A Decision Environment: Going Beyond a Decision Framework to Improve the Effectiveness of Decision Making in Natural Resource Management

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Abstract: The proliferation of decision support systems has addressed a wide range of applications for use in the management and allocation of natural resources. Several decision support systems, including *Facilitator,* have been used as part of the decision process to evaluate resource use options, agency activities and project prioritisation. It is not the intention of this paper to evaluate the effectiveness of these decision support systems, however, the fact that there is the emergence of the term "decision frameworks" suggests that previous decision support systems, as stand alone support tools, have fallen short of expectations. From our practical experiences and application of more than 25 case studies, we have identified a broader construct called a *Decision Environment.* This environment is required by project facilitators to improve the effectiveness of a decision framework, ensure all aspects of the decision process are considered and integrated to bring about the implementation of agreed outcomes. In this sense, the Decision Environment provides a guide for linking decision frameworks. Applications to catchment planning and community-based decision making are considered.

Keywords: Decision Support Systems; Frameworks; Natural Resource Planning

1. INTRODUCTION

Decisions for catchment or regional planning to achieve natural resource management outcomes are complex. In many cases this complexity arises because embedded in the decision making is a desire for a balance between economic growth, social cohesion and environmental quality. To focus on a single issue in favour of the others is to place at risk the natural resources and those who depend on them. Given the complexity of decision making, it is not surprising that tools to support decision makers have become popular and advanced. Many multiple objective decision support systems (MODSS) have been developed for use in natural resource management to address a wide range of applications. Some examples include Java-AHP for regional resource planning [Zhu and Dale, 2000] and vegetation management [Zhu et al., 2001], water resource infrastructure planning [Lawrence et al., 2000]. However, while the degree of sophistication of these tools to integrate information and determine trade-offs between alternatives has increased considerably in the last five years, there is a notion that the software tool represents an end point in the decision process. This further suggests that the decision support *system* is largely a computer-based system, and that the tool is subsequently available for any problem solving application. The short-coming of this view-point is that the software tool becomes disconnected from the process of decision making.

In this paper, we develop a broader construct called a *Decision Environment.* This environment is required by project facilitators to improve the effectiveness of a decision framework and bring about the implementation of the agreed outcomes. It may serve as guide to develop better decision making processes, particularly for planning. In addition, the concept promotes the idea of interconnected decision frameworks. In its broadest sense, a decision environment is a process for recognising the individual components of a decision framework, and their connectedness. These components include an effective process for stakeholder representation and involvement; the consideration and integration of biophysical, social, economic and cultural impacts; compliance with existing legislations and policies; access to information and expert opinions, and the use of visualisation technology to communicate complex

spatial and temporal impacts. Further, the decision environment explicitly recognises that a decision support system is an analysis tool within a larger decision process.

The current focus on management actions to repair landscapes impacted by salinity and water quality is a case in point. The approach requires information to be integrated across time, space and function. The formulation of strategies is somewhat guided by an emphasis on resource assessment activities. These will provide the status and spatial extent of the current problem. However, the development of management scenarios requires a much broader interpretation of the most effective and cost efficient actions, and this will need to involve social and economic factors, both at farm and catchment scales.

2. DEFINITIONS

Before proceeding with the description of a decision environment, it is important to distinguish two existing terms, namely a decision support system and a decision framework. For the purposes of this discussion, we define a decision support system (DSS) as the *analysis tool by which the best available information is integrated and feasible alternatives are evaluated using decision criteria.* Typically, a DSS is computer-based for ease of calculation, scenario analyses and presentation of the outcomes. It may incorporate databases, GIS, and provides the mechanics of assigning weightings to criteria and ranking of options. In contrast, a decision framework can be defined as *the underlying set of ideas, principles, agreements, or rules that provide the basis for decision making or the outline for something that is more fully developed at a later stage.* This notion focuses on the processes of decision making within the context of evaluating the alternatives. In this sense, a DSS is a sub-component of the decision framework. Further, consideration of the broader term decision framework provides a basis for merging quantitative and qualitative information, and highlights that the process of decision making deserves as much time and resources of effort as the analysis. The two terms are linked by the process of decision making, which reflects an agreed, transparent process to resolve issues of conflict and problem solving.

