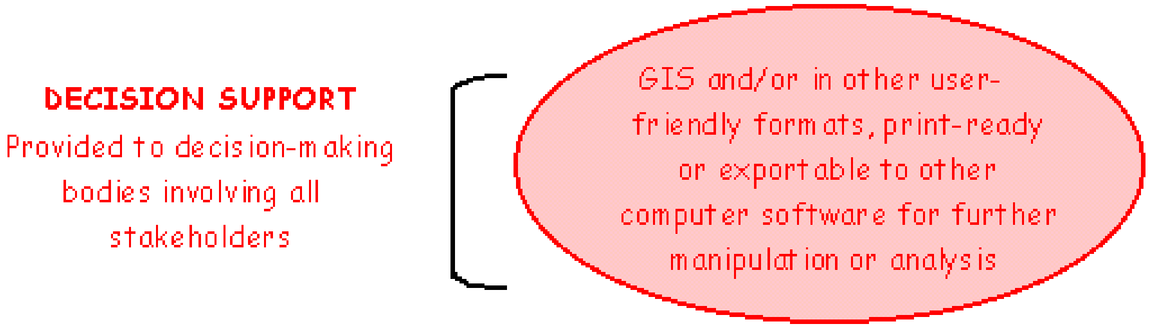
To fully take into account the impact of policy reforms or institutional restructuring, it was crucial to understand the interactions between stakeholder groups within their altered operational settings. The socioeconomic and environmental effects of change will ultimately depend on decisions that stakeholders make in the field. To assess these effects, the DSS attempted to capture stakeholders' decision-making behavior within the context of the constraints imposed by natural processes and the existing legal and cultural arrangements.

The DSS is thus composed mainly of a biophysical and socioeconomic model (referred to as "the model" in the following discussion) that can explain cause-and-effect relationships and predict the effects of interactions within the system. It also includes a GIS system that is capable of spatially depicting the summary characteristics of linked databases and the simulation and optimization results of the models. The model represents stakeholder groups as discrete modules, each with characteristic decision-making behaviors and patterns (Fig. 3). These modules are interrelated to the extent that their production and consumption decisions affect each other, with the combined impact of decisions made (or not made) determining the likelihood of achieving their envisioned future.

---

**Fig. 3.** Sample structure of the biophysical and socioeconomic model.




---

The core of this DSS is the farm household as the main decision-making unit or resource management unit (RMU). Households were classified into groups based on their ownership of high-quality paddy land and access to irrigation, the two most important factors that determine household decisions. This classification resulted in 5–10 RMU types per region of agricultural activity (Walker and Scoccimarro 1999). Embedded in the farm household model is a crop model for analyzing the bioeconomic viability of various farming practices. This allows decision makers to assess the environmental feasibility of adopting best-practice farming methods and planting high-yield crop varieties as farmers respond to challenges in their operational settings brought about by policy and institutional changes or anticipated climatic conditions.

Although farmers are the main managers of land and water resources, other parties, including local and national governments and nongovernmental agencies, influence their decisions. In general, these other stakeholders were represented as auxiliary modules, and the choices they make feed into the main RMU as exogenous factors. The impact of other groups was also incorporated by explicitly modeling their decision-making processes. For example, weir management committees are key decision-making units who determine rationing during periods of water shortage. Charges and fines are levied on households who do not obey these rules. Weir management committees are responsible for the repair and maintenance of the weir, for which they draw upon household labor. Households often contribute labor based on how much irrigated land they own or pay an equivalent quantity of cash. In some cases, the committees also negotiate with upstream committees. A weir allocation module was included in the DSS to mimic the current rules used for water allocation. DSS users are able to manipulate the allocation rules by changing policy scenarios. Government policies are also treated as scenarios within the DSS. To allow for differences in objectives, the economic efficiency of government policies was not evaluated at the outset, but this could be assessed later using the DSS.

The DSS is characterized by a highly intuitive user interface that allows decision makers to explore alternatives by changing the values and data in the model. The interface guides nontechnical users through the stages of accessing and manipulating data and developing and assessing scenarios. The DSS was designed to allow future users to identify information gaps, update information, and evaluate critical assumptions or uncertainties; it can also accommodate changes in information and assumptions as the ADMP takes the stakeholders through different stages of social learning. The aim is for researchers and users to be able to incorporate new data and collaboratively define new modeling requirements and refinements (Allen et al. 1996). The results can be summarized in tables, plotted, or collated into an exportable text file, depending on stakeholder needs.

Whereas there is no specific format for designing a user interface, the following principles were considered to be important:

- a format that the stakeholders are comfortable with,
- the availability of on-line help and tutorials,
- easy access to all components of the data and models,
- the ability to interface with other software,

- a format that allows for transfer between computers, and
- the provision of different ways to present the model outputs.

