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Decision frameworks:
Assessment of the social aspects of decision frameworks and development of a conceptual model

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DECISION FRAMEWORKS:
Assessment of the Social Aspects of Decision Frameworks & Development of a Conceptual Model

COASTAL CRC

Discussion Paper - 2005

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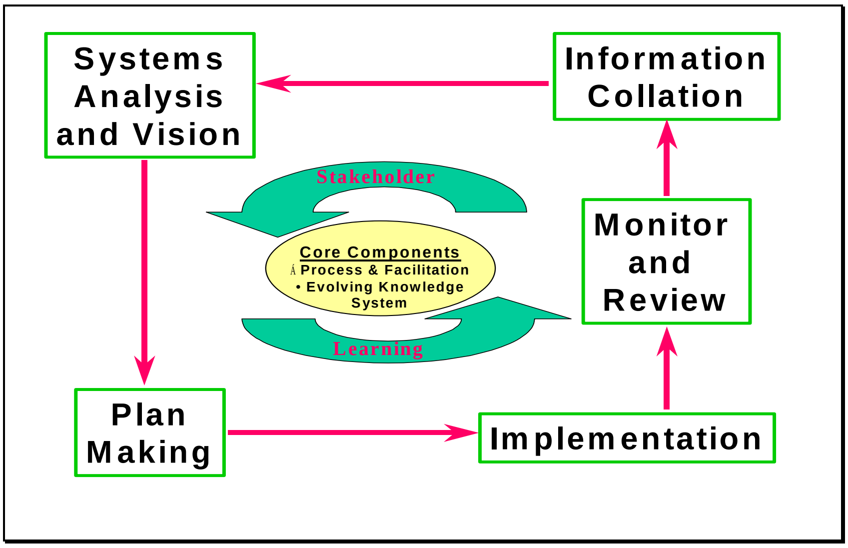

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Executive Summary

Decision frameworks offer a means of facilitating coastal zone decision-making through the integration of ecological, social, economic, cultural and legal aspects. The purpose of this discussion paper was to identify from the decision tool literature the major ways in which social data and questions have been incorporated within decision tools, and how decision frameworks accommodate and support participatory involvement in decision-making. While there is nothing intrinsic to most decision tools to preclude better consideration of the social, as with most areas of natural resource management and decision-making, there is considerably more rhetoric in relation to dealing more adequately with social questions than there are sophisticated attempts to do so.

A review of published literature on the participatory application of decision tools suggests:

- limited attention to 'invisible outcomes' such as stakeholder commitment and capacity building;
- insufficient attention to the facilitation of group decision-making;
- better models are produced by the inclusion of subjective and objective sources of knowledge;
- a tendency to equate participation with quantified data collection; and,
- the importance of negotiation and consensus seeking approaches.

Similar examination of literature on the incorporation of social data within decision frameworks suggests:

- a tendency of studies to privilege the economic and ecological;
- frequent limitation of social data to the stated preferences of those directly involved in the application of the decision tool or to quantitative data;
- limited consideration of the distribution of costs and benefits across the community;
- potential to aggregate individual preferences into outcomes that are unrepresentative or which disadvantage particular stakeholder groups; and,
- difficulty generally dealing with uncertainty.

The difficulties encountered by practitioners in the use of social data in decision frameworks which have been identified by this study is partially due to the problem of defining the causal and conceptual relationships between social, economic and biophysical data sets at a variety of decision-making scales. Conceptual models such as Adaptive Management and Pressure-State-Impact-Response modelling offer opportunities to integrate social data collection with biophysical and economic data collection through processes of social learning.

Introduction

Lack of integration, duplicated effort, poor public participation, stakeholder conflict, under-utilised data, information overload, contradictory research results and institutional inertia are too frequently the focus of complaints regarding natural resource management. Regardless of the extent to which such complaints are justified in any given situation, dealing with the potential for them to arise absorbs considerable resources and intellectual energy. It is within this context that decision frameworks, tools and conceptual models of a number of kinds are proposed as vehicles to deal rationally with the plethora of issues, interests and data sources confronting resource managers. Although such terms often are used interchangeably, for the sake of consistency we will define, in this paper:

- **decision tools** as specific methods and techniques for the organisation and interrogation of data in support of planning and decision-making. Examples of most relevance here include Decision Support Systems/Multi-Objective Decision Support Systems (DSS/MODSS), Geographic, or Spatial, Information Systems (GIS/SIS), Expert Systems and Scenario Modelling;
- **conceptual models** as systematic attempts to describe and theorise the nature of relationships between component parts of a particular decision type, process or environment. Conceptual models may, or may not, be implicit within specific decision tools; and,
- **decision frameworks** as the complexes of tools, conceptual models and institutional arrangements found, or proposed, within specific planning and decision-making situations.

Thus, while there is some overlap between the concepts of decision tools, conceptual models and decision frameworks, in broad terms they may be seen to deal respectively with technique, explanation and application.

The main foci of this discussion paper are decision tools and the conceptual models that underpin their application in support of specific decision frameworks and situations. The question we are concerned with in relation to such tools is how adequately they deal with the social dimensions of natural resource management. These social dimensions may themselves be conceptualised in a number of ways, but for convenience sake they are dealt with here in terms of both:

- **content**—the ability of decision tools to incorporate social data (both quantitative and qualitative), address social issues and promote socially ascribed values; and,
- **process**—the ability of decision frameworks to support decision-making processes that promote socially desirable resource management outcomes including equity, participation and social learning.

The manner in which decisions are made—and the perceived fairness of that process—has been found by Syme et al. (1999) to be at least as important to their success as the seemingly more concrete outcomes of decision-making. Neglecting to address social issues and incorporate a diverse range of knowledge and values in natural resource decision-making—deliberately or otherwise—frequently is responsible for policy failure (Dryzek 1990). Enhancing public participation in negotiation and decision-making offers opportunities to improve environmental decision-making by:

- enhancing access to **local knowledge** of environments and communities, and how they are likely to respond to change;
- improving **communication** among groups of stakeholders;
- increasing the **responsiveness** of communities and resource management agencies to changing environmental circumstances;
- supporting the **democratic** rights of people to participate in decisions that affect their lives;
- **reducing conflict** and polarisation over management goals and actions; and
- **increasing commitment** to agreed courses of action (Dryzek 1990; Batenburg and Bongers 2001).

Conflicting interests and contradictory aims, values and aspirations among stakeholders do not exclude the possibility of shared understanding of appropriate decision-making rules and, consequently, acceptance of jointly negotiated decisions as fair and just.

This paper thus reviews existing literature on the application of decision tools to natural resource management, ecosystem management, and coastal zone management in relation to how social data is incorporated within the application of such tools and how they are utilised to support participatory approaches to natural resource management. It is important to stress that this review is focussed primarily on the application of decision tools and rather less on the technical capacity of these tools to assimilate data of different kinds. In other words, it is widely accepted that MODSS, GIS and other tools can incorporate social, economic and biophysical data. The question is, how do we conceptualise the relationships between these kinds of data such that the tools may be applied in a rigorous and rational manner in support of better social and environmental outcomes?

In order to evaluate how well decision tools address and incorporate social issues, and how this might be improved, a comprehensive review was conducted of published materials available through scientific indexing services. Keyword searches were conducted on all databases available through the Central Queensland University library utilising the search parameters: social *and* decision tools, social *and* decision frameworks, social *and* Decision Support Systems, and so on. A comprehensive annotated bibliography based on these searches was compiled (available via the Coastal CRC website at **www.coastal.crc.org.au**) to supplement the smaller subset of references used within this discussion paper.

Box 1: Widely used decision tools: some definitions

MODSS: Multiple Objective Decision Support System, or Multiple Criteria Analysis (MCA), provide a decision-making approach for complex natural resource management problems by identifying management options or options that best satisfies the interests of affected stakeholders (Robinson 2002). This approach is viewed positively because it facilitates information integration from multiples disciplines, improves communication between stakeholder groups in conflict situations, and builds a better understanding of the problem and options for greater acceptance and compliance (Robinson 2002).

GIS: A Geographical Information Systems is designed to collect and store spatially referenced data and information, and provide sophisticated mapping and display facilities, particularly where geographic location is important or a feature of the analysis (Fabbri 1998). Many contemporary GISs come with built-in analysis tools in addition to their data storage, manipulation and representation tools. GIS can be used as a spatial assessment method for improving resource management and conservation, and is commonly used in land-use planning in human-relevant ecosystems (Webb and Thiha 2002). GIS underpin many of the decision support technologies for catchment scale management (Walker et al. 2001) and the development of land-use suitability models (c.f. Zhu et al. 1998).

Expert systems: A type of decision support system incorporating expert knowledge to aid the understanding and processing of complex information to support the process of decision-making. This system allows easy retrieval of that archived expert knowledge from a database to support decisions by non-experts (Zhu et al. 1998; Crist et al. 2000).

Scenario Modelling/Planning: Scenario planning is a widely accepted management tool for decision support in identifying plausible futures (Daud Ahmed et al. 2003). It is a group decision support method used to facilitate participation in resource management. This tool allows people to model alternative uses for a resource, and then visualise and measure the economic, environmental and social impacts of each alternative. A scenario-driven decision support system is defined as "an interactive computer-based system, which integrates diverse data, models and solvers to explore decision scenarios for supporting the decision makers in solving problems" (Daud Ahmed et al. 2003, p. 2).