However, given this connection, when a decision making process commences, it may become evident that further issues need attention, or that the group may not have scoped all critical issues, thus providing a complicated situation that could lead to a breakdown in communication and a marginalised position for negotiation between stakeholders. This emphasises the iterative nature of a decision process. Consequently, an analysis of a problem or planning opportunity should be linked to objectives. This involves the recognition of the type of problem, the definition and interactions between its components and its relation to values and experiences. Additionally, the problem definition process is achieved by studying and articulating reasoning activities involved in a choice process. Simon [1960] suggests there are three components of decision making, namely intelligence (information gathering and setting assumptions); design (exploring and testing alternatives and their impacts); and choice (identifying a satisfactory decision and verification). This places choice and the process of choice at one level. However, the framing of the choice process to consider a range of perspectives and environmental, social and economic issues as well as the implementation of the preferred option may not be achieved by Simon's linear approach.

Within this context, there is a need to recognise a broader, muti-faceted framework of decision making and planning that must satisfy a hierarchy of decision objectives and constraints. Apart from being strategic, the framework should also provide a logical sequence of actions and considerations for catchment groups and planners to apply.

3. KEY ELEMENTS OF THE DECISION ENVIRONMENT

A Decision Environment serves as a framework for the requirements for a systems perspective. A key aspect of any process is that consideration be given to a range of issues. In natural resource management, it is imperative that issues related to biophysical and resource assessment be considered. Furthermore, it is important to integrate these issues with economic, social, cultural and legislative factors.

The key elements of the Decision Environment are: (i) a planning opportunity; (ii) defining the strategies and solutions; (iii) the process of facilitation and group decision making; (iv) gathering information; (v) the decision analysis; (vi) making the decision; and (vii) implementation and life-cycle assessment of the decision. While each element provides a prompt for further investigation, there is an iterative process from the implementation to the planning opportunity.

These seven components and their subtexts are schematically shown in Figure 1. The remainder of this section describes the principles of each key element.

3.1 A Planning Opportunity

The planning opportunity represents the commencement of the decision process. The primary focus is largely problem or framework definition, so that a broad understanding of the system functions and considerations is developed. This may include the construction of a conceptual or causal loop model, identification of social, cultural, economic, political, institutional and organisational factors, in addition to the interactions with biophysical components of the landscape.

3.2 Strategies and Solutions

The potential alternatives (including the 'do nothing' case) and decision criteria are defined, discussed and refined during the Strategies and Solutions element. This may not be as straight forward as implied, and the group undertaking the decision process may require external advice on formulating these requirements. During this stage, stakeholder representation and the process of selecting, nominating and recognising stakeholder groups is conducted. Depending on the planning issue at hand, it may be necessary to review the stakeholder representation during the course of the process, particularly if additional options or decision criteria are later defined. Depending on the number of alternatives being evaluated, there may be merit in reviewing or quickly testing the feasibility of all alternatives, and removing any that are possibly redundant or impractical.

3.3 Process of Facilitation

Facilitation represents one of the key areas on the Decision Environment, and distinguishes the process of stakeholder engagement from an application of software technology. It is through this process that participants build trust to enhance communication, articulate aspirations, and become accepting of a different point of view. At the same time, it is critical that the participants decide on an acceptable process to resolve conflicts when these occur. This may even consider use of legal channels to resolve an impasse, which has been used in the United States [Cramer 1999]. Other considerations during this phase include setting a timeframe for the decision process, the type of decisions that are to be made, and an acceptable method for recording and reporting on the discussions within the meetings.

3.4 Information Gathering

Information on the impacts of each option will come from existing databases, utilising metadata bases, measured data, and spatial simulation models. It may be necessary to conduct specific studies that assess economic, social, cultural and institutional impacts, so sufficient time and resources need to be available for these results to be incorporated with other information sources as part of a decision process. Associated with quantifying the impacts, it is important to include an assessment of the risk associated with the impacts, particularly uncertainty in data. Where the issues under consideration are beyond the data sources and the capability of the models, it may be necessary to approach technical experts to rate the impacts using an appropriate scoring system. Issues surrounding the use of experts are recognised in the literature, and include such issues as familiarity of the experts with the study site and planning opportunity, sufficient degree of expertise in the sciences as defined by the decision criteria, and an ability to integrate discipline expertise with other experts to ensure that a holistic examination of the impacts assessment is represented in the assessment matrix. To complete the considerations of information gathering, the group should reach agreement as to how they will deal with gaps in information.