The interlinked models in the DSS were used to assess many management scenarios, and the results were presented to the key stakeholders at workshops. Topics covered included the implementation of forestry regulations, the introduction of crops through agricultural extension, the construction of facilities for storing water, and investment by households in more efficient irrigation systems. Scenarios were assessed using a range of indicators that captured the broad socioeconomic and biophysical processes. Indicators reported for these regions included water supply, water diversion, crop yields, and household performance. Household indicators included gross margins, income from cash crops, on- and off-farm income, and shadow prices of constraining resources. The results of various scenario analyses were presented to different stakeholder groups. The fourth phase of the project will be implemented in 2001–2002.

---

# CONCLUSION

Integrated natural resource management (INRM) that integrates multiple disciplines across spatial and temporal scales and involves stakeholders in key decisions will probably be more effective than the single-disciplinary management approaches of the past. However, for INRM to succeed in practice, it must focus on how people make decisions and how they interact with each other and with their natural environment.

First, all the stakeholders involved will probably have to change their behavior to allow for the planning, research, and implementation of management strategies across traditional and legislatively mandated roles and disciplinary biases. Second, constructivist philosophy should guide a dialectic decision-making process supported by rigorous individual or interdisciplinary research. Third, the specific problem should dictate the scale, scope, and disciplinary mix of the research, and the desired outcomes should be identified through participatory action research, which may require a spatial-analytical framework of hierarchical scales of analysis from local to global. Fourth, research should be integrative and synergistic, crossing disciplinary boundaries and bridging gaps in the perceptions, values, and perspectives of different stakeholders. Actions and policies should be developed in a participatory manner and implemented at different scales to bring about the outcomes that have been identified as desirable based on the decisions that stakeholders actually make in the field. These cycles of behavioral change followed by the search for appropriate management strategies then occur iteratively, with continuous adaptive learning as the cornerstone of the decision-making process.

Thus, the ADMP essentially consists of four cyclical, iterative phases, with each cycle facilitating the selection of more appropriate management strategies and helping to change the behavior of the stakeholders. Every cycle provides an opportunity for learning as long as the stakeholders adapt their decision-making processes to the results obtained. In such a process, researchers play a vital supporting role by using their analytical ability and theoretical understanding to aid in identifying useful questions and by using DSS-based interdisciplinary analysis to help stakeholders negotiate desired use and management strategies.

The ADMP is not easy, because conflicts are inevitable between stakeholders with different views about the nature of the problem, expected outcomes, the research and development strategies needed to achieve the outcome, and the scale. The two case studies presented here demonstrate that reaching a consensus is likely to require time, resources, and commitment on the part of the key stakeholders involved.

---

# RESPONSES TO THIS ARTICLE

## Acknowledgments:

*The origins of the ADMP framework can be found in the two-tiered, macro-environmental standards approach (MESA) adopted in Kosrae by Lal and described in an unpublished (1990) report that later formed the basis of Australian Centre for International Agricultural Research (ACIAR) projects on Integrated Water Resource Assessment and Management (IWRAM) in northern Thailand and the Fiji sugar project. Michelle Scoccimarro is part of the ACIAR Thai project research team, which includes Andrew Walker, Claude Dietrich, Pascal Perez, Sergei Schrieder, Tony Jakeman, and Nick Ardlie. The views and interpretation of the project are those of the authors and not necessarily those of the rest of the Thai project team. Finally, comments from two anonymous reviewers and the editor helped improve the paper, and their inputs are gratefully acknowledged.*


## LITERATURE CITED


**Allen, W. J., O. J. H. Bosch, R. G. Gibson, and A. J. Jopp.** 1996. Co-learning our way to sustainability: an integrated and community-based research approach to support natural resource management decision-making. Pages 51-59 *in* S.A. El-Swaify and D. S. Yakowitz. *Multiple objective decision making for land, water, and environmental management.* Lewis, Honolulu, Hawaii, USA.

**Antunes, P., and R. Santos.** 1999. Integrated environmental management of the oceans. *Ecological Economics* **31**(2):215-226.

**Bellamy, J. A., and A. K. L. Johnson.** 2000. Integrated resource management: moving from rhetoric to practice in Australian agriculture. *Environmental Management* **25**(3):265-280.

**Blaikie, N.** 2000. *Designing social science research.* Policy Press, Cambridge, UK.

**Born, S. M., and R. D. Margerum.** 1993. *Integrated environmental management: improving the practice in Wisconsin; University of Wisconsin-Madison report by the Department of Urban and Regional Planning for the Wisconsin Department of Natural Resources.* University of Wisconsin-Madison, Madison, Wisconsin, USA.

**Born, S. M., and W. C. Sonzogni.** 1995. Integrated environmental management: strengthening the conceptualization. *Environmental Management* **19**(2):167-181.

**Buckles, D., and Rusnak, G.** 2000. Conflict and collaboration in natural resource management. Pages 1-10 *in* D. Buckles, editor. *Cultivating peace: conflict and collaboration in natural resource management.* International Development Research Centre, Ottawa, Ontario, Canada, and World Bank Institute, Washington, D.C., USA.