Analytic Hierarchy Process: A flexible decision making process to help decision-makers set priorities and make the best decision when both qualitative and quantitative aspects of a decision need to be considered. This decision tool is well suited to management decisions involving multiple conflicting objectives and human judgements (Srdjevic et al. 2002). The best decisions are determined using clear rationale and a process that reduces complex decisions to a series of one-on-one comparisons, then synthesises the results. It is a systematic method that facilitates the identification of trade-offs among social, economic and environmental issues for each alternate management plan. The approach makes explicit value judgements, integrates the values of decision-makers and public opinion, and incorporates policy and management goals with technical information (Zhu and Dale 2001).

Background: Decision Framework and Citizen Science Research in the Coastal CRC

The Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management (Coastal CRC) was established in 1999 with the goal of delivering decision-making tools, understanding and knowledge necessary for the effective planning, management and ecosystem health of coastal zones, estuaries and waterways. With a mission to ‘bridge the gaps, between science, policy making and society, the Coastal CRC established key research themes in Decision Frameworks, Citizen Science, Management and Restoration, Ecosystem Processes and Assessment and Monitoring.

The Decision Frameworks theme within the Coastal CRC assumed primary responsibility for the development of multi-objective decision-making frameworks and tools to support planning, conflict resolution, scenario development and impact assessment. In order to facilitate better integration of these tools with the other research themes and activities within the CRC the Decision Frameworks theme developed a conceptual framework based on the principle of adaptive management to inform the second phase of CRC research from 2004–2006. Adaptive management refers to an iterative process of designing and implementing management strategies, and thence revising those strategies, on the basis of learning acquired through testing, monitoring and evaluation. By treating management interventions as tools for learning, adaptive management is particularly useful in situations of scientific uncertainty as it affords opportunities to respond incrementally to changing knowledge and societal needs.

The Citizen Science theme within the Coastal CRC has been concerned primarily with the development of participatory approaches to research, planning and decision-making relevant to government, industry and community groups. It also has been involved in benchmarking community values and aspirations, evaluating communications strategies and capacity building. The emphasis placed within these activities on the synthesis of scientific, local and indigenous knowledges establishes intuitively clear overlaps and synergies with the work of the Decision Frameworks theme.

This paper reflects the need to look more closely at how decision tools might interact with and promote social goals and research within natural resource management. Its relevance extends beyond the Coastal CRC with social considerations increasingly seen both as necessary prerequisites for sustainable natural resource management and, in and of themselves, as legitimate management goals (Lockie and Jennings 2003). Thus, while this review was undertaken with the rather pragmatic goal of informing Citizen Science research within the Coastal CRC, its discussion is likely to be of relevance and interest to catchment groups, government agencies, and others involved in the complex decision processes of natural resource management. In this context, it is important to reiterate that the paper does not deal comprehensively with the technical details of decision tool construction or application. Nor does it deal comprehensively with the adequacy of existing applications in incorporating biophysical or economic data. Readers are referred elsewhere for material on these issues.

Review of the Use of Decision Tools

Difficult decisions face governments and communities as environmental problems of land degradation, water pollution and resource competition increase. Decision-making is becoming increasingly complex as decision-makers seek to deal with uncertainty, a variety of information forms, and outcomes that have long-term effects. Decision tools provide decision-makers with opportunities to systematically process information, explore and improve their understanding of management options, improve the transparency and reproducibility of decisions, engage stakeholders, identify gaps, and thus assist in the management of natural resources.

Decision Tool Characteristics

Decision tools exist frequently as computer-based applications for use in planning, management, monitoring, evaluation and other aspects of the decision-making process. They are capable, to varying degrees, of incorporating multiple objectives and views, covering multi-disciplinary subject areas, and dealing with incomplete data and information. As such, decision tools function to assist decision-makers to efficiently and effectively utilise data, information and knowledge, and thence to apply them to particular problem areas (Zhu and Dale 2000). Apart from the storage and organisation of data, decision tools are valued often for their modelling and simulation features.

A range of decision tools developed in the environmental and natural resource management area to assist decision-making are listed in Box 1. These predominantly focus on integrating expert systems, spatial information management, and the management of spatial units for strategic land use planning (see also Loh and Rykil 1992; Nijkamp and Scholten 1993; Fedra 1995; Bellamy et al. 1996). Frequently, decision frameworks act as information systems and decision analysis tools and, amongst other functions, provide statistics and identify risks and uncertainty.

Decision tool applications may be found across numerous discipline and research areas. Some of the more common areas of application include water resources, oceanography, climate and atmosphere, global change, ecology, agriculture, forestry and fisheries, business and tourism, demography, econometrics, and economics. Decision tools have been shown to deliver benefits to industry, mining, public health, medicine, and epidemiology. In the natural resource management field there is an expanding use of decision frameworks to support ecological monitoring and modelling (Gunn et al. 1999; Wirtz 2001; Matejicek et al. 2002; Munier et al. 2002; Tremblay et al. 2004). In the coastal zone environment, spatial decision tools have been particularly popular as means to promote consistent decision-making, evaluation of coastal development alternatives, and to ensure ecological sustainability (Fabbri 1998; de Kok et al. 2001; Westmacott 2001; Chang and Chang 2002; Maksimovic and Makropoulos 2002; Brody et al. 2004). However, to achieve a sustainable coastal zone environment and management of resources, Fabbri (1998) argues that their remains a need to better understand the inter-relationships between natural and socio-economic variables.

A valuable feature of some decision tools is their ability to present complex information to non-technical decision-makers (e.g. community) in a simple way for interpretation and understanding. Applied in this manner, decision tools may provide a platform for collaborative learning between scientists and local community experts (c.f. use by McCown (2002) in agricultural systems). An example shown by Carberry et al. (2002) used a participatory research approach to test a decision support tool that guides science-based engagement with farm decision making. However, a problem encountered and reported by Helly et al. (2001) in their study of collaborative management of natural resources in San Diego Bay, was the presence of socio-political factors overriding the benefits of decision tools. Researchers referred to this as the 'ambiguity-of-ignorance syndrome of groups', where in some cases the information limits flexibility in negation and there is a strong disincentive to using the measured data. Computing and information technologies used by decision tools must be applied in situations in which decision-makers desire information products and used in a neutral and objective forum (Helly et al. 2001).

Decision Tool Applications

While decision tools also may usefully be applied at a variety of scales (Gauthier and Neel 1996), in practice, their application to natural resource management in Australia has been predominantly at the regional scale in support of processes such as Integrated Catchment Management (ICM). This is not surprising given the need for support in understanding and modelling complex problems surrounding regional resource use, planning, and management. The application of decision frameworks at the regional, or catchment, scale is especially useful when planning is faced with dilemmas such as finding a compromise between land use and conservation (c.f. Zhu and Dale 2000). The complexity of decision-making at this scale is reflected in an extensive list of requirements for the decision-making environment generated by Westmacott (2001)(see Box 2). However, while Westmacott's list gives consideration to institutional capacity and cooperation amongst stakeholder groups, absent from the list is consideration of social processes, and the availability of information on social aspects and impacts. In the ICM environment, the decision framework needs to incorporate the multiple objectives and views of the different stakeholders (Westmacott 2001).

Box 2: Westmacott's list of requirements for effective ICM decision-making

Education level: a broad understanding of multiple subjects

Analytical capacity: ability to analyse economic-ecological interactions

Institutional capacity: experts, negotiators and managers from all stakeholder groups to help towards developing a balanced management plan

Cooperation: cooperation between multiple stakeholder groups with differing views and objectives

Communication: active communication between multiple stakeholder groups

Financial resources: adequate finances for both development as well as conservation

Financial resources for development of alternative activities

Awareness: awareness of the impacts human activities have on the environment and the impact environmental degradation has on human welfare and the economy

Information: available data on both the economy, ecology and their impacts on one another
(taken from Westmacott 2001)

Within the context of their regional application, use of decision tools in environmental planning and management in Australia has focussed three main activities. These include:

1. *Evaluation and risk assessment:* providing a methodological framework for spatial planning and integration of multiple objectives and criteria in order to, for example, assess land suitability for specific human activities.
2. *Knowledge and information management:* at an organisational level of management, providing geographical information systems, systems analysis and integration of different information systems, rationalisation of decisions, and a knowledge elicitation tool similar to the adaptive environmental assessment and monitoring approach (AEAM).
3. *Group decision-making and decision support:* providing decision support and facilitating multi-criteria decision-making using processes such as Analytical Hierarchy Process (AHP)(Saaty 1980; 1993). Research from an organisational behaviour perspective has examined the advantages and disadvantages of this tool in terms of effect of group support systems on anonymity, locus of control, minority influence, group communication and leadership, social processes and psychological effects (McLeod et al. 1997; Blanning and Reinig 1999; Huang and Wei 2000; Batenburg and Bongers 2001; Geurts and Joldersma 2001).

From a social perspective, according to Westmacott (2001), decision tools have been assigned three key roles:

1. *Accessing a wider range of data:* decision tools have provided mechanisms to facilitate the collation and synthesis of data and information from a variety of groups who may not otherwise have shared their information.
2. *Public education:* decision tools have been used to highlight the interactions and impacts between different coastal activities and environments.
3. *Deliberation and participation:* decision tools have provided a facilitative role for interaction and negotiation between stakeholder groups by focusing discussion on the variables informing decisions and their interactions. The participation of stakeholders thus enables the setting of parameters for Multi-Criteria decision frameworks while, iteratively application of such frameworks supports greater stakeholder participation.