3.5 Decision Analysis

Having completed an effects matrix using the decision criteria and all available information, it is possible to evaluate the feasible options where there are conflicting objectives. This is typically done using a multiple criteria analysis or decision support system. Perhaps the most contentious issue to be addressed during this phase of the decision process is the weighting algorithm and method used to rank the alternatives. The work by Hajkowicz [2000] provides a quantitative examination of several methods in a resource management context. Systems that allow 'what-if' scenarios to be run interactively and efficiently are particularly useful during this phase of the decision process. Using stakeholder preferences, the decision criteria can be weighted to ensure the analyses consider environmental, economic, social and cultural aspirations. These outcomes represent a preferred choice or possibly a selection of alternatives for further more detailed analyses. Importantly, the group should also consider whether there are any additional factors that need to be recognised at this time. These may include intangible factors, political issues, whether the decision is irreversible or consistent with draft policy, or requires a 'cooling-off' period in which to contemplate the outcomes.

3.6 Making the Decision

Having agreed to a preferred position, the outcomes

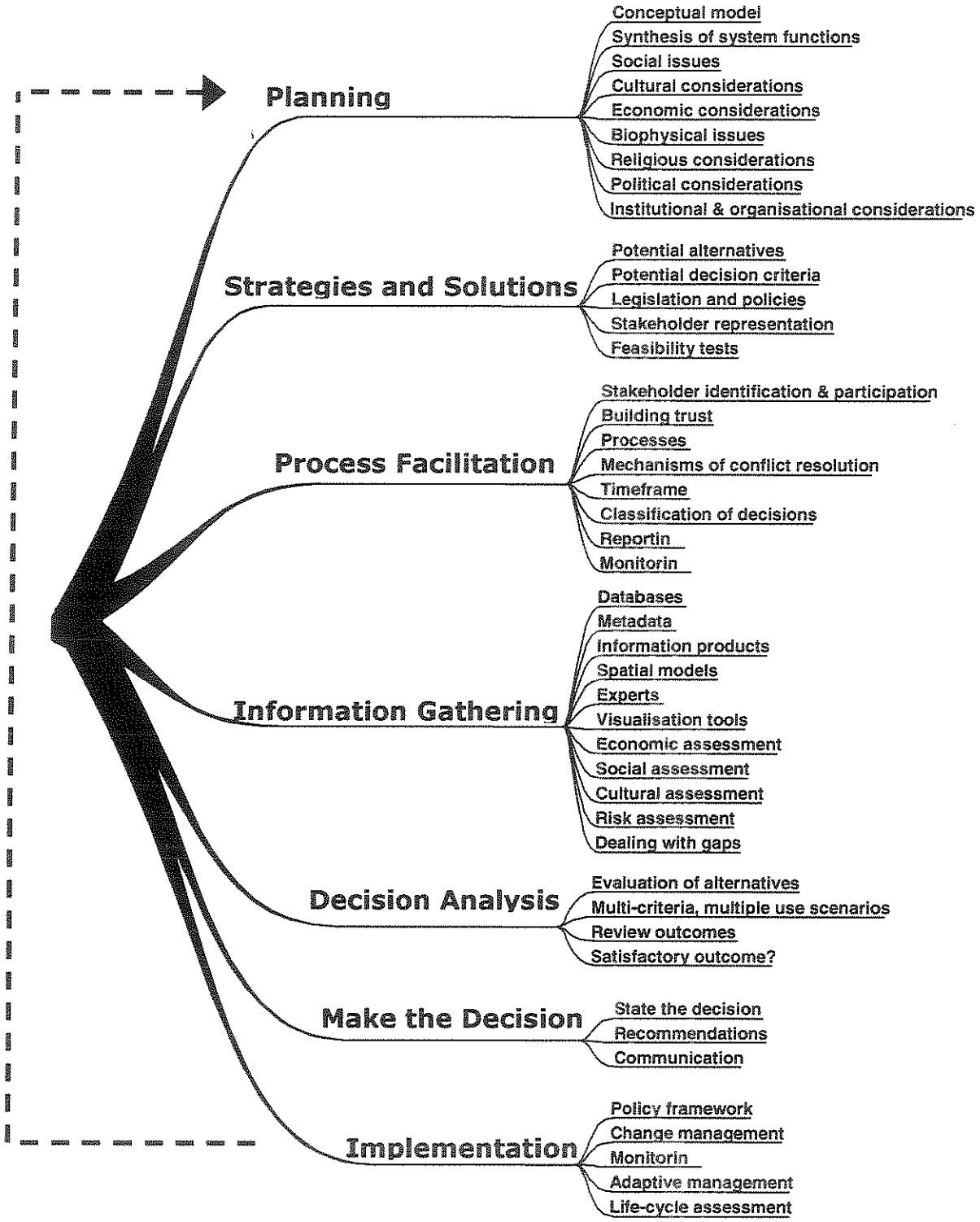

Figure 1. Key elements of the Decision Environment

from the decision process need to be stated and communicated to the wider community. Along with letters of recommendation to higher levels and media releases, these actions need to ensure reports, summaries, results are available. If the outcomes from the decision planned are an input to another stage in the decision process, then it is essential that the information be available in a format that is useful and fully utilised. The available information should also be included onto organisational metadata bases and catalogues.