**Cairns, J., Jr., editor.** 1991. *The need for integrated environmental systems management: integrated environmental management.* Lewis, Chelsea, Michigan, USA.

**Chamala, S., and K. Keith.** 1994. *Participative approaches for landcare.* Australian Academic Press, Brisbane, Australia.

**Cicin-Sain, B.** 1993. Integrated coastal management. *Ocean and Coastal Management* **21** (Special Issue):376.

**Cornwall, A., and R. Jewkes.** 1995. What is particpatory research? *Social Science and Medicine* **41**(12):1667-1676.

**Costanza, R., F. Andrade, P. Antunes, M. Belt, D. Boesch, D. Boersma, F. Catarino, S. Hanna, K. Limburg, B. Low, M. Molitor, J. G. Pereira, S. Rayner, R. Santos, J. Wilson, and M. Young.** 1999.

Ecological economics and sustainable governance of the oceans. *Ecological Economics* **31**(2):171-187.

**Dixon, J. A., and K. W. Easter.** 1986. Integrated watershed management: an approach to resource management. Pages 3-15 *in* K. W. Easter, J. A. Dixon, and M. M. Hufschmidt, editors. *Watershed resources management: an integrated framework with studies from Asia and the Pacific.* Studies in Water Policy and Management Number 10. Westview Press, Boulder, Colorado, USA.

**Dover, S.** 1999. Public policy and institutional R&D for natural resource management: issues and directions for Land and Water Resources Research and Development Council. Pages 78-107 *in* C. Mobbs and S. Dover, editors. *Social, economic, legal, policy and institutional R & D for natural resource management: issues and directions for LWRRDC.* Land and Water Resources Research and Development Council, Canberra, Australia.

**Downs, P., and K. Gregory.** 1991. How integrated is river basin management? *Environmental Management* **15** (3):299-309.

**Guba, E. G.** 1990. The alternative paradigm dialog. Pages 17-27 *in* E. G. Guba, editor. *The paradigm dialog.* Sage, London, UK.

**Gunderson, L. H., C. S. Holling, and S. S. Light, editors.** 1995. *Barriers and bridges to the renewal of ecosystems and institutions.* Columbia University Press, New York, New York, USA.

**Holling, C. S., F. Berkes, and C. Folke.** 1998. Science, sustainability and resource management: linking social and ecological systems, management practices and social mechanisms for building resilience. Pages 342-362 *in* F. Berkes and C. Folke, editors. *Linking social and ecological systems.* Cambridge University Press, Cambridge, UK.

**Janssen, W., and P. Goldsworthy.** 1996. Multidisciplinary research for natural resource management: conceptual and practical implications. *Agricultural Systems* **51**:259-279.

**Kersten, G., Z. Mikolajuk, and A. Gar-On Yeh.** 2000. *Decision support systems for sustainable development.* International Development Research Centre, Ottawa, Ontario, Canada, and Kluwer Academic, Dordrecht, The Netherlands.

**Kuhn, T. S.** 1970. *The structure of scientific revolution.* Second edition, enlarged. University of Chicago Press, Chicago, Illinois, USA.

**Lee, K. N.** 1999. Appraising adaptive management. *Conservation Ecology* **3**(2):3. Available online at http://www.consecol.org/vol3/iss2/art3.

**Margerum, R. D., and S. M. Born.** 1995. Integrated environmental management: moving from theory to practice. *Journal of Environmental Planning and Management* **38**(3):371-391.

**May, P.** 1992. Policy learning and policy failure. *Journal of Public Policy* **12**:331-354.

**Okali, C., J. Sumberg, and J. Farrignton, J.** 1994. *Farmer participatory research: rhetoric and reality.* Intermediate Technology, London, UK.

**Panayotou, T.** 1998. *Instruments of change: motivating and financing sustainable development.* Earthscan, London, UK.

**Resource Assessment Commission.** 1993. *Integrated resource management in Australia.* Australian Government Publishing Service, Canberra, Australia.

**Rittel, H. W. J., and M. M. Webber.** 1973. Dilemmas in a general theory of planning. *Policy Sciences* **4**(2):155-169.

**Tacconi, L.** 2000. *Biodiversity and ecological economics: participation, values and resource management.* Earthscan, London, UK.

**Tanabe, S.** 1994. *Ecology and practical technology: peasant farming systems in Thailand.* White Lotus, Bangkok, Thailand.

**Walker, A., and M. Scoccimarro.** 1999. *A resources management unit (RMU) approach to catchment analysis in northern Thailand.* ICAM Working Paper 1999/2. Australian National University Press, Canberra, Australia.

---

**Address of Correspondent:**
Padma Lal
National Centre for Development Studies
Australian National University
P.O. Box 4
Canberra, Australia 0200
Phone: 61 02 6125 0093
Fax: 61 02 6125 8448
padma.lal@anu.edu.au

---