However, the inclusion of social data within applications of specific decision-tools is, in practice, limited, especially in terms of decision tools that incorporate ecosystem data such as spatial information systems. Consideration of the processes of social learning and/or conflict resolution is similarly limited, a situation that is likely to contribute to dominance of decision-making processes by those with existing access to scientific expertise. In the absence of concrete strategies to incorporate social data and provide mechanisms for participation, the result of decision-making processes is likely to be ‘outcomes that are neither fair nor efficient and that reflect the values and interests of certain stakeholders more than others, even in the absence of overt conflict’ (Pelletier et al. 1999).

Taking an alternative approach that is inclusive and pluralist ‘by design’ (Holberg 1992, cited in Overdevest 2000) requires the development of decision frameworks that enhance the capacity of all stakeholders to contribute in a manner that allows decisions to be based solely on the strength of argument rather than on access to resources and articulate spokespeople. Such capacity is dynamic and multi-dimensional; incorporating technical, financial, institutional, social and political aspects (De Leo et al. 2002). Attempts to build capacity and improve decision-making must, therefore, recognise that different competencies are relevant in different circumstances and that it is not always currently marginalised stakeholders whose competence is limited. Nevertheless, as the following sections will demonstrate, there is considerable unrealised potential among decision frameworks to enhance the quality of public participation and decision-making.

Participatory Applications of Decision Tools

Widespread participation in decision-making is not in itself sufficient to ensure that fair and rational natural resource management outcomes are achieved. Planning for natural resource use and management is often not effective in reaching and implementing binding agreements between stakeholders or in managing conflicts (Zhu and Dale 2000). This does not necessarily reflect a lack of good will on the part of participants. Drawing on the experiences of Australian Indigenous communities, O'Faircheallaigh (1999), for example, argues that participation easily is undermined by:

- weak connections between involvement in participatory processes and the authority and resources actually to make, approve and implement decisions;
- failure of decision-making processes to acknowledge community values, knowledge and traditional rights;
- insufficient resources and experience of decision-making processes among community members to participate effectively; and,
- the fragmentation of planning and decision-making into a multitude of individual projects with little consideration of the spatial or temporal accumulation of impacts or the demands that multiple decision processes place on stakeholders.

It is widely acknowledged within the decision frameworks literature that tools must facilitate negotiation and consensus seeking if they are to meet the needs of multiple user groups and attain public support for their use and for the outcomes produced. However, few papers outline specific facilitation techniques and even fewer give emphasis to what Geurts and Joldersma (2001) refer to as the 'invisible outcomes' of increased understanding, consensus and commitment to decision framework results. Often, participation is equated with social data collection through the use of surveys and interviewing. Some of the ways in which participation may be incorporated within specific tools, despite this neglect, include:

- **Analytical Multiple Criteria Analysis** tools (e.g. Analytical Hierarchy Process, weighted summation) are used to evaluate and prioritise resource use options and to allocate resources (Zhu and Dale 2000). These tools have also been widely applied in land use decision-making (c.f. (Bantayan and Bishop 1998). Facilitated participation in this process encourages among stakeholders the integration and building of joint problem representations (Zhu and Dale 2000). Use of the WWW environment user interface by Zhu and Dale (2001) avoided system compatibility problems and provides an easy way for a number of decision-makers from different geographical locations to share information, understand other decision-makers' positions and identify conflicts for collaborative decision-making.
- **Electronic meeting systems** support group meetings through a facilitated process which enable electronic brainstorming, structuring of generated ideas and parallel communication. This electronic exchange of information also allows normal conservation to take place (c.f. Geurts and Joldersma 2001). Electronic meeting systems offer participants the opportunity to engage in negotiation with others while maintaining anonymity and encouraging frank and open comment on the goals and strategies of other stakeholders. This is likely to be particularly advantageous where stakeholders have good reason to believe they may suffer negative sanctions if seen to be publicly critical of others.

- **Group decision frameworks** are a particular type of Multiple Criteria Analysis that focuses on the integration of subjective and objective sources of knowledge from a variety of stakeholders. Scientific insights are combined with subjective knowledge resources, with the bonus of improved communication between those stakeholders involved and creating a basis for collaborative problem solving that addresses the social, ecological and economic aspects of a decision situation. Greater emphasis is placed on interaction and participation between citizens and decision-makers in policy-making processes by designing policy-analytical forums with government employees available for consultation, and facilitating and supporting debate (Batenburg and Bongers 2001). Most approaches employ process facilitators to actively stimulate open discussion amongst participants.

Box 3. Group Decision Support Systems in practice

Guerts and Joldersma (2001) utilise group decision support systems (GDSS) to provide participatory methods that allow: (1) participation among the relevant stakeholders; (2) facilitation of communication to take into account stakeholder and expert judgements; (3) inclusion and integration of social data from experts and stakeholders with scientific data; and (4) a process for step-by-step learning. They applied three participatory policy analytic methods of gaming/simulation, consensus conference and electronic meeting system to complex, ill-structured policy problems. The participatory policy analytic methods included:

Gaming/simulation focused on a better understanding of the policy issue using role-playing and the interaction of stakeholders in a simulated environment. When this method was applied to a regional scale service delivery issue for a specific community, it allowed insight into available options and dealt with the consequences of proposed government policy. The game provided an adequate representation of reality, increased their insights into societal developments and generated valuable options for policy. The method used focused more on the social interaction between participants and less on satisfying analytic criteria. As a result most participants learned about the interests, strategies and visions of the other participants.

Consensus conference sought a consensus on a policy issue by reinforcing the influence of informed citizens. The method engaged the active participation of citizens and experts in debates on controversial and complex societal problems. Often applied to medical issues or ethical or political concerns, the conference facilitates communication and the integration of scientific data, and the judgement of experts and stakeholders. The outcomes of the process was a more supportive and better informed citizen panel, development of a high level of consensus and greater levels of knowledge and insight into the subject.

Electronic meeting systems used computer assistance to gather exchange and structure the information of stakeholders. In the past this participatory methods has been applied to such issues as disputes over technology use. Past studies have found this method supports information gathering and exchange rather than interaction. Interestingly, anonymity and parallel communication were not as highly valued in reality as initially theorised. The outcome suggests the method is an effective tool for generating multi-disciplinary discussions, promoting learning and the participation of relevant stakeholders, but is weak at providing insight into individual viewpoints.

The use of facilitation of group decision-making has many recognised benefits (Allen and Kilvington 1999; Batenburg and Bongers 2001; Geurts and Joldersma 2001; Lawrence et al. 2001). Developing a supportive environment for wider learning amongst stakeholders is crucial, and it requires process outcomes (creating the conditions for participation) and task outcomes (getting information flows in place on-the-ground) that are supported by facilitation (Allen 2001). It is through the process of facilitation that “participants build trust to enhance communication, articulate aspirations, and become accepting of a different point of view” (Lawrence et al. 2001). Further papers supporting the use of facilitation can be found at: www.coastal.crc.org/modss/conference99.

Drawing on those examples that can be found within the literature, it is possible to suggest a number of principles for the promotion and use of stakeholder participation through decision tools such as those described. These include:

- **Ensuring outcomes—**public support comes from producing desirable results that are representative of participants' views and interests (Zhu and Dale 2000).
- **Accessibility—**decision tools must be applied in a manner that is, 'acceptable and friendly to the end users' (Zhu and Dale 2000 p. 372). In the case of computerised tools, graphical interfaces may assist non-technical participants to understand the process and travel through the decision-making.
- **Equity—**decision tools must be available to all stakeholder groups potentially affected by a decision (Zhu and Dale 2000).
- **Resourcing and capacity building—**those groups must be provided also, where necessary, with the resources and expertise to access tools and the social, economic, and environmental information they embody.
- **Transparency—**the processes through which decision tool inputs (data, values etc) are translated into models, recommendations, and so on must be explicit in order to build acceptance of outcomes and understanding of resource management systems and interactions (Fabbri 1998).
- **Social learning—**the process of model development and revision offers as much potential for learning among stakeholders as the application of completed models to test scenarios, compare alternatives, and so on. Model building may be used to encourage group discussions that support strategic thinking, the structuring of knowledge and the integration of ideas and perceptions (Batenburg and Bongers 2001; Geurts and Joldersma 2001). This process facilitation has been found in some studies to have more influence on group processes and outcomes than the actual use of a computerised group support system (Batenburg and Bongers 2001).
- **Acknowledging uncertainty—**if models are to be widely used and accepted they must not only involve stakeholders and potential users, they must utilise the knowledge of these stakeholders and recognise the influence of uncertainty in technical knowledge (Argent et al. 1999 p. 693).
- **Conflict resolution—**as long as people have differing values, experiences and interests, the provision of information will by itself be insufficient to resolve resource use conflicts (Bellmann 2000). Decision tools must be used not just to arrive at answers but to encourage understanding of alternative perspectives.
- **Proactive facilitation—**as suggested above, conflict is not necessarily irrational. Utilising decision tools to move beyond conflicts of interest requires proactive facilitation to develop shared visions, expectations, commitment and 'rules of the game'. Some decision tools are intrinsically better than others in encouraging participation and integrating different sources of data (Geurts and Joldersma 2001), but the quality of facilitation is also a significant determinant of success (Batenburg and Bongers 2001).

- **Purposefulness—**if a group commencing a decision making process can not define clearly the issues to be resolved (or planning opportunity) beyond a general objective, then it is prone to being a waste of time for those involved. It is essential for all representative stakeholders to state their purposes for being involved in the process.
- **Personalisation—**collaboration is enhanced when individual stakeholders' own worldviews and 'mental models' of the decision environment are acknowledged and shared (Geurts and Joldersma 2001).
- **Communication and integration—**decision frameworks rely often on the joining together of several individual disciplinary models (e.g. river flow, economic, social). For this to be successful, attention is required to the technical details of interactions between system components, the connections between different datasets (esp. spatial and temporal discontinuities), and the processes of developing an integrated model (Argent et al. 1999). The basis for development of multidisciplinary models involves social interactions between and among scientists and stakeholders, and the facilitation of information sharing processes (Geurts and Joldersma 2001).
- **Data quality—**whether qualitative or quantitative, 'junk in, junk out'.

Incorporation of Social Data within Decision Tools

There is nothing intrinsic to any of the decision tools mentioned throughout this paper that would exclude entirely the incorporation of social data. Such social data might take numerous forms, some quantified and some not. More common forms of quantitative social data include:

- Demographic data relating to population composition and characteristics (e.g. age and gender profile, ethnic composition, education, employment and income levels, etc).
- Attitudinal data reflecting peoples' predispositions consistently to express particular views in relation to pre-defined issues such as the importance of environmental issues.
- Behavioural data relating to, for example, social interaction, voting patterns, health behaviours, environmental practices, and so on.
- Population health and epidemiological data such as mortality and morbidity rates, exposure to environmental health hazards, and so on.

Indeed, almost any aspect of human thought, interaction and behaviour that may be defined with a high level of specificity may be measured and quantified given sufficient resources and expertise. In many cases, however, quantification either is impractical, unnecessary or invalid. Less easily quantified social data include the ways in which people conceptualise the relationships between complex social and environmental problems, the thinking that underlies stated attitudes and priorities, and so on. While methods exist to collect and analyse qualitative data in a rigorous and systematic manner, consideration must also be given to the processes of social learning and change potentially involved in natural resource management and the potential of social science research to support this (Dale and Lane 1994; Lockie 2001).

Examination of the decision tool literature reveals a preponderance for analysis to focus on the economic and ecological to the exclusion of social analysis. Further, despite the recognition described in the previous section that stakeholder participation is important to ensure end-user support of decision tools and outcomes (Argent et al. 1999; Westmacott 2001), it often is the case that little social data is used to inform group decision frameworks beyond the stated preferences of those directly involved (Bantayan and Bishop 1998). According to Zhu and Dale (2000), this tends to promote a technical view of natural resource management issues that ignores equity considerations such as the distribution of costs and benefits and other human welfare implications of natural resource management. Economic activities and associated indicators—such as gross regional product, employment levels, industry output etc—often are used as indicators of general community well-being (Beckley et al. 2002). More recently, the use of community well-being indicators has been expanded to include measures of human well-being beyond traditional economic indicators (Gahin and Paterson 2001; Beckley et al. 2002).

Nevertheless, as stated above there is nothing intrinsic about decision tools to exclude social data. Examples of tool application that has included social data include:

- Recently Webb and Thiha (2002) showed improved land use planning by integrating spatial sets of social and economic data into a GIS. An integrated GIS approach using biophysical data, perceptions and preferences of communities (social suitability), and quantitative social and economic data was found to have benefits over the traditional method of considering only biophysical spatial data. Webb and Thiha (2002) also highlight the value of improving decision framework tools by integrating spatial sets of socio-economic data. When an integrated GIS approach is taken incorporating the perceptions and preferences of local communities (social suitability) and quantitative socio-economic data, the results produced were positive. Outcomes led to higher levels of community acceptance and social capital because social preferences were taken into account.
- To restore degraded landscapes and improve current economic and social conditions Bellmann (2000) developed and applied a decision framework to conduct a comprehensive analysis of the whole regional system (landscape, ecological and hydrological components linked with the economic and socio-economic components) (see Box 4). Socio-economic data (unemployment, emigration, population density) was used to understand the key causal relations between the integrated economic/socio-economic/ecological systems. The overall effect produces dependencies between the dynamic processes of all the system components. Simply, the use of social data needs to be linked to other system

components to ensure the structuring of that problem and generation of alternatives are reliable.

- Multiple objective decision support system (MODSS) process models are able to incorporate stakeholder preferences and support the judgement of individuals and groups in decision-making processes (Robinson et al. 2000). In the application of decision frameworks the advantage and preference given to multi-criteria analysis over cost-benefit analysis for evaluating alternatives, is the ability to deal with qualitative multidimensional effects of decisions (Fabbri 1998). Recent trends support the application of multiple objective or multiple criteria techniques due to the emphasis on the process of decision-making, as opposed to getting to an end decision (Robinson et al. 2000).
- Decision framework models developed for practical Integrated Coastal Management application have used stakeholder interviews and consultations to gather data to build models reflecting the concerns and interests of the coastal communities (Westmacott 2001). The final model may consist of several sub-models of the different systems (economic, ecological, and biophysical) that are then integrated through a social process of interpretation. The social aspect is fulfilled through the use of this facilitatory social process, which attempts to capture the social impacts, issues and attributes of all affected stakeholders in a geographically small local area.
- The Screening, Scoping, Scanning (SSS) methodology for integrated coastal zone management presented by Fabbri (1998) gathers social data in a scoping phase to define the problems and objectives from a stakeholder perspective and to elicit views to sustainable development. Social and economic indicators used with environmental indicators assess alternatives generated in the scoping phase, at which time conflict analysis is used to determine the political feasibility of the best development strategies identified. Importantly, the social and economic data is used to describe the environmental quality of the coastal zone in a similar way to the ecological/biophysical data. Fabbri (1998) developed this SSS methodology around the spatial decision support system (SDSS) through the integration of GIS and multiple criteria evaluating techniques to obtain a better understanding of the inter-relationships between natural and social-economic variables for sustainability in the coastal zone.

Box 4. Spatial integration of social, economic and biophysical data: The case of the disturbed Lusatian coal mining region

The case involved multi-scale spatial and temporal modelling of a large scale regional landscape system that recognised the connectedness of ecological and economic systems. In building the model the ecological and socio-economic structure of the geographical area was used to structure the problem to allow analysis, and the use of if-then simulation in scenario analysis. The socio-economic system was analysed by deconstructing its components and links, and analysing the data sets and current level of process knowledge. The social and economic data formed part of a rough schema that linked with the other landscape (e.g. ecological data) components, allowing the calculation of economic and socio-economic aspects.

According to Bellmann (2000), social and economic data may be used in relation to the spatial dimension of the landscape, or in relation to the different production and service sectors. Furthermore, Bellmann (2000) found the use of social data at a macro level has also to consider external driving forces or circumstances (e.g. political and economic), and production and economic sectors need to recognise linkages to the ecological and water resources. Also, the specific components of a comprehensive regional model (landscape, ecological and hydrological linked with the economic and socio-economic) need to be horizontally and vertically linkable for better understanding and evaluation of management options.

There are a number of limitations of decision tool applications in providing for public participation to inform decision-making and the incorporation of social data. For example, in many cases it seems that following an initial phase of model development and social data collection, no further stakeholder participation is undertaken. Some processes fail to provide flexibility in the inclusion of both quantitative and qualitative forms of social data (Bantayan and Bishop 1998). The process of aggregating the preference patterns of individual decision-makers to arrive at a group opinion would seem to have many problems, none more so than the reduction of multiple preferences to an outcome that is potentially unrepresentative in general and disadvantageous for discrete stakeholder groups in particular. This was not, of course, true of all studies. Bantayan and Bishop (1998), for example, used a combination of two decision tools, arguing that a group view on the value of resource use options generated using, for example, the Analytical Hierarchy Process could be combined with GIS to offer a greater sense of control through map and information access.

Debate also exists over the use of social data in the form of human preferences with its 'uncertainties' and 'fuzziness', and the reduction of this intangible information to sets of measurable variables that in the end may not be representative of the issue, or capture what is important. Fuzzy set theory has been adopted for decision-making to deal with the problem of including social data and subjective modelling. Akter and Simonovic (2004) used fuzzy set theory for short-term reservoir operation to represent subjective human preference uncertainties of decision-makers surrounding optimal release and storage values.

Many papers mention uncertainty in the data and coastal zone management, and the need to understand and assess the degrees of uncertainty (Fabbri 1998; Zhu and Dale 2000). Decision frameworks need to manage and minimise uncertainty in the data, analysis, and final outcome. Uncertainty arises from insufficient, inaccurate or unavailable data, external developments and cross-boundary issues, and the unpredictability of human behaviour (Westmacott 2001). The use of a 'learning by doing' approach, otherwise known as adaptive management, assists in closely monitoring decisions to confirm their effectiveness, and to help refine future actions (Allen et al. 2001). This approach recognises the need and value of including community participation with scientific input to deal with uncertainty. Information flow is improved and shared learning is achieved in this collaborative environment.

Returning to our earlier discussion of why wide stakeholder participation in natural resource management is critical to the development of successful policy and management outcomes, it is clear from the literature reviewed here that participation in the research used to inform decision frameworks is necessary to ensure community understanding and acceptance of the decision framework methods and products. This activity necessitates capacity building initiatives for community leaders to assist them in decision-making (Velazquez et al. 2001). The decision framework success requires the design of the decision framework for 'the end user needs rather than the needs perceived by the developers' (Westmacott 2001 p. 72). These points are particularly relevant from the perspective of advancing a citizen science approach and ensuring capacity is developed in stakeholders and partner organisations. The shift towards a two-way model of communication and collaborative learning, forms the basis of adaptive management (Allen et al. 2001). Ownership of decision tools and frameworks is thus given to communities as they become the trainers and those responsible for further training of other communities. Participatory decision frameworks allow stakeholders to interactively experience and understand how systems work, how to visualise outcomes and how to look forward into the future in a realistic setting.

Conceptual Models for the Integration of the Social in Decision Tools

Thus far this paper has argued that meaningful integration of the social within decision tools requires attention both to content and process. In other words, at the same time that incorporation of social data and serious attention to social issues and values is likely to enhance stakeholder involvement and commitment to decision processes, widespread involvement is likely to increase the quality and relevance of social data. That a comparatively small proportion of published examples of decision tool applications include substantial social data and participation components may, therefore, seem surprising. While it might be tempting to attribute this to a technocratic rationality that undervalues social issues and the potential contribution of non-specialist stakeholders, it also is possible to suggest that the limited use of social data in decision tools stems, at least in part, from difficulty in defining the causal and conceptual links between social, economic and biophysical data sets at a variety of scales.

According to Coakes et al. (1999; see also Lockie and Jennings 2003), there are three core theoretical and methodological issues that need to be addressed in relation to the development and analysis of social indicators. These include: the development of theoretical and conceptual models; the definition of appropriate units of analysis; and, measurement. Conceptual models, they argue, must be able to explain the relationships between component parts of the model and account for variability within each of those key components. The failure of many social indicator selection processes is attributed by Coakes et al. (1999) to the requisite failure to specify clear and valid conceptual models.

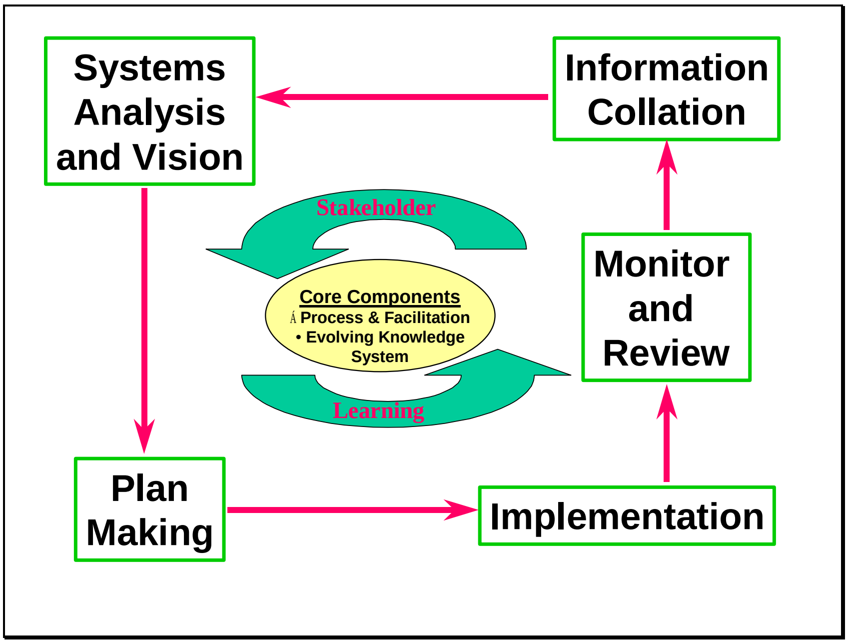
This is not to say that the successful deployment of all decision tools hinges on the specification, in advance, of causal explanations for the relationships between all system components. Indeed, developing such models may be seen instead as an essential sub-process within the overall process of decision tool design and use—a sub-process that is likely to benefit from stakeholder participation. Further, decision tools may be used for the very specific purpose of developing the conceptual models that are used to structure, and interpret the results of, indicator monitoring programs as described by Coakes et al. (1999).

Nevertheless, the relative lack of significant social components within published decision framework studies suggests that broad conceptual models for the integration of social, biophysical and economic data may be useful. This section examines the adaptive management and PSIR models as frameworks to link social and biophysical data about environmental change. The PSIR model and adaptive management approach are then discussed in reference to each other.

Adaptive Management: NRM as a Learning System

The concept of adaptive management does not provide a conceptual model of how ecosystems function or inter-relate with social and economic processes. Nor does it provide specific tools for data management and interrogation. Rather, it provides a conceptual model of natural resource management as a learning system in which core processes include process facilitation and knowledge system evolution. Accepting that natural resource management is inevitably characterised by various degrees of scientific uncertainty, changing environmental conditions and knowledge, and the need to negotiate conflicting values and interests, adaptive management seeks to treat management strategies as experimental steps in an ongoing process of social learning. The iterative processes of information collation, planning, implementation, monitoring, re-planning and so on are applied by the adaptive management model as much to the institutional arrangements in place to manage natural resources as they are to the ecosystems and resources those arrangements are responsible for. The basic steps involved in adaptive management are shown in Figure1.

Figure 1. Components of an adaptive management framework (Bennett and Lawrence 2002).



Adaptive management and community-based natural resource management through regional organisations, and catchment and Landcare groups, function well together because of the need to use an active civic process that recognises the social values and conflict surrounding problems. Kusel et al. (1996) argue that successful adaptive management requires an active public role similar to scientists and managers, and that public input be given equal consideration as other information and genuinely integrated into the adaptive process. Each of the components in Figure 1 utilise stakeholder input and information alongside on-going research to refine the systems understanding and generate solutions (or hypotheses for experimentation) and this is discussed further next.

During the information collation phase in Figure 1, better communication and relationships between scientists, managers and stakeholders occur as knowledge and information is pooled, problem identification occurs, and steps towards building trust are initiated. This collaborative problem identification provides the basis for successful planning in the later phase of the process and identifies both ecological and social problems (Johnson and Campbell 1999 in Habron 2003). The systems analysis and vision phase constructively engages stakeholders and focuses on the institutional environment through participatory processes that collectively address the value and aspirations of the diverse interests present. Plan making involves a learning exercise where social, ecological and economic impacts are evaluated and quantified by stakeholders, scientists and managers. Management goals and targets are established using widely sourced and transdisciplinary information and knowledge, and combined with the impact assessment results to define a preferred plan of action. Involving stakeholders in the implementation phase where changed management actions are initiated, progresses learning through 'learning by doing'. The monitoring and reviewing phase involves a monitoring program and assessment process to evaluate if the new management actions are meeting social and environmental values, agreed targets and goals and to take responsive actions for revised management actions. Information is updated and the shared knowledge base expanded, with any revision of the values and targets occurring. Specific decision tools such as MODSS and GIS are relevant at each of these phases although.

Adaptive management is also described by Habron (2003) as a series of linked iterative steps that encompass areas of problem identification, collaborative brainstorming, model development, hypothesis testing, planning, experimentation, monitoring and evaluation. The views, values and aspirations of stakeholders in the adaptive management process are used to inform a number of these steps, as evident from discussions of Figure 1. The stakeholders mentioned are comprised of communities-of-interest and communities-of-place. Communities-of-interest include groups with a specific interest in management of resources and these groups are viewed as 'communities' due to their shared interests. Communities-of-place encompass members of the public who may be affected by or interested in management because they reside within or near the management area.

Public participation in the adaptive management of natural resources helps decision makers and other stakeholder better understand problems, alternatives and consequences, along with the benefit of allowing stakeholders to express and reflect their values and aspirations in decisions (see Box 5). Opportunities for public participation in the adaptive process exist in all phases and steps of the process and a range of techniques and methods exist to facilitate their involvement. As an outcome of public involvement in the adaptive processes of learning, deliberation and analysis, the relationship between scientists, managers and the public is changed. Kusel et al. (1996) characterise adaptive management as "a process embodying deliberate management actions designed to increase opportunities for learning in order to direct management with improved information" .

Box 5. Examples of public participation, MODSS and GIS in adaptive management

In adaptive management approaches, the public participate in the process and need to be seen as an integral part of the overall system. (Kusel et al. 1996) use the term ‘integrated adaptive management’ to refer to the public, managers and scientists interactively working together to design, implement, monitor, evaluate and jointly assess management options in an adaptive process. They describe public participation in the Sierra Nevada Ecosystem Project (SNEP) which used an adaptive approach and provided guidelines for the future to effectively involve the public in integrated adaptive management. In the case of the SNEP, the public participation succeeded in advancing the relationship between scientists and the public, improving the communication of information and influencing the development of scenarios.

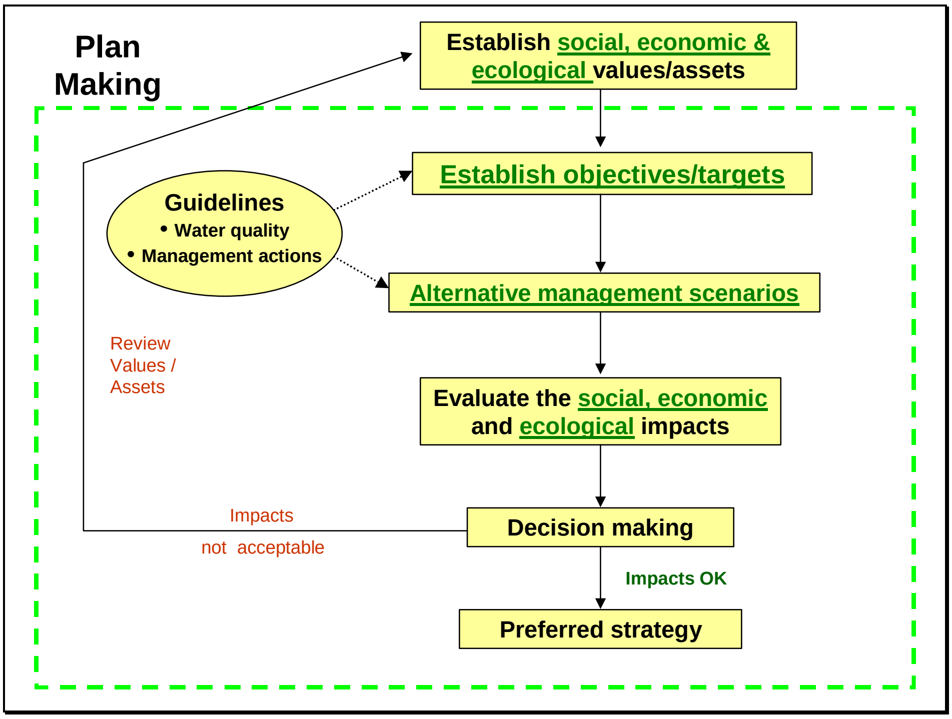
As a result of public involvement in the process and the use of decision support tools (e.g. MODSS) and information systems (e.g. GIS), the public gain skills which build their capacity to participate by assisting their understanding of natural resource use problems, improving opportunities for stakeholder negotiation and the ranking of alternative actions (see Bishof et al. 1999).

A decision support system, such as MODSS, allows stakeholders (public, scientists, managers) to participate in a user-friendly interface that enables the performance of “what if” scenario analyses and to gain a better understanding of the problem in a way that gets them to focus beyond their previous inclinations (Kersten et al. 2000; Lal et al. 2001). MODSS has also been shown to strengthen the effectiveness of the involvement of voluntary organisations in natural resource management (Robinson 2000). Participants become key learners in the process by observing the results of their actions and analysis based on their newly acquired knowledge. This adaptive learning approach allows stakeholders’ new findings to be fed back into the decision process (Lal et al. 2001).

The experimental or “what if” approach is the core to many exploratory analyses in GIS, with the benefit of exploring decision alternatives, seeking consensus and/or compromise and trade-off with other stakeholders through a learning process. Use of GIS is particularly useful with adaptive management because it helps to open and democratise the process, and helps users explore the decision problem by supplying spatial datasets and analytical tools (Carver et al. 1998). (Carver et al. 1998) also state the use of web-based public GIS should be problem specific and combine analytical models and data in such a way that the public can easily explore the decision under investigation in an interactive and recursive system without the need for extensive prior knowledge of the system.

As stated above, the concept of adaptive management provides a conceptual model of natural resource management as a learning system that is sensitive to human values and aspirations. It thus provides considerable potential to assist in the development of resource management processes that contribute to equity and other social outcomes through widespread participation in deliberative processes. Its most explicit guidance on how actually to incorporate social data (beyond the involvement of stakeholders and development of a shared vision) occurs in the plan making phase during which participants are asked to evaluate the social, ecological and economic impacts of potential management scenarios.

Figure 2. Plan making phase of an adaptive management framework (Bennett and Lawrence 2002).



Nevertheless, the scope for social issues to be raised within adaptive management processes, we would suggest, is likely to be enhanced by a more explicit theorisation of the linkages between social and natural resource data and issues. Consideration must also be given to how to incorporate within decision frameworks social data and issues of which those stakeholders involved may not themselves be aware or accord high priority. The PSIR model is discussed below as a conceptual framework to address this issue.

Pressure-State-Impact-Response: Conceptualising the Linkages

The conceptual framework described here illustrates how social, economic and biophysical data may meaningfully be related by focussing on the processes and outcomes of environmental change. The framework does not provide a comprehensive model of social issues, processes and structures within any defined geographical area and may not be considered adequate for social planning. Nevertheless, by focussing more specifically on the ways in which anthropogenic processes drive environmental change, and the social consequences of these changes, it provides a potentially useful tool for natural resource and social planners as an adjunct to the adaptive management model. The conceptual model is based on an elaboration of the Pressure-State-Response (PSR) model used for state of the environment reporting in Australia and elsewhere and which is described in more detail below.

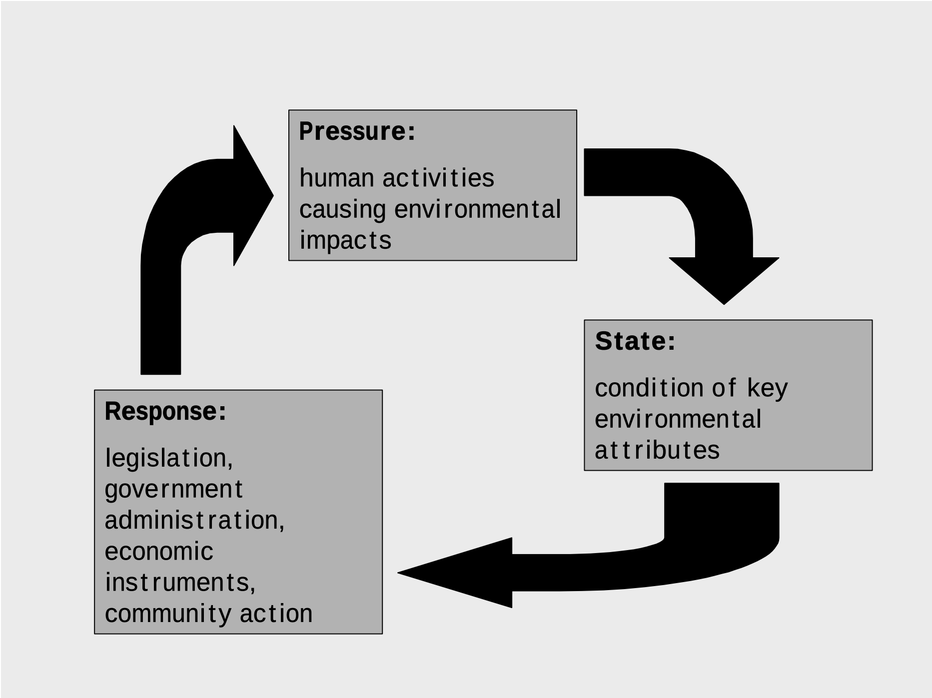
Pressure-State-Response Model

The PSR model is used for the purpose of reporting on the environment, providing up-to-date information, informing debate, and stimulating new adaptive responses. This approach is designed to allow priority setting of key environmental issues and to direct appropriate responses to these issues. In practice, the key environmental issues of focus are those identified by a group of experts and informed through community consultation. The model tries to reflect the particular state of the environment in a defined geographical area or region. Attached to each part of the model are indicators—as a measure of the severity and extent of the issue (condition indicator), a measure of cause(s) (pressure indicator), and a measure of society's response (response indicator) (c.f. Government of Western Australia 1998). Indicators are key tools with multiple purposes of linking policy objectives and targets, communicating to stakeholders' data priorities, and providing simpler ways of reporting complexity to government and community audiences (Casazza et al. 2002).

PSR models thus incorporate three key components:

1. *Pressure* of human activities causing environmental issues;
2. *State* or condition of the environment; and
3. *Response* to these pressures and conditions in the form of legislation, government administration, economic instruments and community action (see Figure 3).

Figure 3. Pressure-State-Response model



While used primarily as a monitoring and reporting framework at state and regional scales, other applications of the model include:

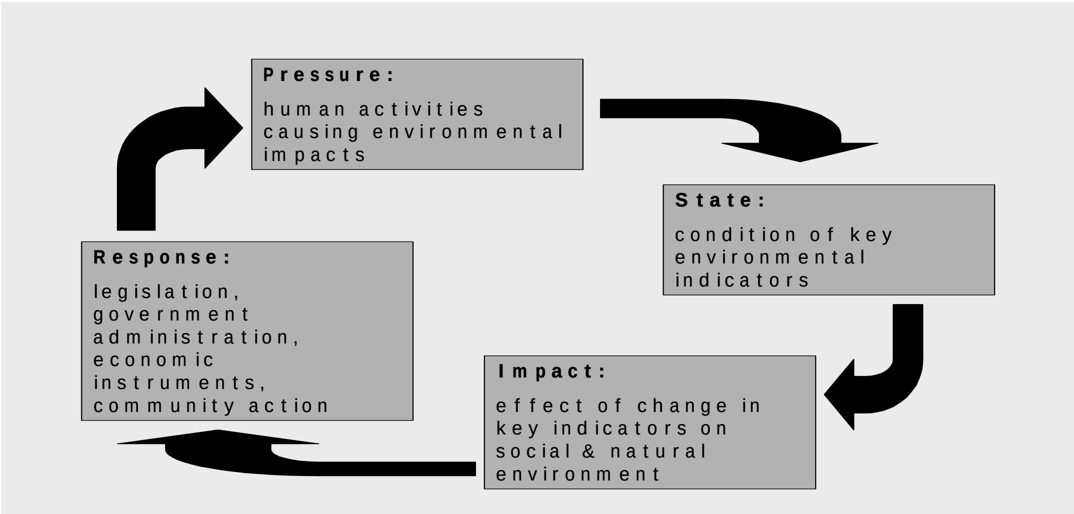
- identification of indicators to assess sustainability;
- provision of a framework for use in the development of integrated research and development programs; and,
- a communication tool and basis for stakeholder discussion of problem situations and alternatives.

The PSR model is not intended as a one-off tool to be applied to a single problem but as a conceptual model to inform monitoring, reporting and communicating ecosystem and social data on an ongoing basis. One of the virtues of this model is its simplicity. However, this same simplicity means that the model does not provide a clear or overt conceptualisation of the relationships between system components or of their spatial and temporal variability. Nor does it provide clear guidance on how or when stakeholder engagement and negotiation should take place. Thus, while application of the PSR model may support the implementation of adaptive management by providing a conceptual basis for the institutionalisation and review of monitoring, reporting and communication systems, it is not intended as an alternative to adaptive management.

Pressure-State-Impact-Response Model

Extensions to the PSR model have been proposed by a number of authors. While it is reasonable to question the extent to which the addition of extra categories merely complicates and replicates existing model components, the interest of this paper in the PSIR model described by Turner et al. (1998)(see Figure 4) lies in the explicit attention it pays to the impacts of changes in the natural environment on people and the communities of which they are a part. Expanding the PSR model to include the impacts of changes in environmental state indicators on the social and natural environments makes it is possible to begin understanding and managing the coastal zone and other ecosystems as one co-evolving ecosocial system. Current thinking supports the need for coastal areas to be 'viewed as the spatial and temporal context for jointly determined socio-economic and ecological systems on a co-evolutionary development path' (Turner et al. 1997 in Turner 2000 p. 448).

Figure 4. Pressure-State-Impact-Response model



As we seek better ways of managing the environment and the impact of human activities we need more integrated approaches to understand the causes and effects of environmental change. Integrating the natural and socio-economic environments provides:

1. an understanding of the pressures and effects of socio-economic change (e.g. population pressure, urbanisation); and ,
2. the ability to assess the human welfare impacts of changes due to processes and functional changes in coastal resource systems (e.g. determine the tradeoffs between social costs and benefits with resources)(Turner 2000).

The state of the environment is reported on through a framework of indicators describing the health of the environment. According to Turner (2000), following the scoping of coastal science and management issues and problems it is possible to identify and understand the multi-sectoral relationships, and the dynamic characteristics of, ecosystem and socio-economic changes. The use of indicators for the purpose of understanding fluxes in the system supports cross-discipline communication and inter-disciplinary research linking the natural and social sciences (Turner et al. 1998). Responses include the combination of government and community actions to these problems and issues. The aspirations and values expressed by stakeholders and communities guide the response, including the policy development and the establishment of definitive environmental indicators. In the process of developing policy to respond to environmental issue, consideration is given to the overarching objectives set forth in state and national strategies. Further, by understanding underlying pressures on the coastal system it is possible to direct responses to the source of problems (Casazza et al. 2002).

Indicators within Turner et al.'s (1998) conceptualisation of the PSIR model are organised across three levels:

1. biophysical fluxes involving, for example, carbon, nitrogen, phosphorus and water flows and ensuing financial/economic fluxes reflecting changes in value from changes in the physical, chemical and biological:
2. changes in coastal system properties, such as reduced habitat function to support fish stock; and,
3. outcomes for human welfare conditions resulting from fluxes and changes in the biophysical and economic (e.g. economic value and productivity from changes in fish stock levels).

These indicators are then used to monitor the system's response to environmental pressures, both anthropogenic and non-anthropogenic (e.g. land use change, urbanisation, climate change), by taking into account continuing and future changes in the system's condition or drivers. Interpretation of the significance of any fluxes in the state/condition of the coastal system and the implications for the human condition is then used to inform policy, management and investment actions. A summary of those indicators for the Italian coastal environment selected and used by (Casazza et al. 2002) for environmental assessment is provided in Box 6.

Box 6. Applying a DPSIR framework to the Italian coastal environment

Casazza et al. (2002) selected a series of indicators based on their relevance, priority and data availability for integrated environmental assessment by using a DPSIR framework. The objective was to use new methodological and conceptual criteria to identify indicators that would integrate available environmental data at a common scale, for the purpose of communicating complex data in a simply way to policy makers and the public. The example used to illustrate this methodological approach involved littoral communes along the Italian coastline.

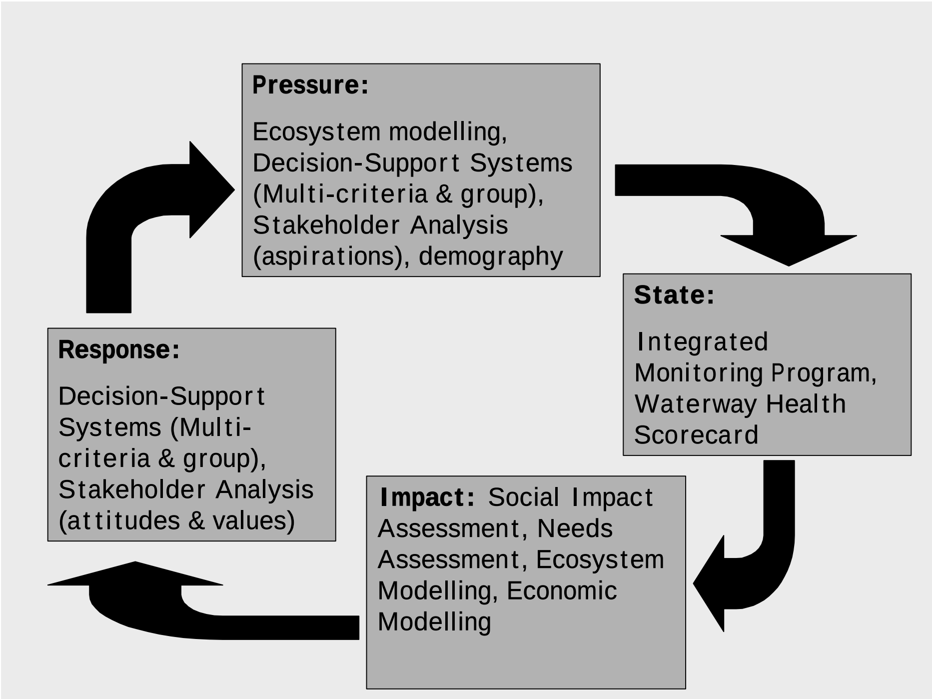
Indicators selected included:

- Driving – population density, demographic increase, distribution of GDP, tourism;
- Pressure – land use, employment, nutrient loads, organic loads, maritime transport, fishing fleet, fishery, and aquaculture;
- State – trophic index;
- Impact – bathing waters;
- Response – depuration budget, waste waters register, distribution of industrial and urban discharges along the coastal area, marine protected areas.

The PSIR model is designed to:

- integrate socio-economic and natural science into a single model;
- allow shifts in scale to larger or smaller models from a regional context, and to draw out smaller models of individual components such as for population pressure;
- support interdisciplinary and participatory process for the interpretation and communication of knowledge;
- make value laden assumptions more transparent;
- utilise a variety of decision tools including multi-criteria assessment that support the identification of practical trade-offs (see Figure 5);
- respond to change and uncertainty;
- ability to incorporate decision tools (Turner et al. 1998; Turner 2000).

Figure 5. Potential incorporation of decision tools within the PSIR Model



However, several issues remain that require different conceptual solutions for optimum application of this model:

- data occurs at different scales and data collected for economic, social or ecological purposes may be collected from different units or spatial sizes;
- the ability to reach a balanced decision may be compromised when data is lacking from one discipline area;
- identification and use of indicators, including the establishment of clear and brief definitions, their significance, measurement units, recommended methodologies for their computing, time periods intervals and coupling with other cross-disciplinary indicators etc.; and
- difficulty in measuring the social state of the environment as compared to the physio-chemical parameters used to evaluate coastal environments.

PSIR Model and Adaptive Management in Managing Environmental Change

The PSIR and adaptive management are both useful approaches to conceptualising relationships between the environment and human influence driving change. They differ in that they model different kinds of processes. The PSIR describes relationships between social decision-making and other actions (e.g. institutional responses) and environmental outcomes. Adaptive management is an approach describing the process of social learning (see Figure 1.). In essence, each approach subsumes the other and is an embedded part of the process to manage a changing environment to achieve desired objectives (see Figures 6 and 7). Both models:

- function to assist decision-makers to make informed choices in complex situations where multiple interacting factors exist;
- utilise scientific and non-scientific information;
- require social and institutional learning with evolving knowledge to direct change—“learning while doing”;
- cycle through a process of monitoring, evaluation, re-adjustment, and changed policy and management practice;
- support predictive scenarios through modelling, assessment of risks, and monitoring of impacts; and
- incorporate social processes of multi-stakeholder participation and negotiation to define values, targets, objectives against which the outcomes from the management actions are continuously evaluated.

The similarities that the PSIR model shares with the adaptive management framework enables the model to act as a vehicle for the adoption of an adaptive management approach by regional organisations and state government agencies involved in natural resource management. In each step of the model and framework, similar tools and processes are used to achieve improved decision-making.

In conceptualising the potential linkages between the adaptive management and PSIR models it is critical to keep in mind that while the former offers a conceptual model of an ideal-typical process of social learning, the latter offers a conceptual model of how data should be categorised and related for the purposes of monitoring a reporting. On this basis, both conceptual models may be seen as potential subsets of the other (see Figures 6 and 7). In other words, implementation of a monitoring and reporting framework as offered by the PSIR model may be seen as an essential step within a process of adaptive management. At the same time, adaptive management may be seen as one institutional response that requires monitoring in relation to its impact on key environmental state indicators within a state of the environment monitoring and reporting system.

Figure 6. Potential incorporation of the PSIR approach within an adaptive management framework.

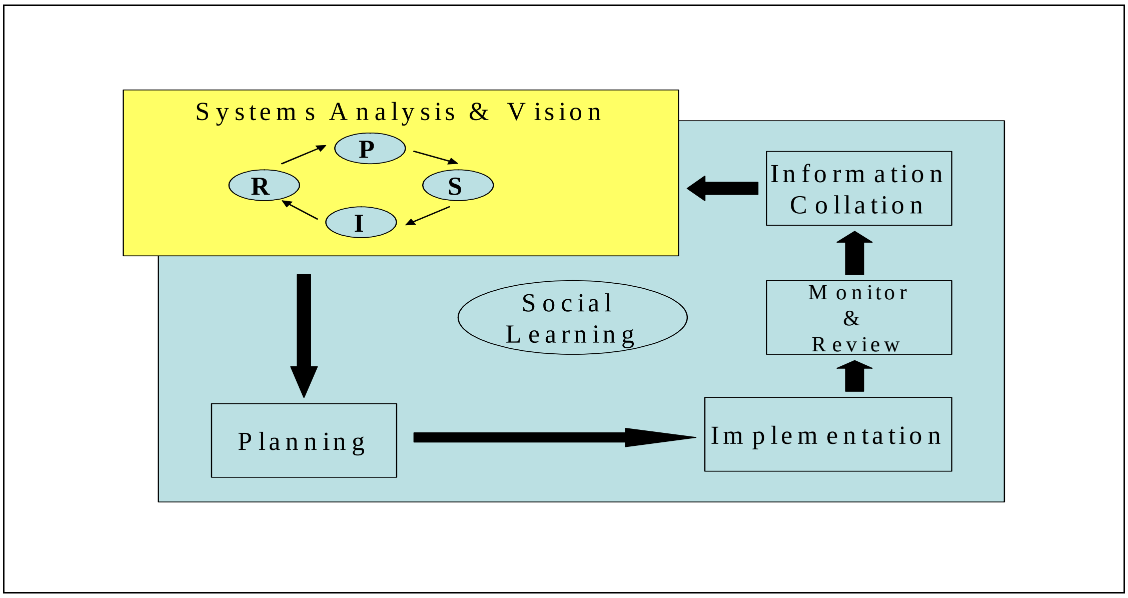
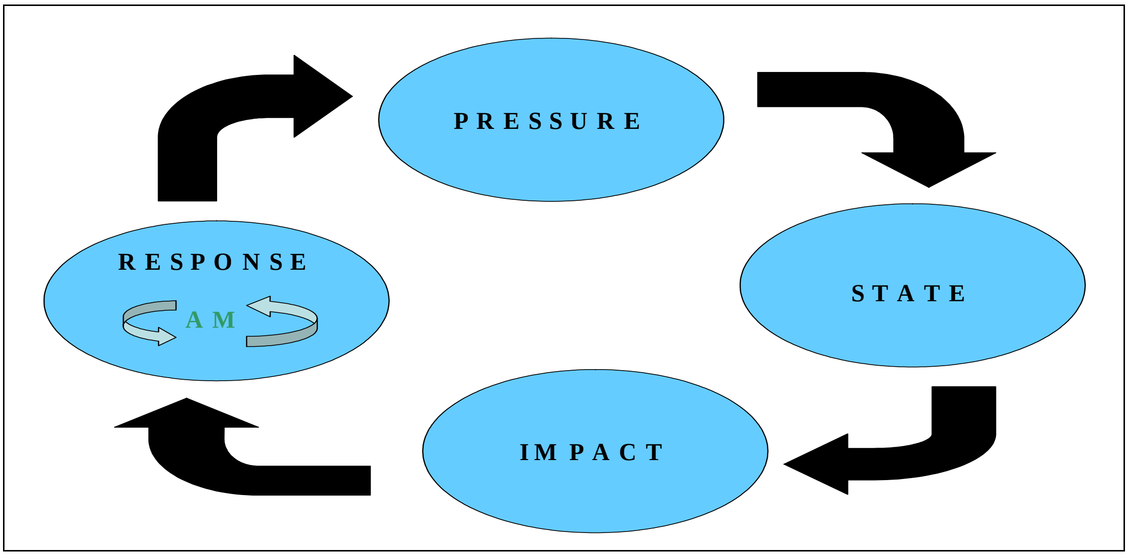


Figure 7. Adaptive management within the PSIR model



Conclusion

The purpose of this discussion paper was to identify from the decision tool literature the major ways in which social data and questions have been incorporated within decision tool, and how decision frameworks accommodate and support participatory involvement in the process. This review shows that, as with most areas of natural resource management and decision-making, there is considerably more rhetoric in relation to dealing more adequately with social questions that there are sophisticated attempts to do so. Indeed, review of the decision frameworks literature found there has been little use of social data within DSSs, consideration of how DSSs interact, or the incorporation of the social processes of decision-making. This, in part, may be seen to stem from a lack of conceptual clarity over how data related to biophysical, economic and social processes may meaningfully be related and to competing perspectives on the validity, and relative importance, of different types of data.

The decision tools arena has in the past received a great deal of attention due to the multiple approaches available and benefits on offer to decision-makers. Decision tools are progressively becoming more participatory with steps taken to facilitate participation and negotiation amongst stakeholders, and to integrate social data for an analysis of the whole system. Acceptance by the public of decision outcomes and the management of uncertainty are a few of the benefits arising from participatory and integrated models of decision-making.

Some of the key findings from reviewing the literature for participatory applications of decision tools include:

- limited attention to the 'invisible outcomes' of participatory application of decision frameworks including stakeholder commitment and capacity building;
- insufficient attention by decision tools to the facilitation of group decision-making;
- better models are produced by the inclusion of subjective and objective sources of knowledge using participatory approaches;
- a tendency to equate participation with social data collection methods such as surveying and interviewing; and,
- the importance of negotiation and consensus seeking approaches is recognised but few participatory approaches are specified in papers to achieve these.

Examination of the literature to assess the incorporation of social data within decision frameworks found a number of key findings:

- a tendency of studies to focus on the economic and ecological, to the exclusion of social analysis;
- where social data was used, it often was limited either to the stated preferences of those directly involved in the application of the decision tool or to quantitative data, neither of which provide a comprehensive or representative picture of the decision environment;
- limited consideration of the distribution of costs and benefits across the community;
- potential to aggregate individual preferences into outcomes that are unrepresentative or which disadvantage particular stakeholder groups; and,
- difficulty generally dealing with uncertainty.

The difficulties encountered by practitioners in the use of social data in decision frameworks which have been identified by this study is partially due to the problem of defining the causal and conceptual relationships between social, economic and biophysical data sets at a variety of decision-making scales. To address this problem the use of adaptive management and PSIR models as frameworks to link social and biophysical data about environmental change (e.g. resource use and condition) offers scope for the integration and use of social data.

The conceptual PSIR model is aimed at capturing the dynamic complexity of the social, economic and ecological sub-systems as the resource condition and use changes over time and space, and is well suited to inform regional planning and management of natural resources. It shows the integration of current socio-economic and ecological data, and the process leading to the appropriate policy and community responses to pressures and impacts. The PSIR model is focused on constructively using social data gathered through stakeholder analysis to understand: *pressures* generated by population, stakeholder aspirations and economic growth; *state* of the environment through modelling of the biophysical processes; resultant *impacts* on the sub-systems (economic, social, ecological); and *response* to these pressures and impacts by institutions, planning processes and communities using decision support systems and informed by stakeholder attributes. Social data gathered on stakeholder communities consists of values, interests, attitudes and future aspirations, in both quantitative and qualitative forms. Use of social data means responses in the form of policy-making and planning within an adaptive management approach are cognizant of stakeholder aspirations and key values.

From the examination of the PSIR model several benefits can be identified:

- Consistency with current state of the region and environment reporting for regional natural resource management organisations, State and Commonwealth Governments;
- Addresses stakeholder concerns by incorporating social aspects and involving stakeholders in the identification of indicators;
- Allows an adaptive management approach that integrates all components of the environment (social, economic, ecological) and further supports Integrated Coastal Zone Management;

Frequently models and decision frameworks fail to incorporate social data, and support social processes in the design and process. Too often a technocratic approach is taken to environmental problems by government and other stakeholders, with less than ideal processes and outcomes. Important social data is neglected in policy-making and planning, and the ‘elite’ views of certain stakeholders preside. The PSIR model and adaptive management approaches seek to overcome many of the problems and limitations discussed in this paper, and to provide a suitable platform for coastal zone management by delivering the best social and institutional responses.

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