3.7 Implementation

The final element of the Decision Environment also includes the critical stage of implementing the decision. In many cases, the outcomes from planning processes are not implemented due to funding restrictions, changed priorities or due to strong external factors. Nonetheless, decisions that are reached with stakeholder support need to maintain that support through the implementation and adoption phase. Issues that require consideration include possible change management, capacity building and incentive schemes. In addition, appropriate environmental, social, economic, and institutional indicators need to be defined and implemented as part of an integrated monitoring network that will detect change and initiate adaptive management programs.

Although the seven elements of the decision environment are presented here as a logical sequence of steps, it is recognised that in reality the process may be far from sequential and continuous. In practice, the whole process is iterative, possibly having points of internal conflict that require resolution, stakeholder involvement that needs constant encouragement and on-going review of the whole process to ensure an agreed set of goals remains a common thread.

4. APPLICATIONS

The Decision Environment concept lends itself as a guide for community-based groups or planners to undertake a holistic approach to developing a catchment plan. In instances where a group may be embarking on a planning exercise for the first time, the decision environment may simply be a checklist against which the group progresses through the decision process in a semi-structured way. Two examples are briefly described.

4.1 Developing Catchment Plans

The announcement of the National Action Plan for Salinity and Water Quality outcomes will bring a focus to regional and catchment scale planning. In particular, it will highlight the complexity of satisfying potentially conflicting objectives of physical, social, economic, and cultural issues that need to be incorporated in the development of a catchment plan, as well as any requirements contained within existing legislation at the local, state and federal level. Additional considerations include time, the availability of science information at an appropriate scale, and tools for integration.

Under these circumstances, the Decision Environment may be used as a semi-structured approach in the process of developing a catchment plan. The initial planning opportunity may provide the broad scoping for conceptualising the physical functions of water and sediment movement within the catchment. This activity may produce a causal loop model similar to that as described by Chaloupka et al. [2001]. A similar process may be used to identify the major social, economic, cultural and institutional concerns that need to be addressed within the plan. In the next step, all feasible strategies and possible solutions should be defined. An important factor of this element in the Decision Environment is the process of defining the decision criteria so that the economic and social standing and capacity of the small and rural towns, as well as any temporal and spatial variability within the catchment, are acknowledged. Furthermore, it is desirable to undertake a "reality" check to test the feasibility of the alternatives against the financial capacity of the catchment community to implement, and ensure that all options are within the existing state and local legislation.

As previously emphasised, the facilitation process represents one of the most important elements in the Decision Environment as it forms the framework for maintaining dialogue between the many stakeholder, interest and industry groups and laying out an agreed pathway for building trust and resolving conflicts. In some circumstances, many of these groups may not have interacted before, so communication and acceptance of differing opinions is important. A catchment group may employ the services of an independent facilitator and define a set of guiding principles for meetings, coordinate actions between meetings, maintain the momentum of the decision process and reporting progress to the wider community.

Sourcing and accessing catchment scale information would draw on existing community information, agency metadata and corporate databases. Re-formatting and synthesising the information so that it can be understood by the catchment group may be required. In addition, the catchment group may also decide to establish an expert panel to aide interpretations and provide judgements when the information required is beyond the capability of existing simulation models. The desirable outcome from this stage of the Decision Environment is an effects matrix, which provides the quantified assessment of the impacts or scores of each alternative against the decision criteria.

The effects matrix forms the basis for conducting a multiple criteria analysis using an appropriate decision support system. Various scenarios of land management changes within the catchment may be developed through differing weighting assignments that reflect stakeholder preferences and the degree to

which the option meets agreed water quality or salinity targets. It may be possible to meet agreed environmental targets using a number of catchment plans. Where catchment plans are accredited, the Decision Environment allows for a pathway of continued refinement and to ensure there is sufficient rigor and acceptance of preferred actions by the whole catchment.

4.2 Community-based Landuse Planning

In Zimbabwe, there is growing recognition by the government and NGOs to implement community-based planning for resource use and management. In the past, government developed land use plans had a very low rate of adoption at the village and district level [Thwaites et al., 2000]. Furthermore, land settlement issues currently in the country have further highlighted the need for broader based plans to recognise social and cultural factors.

The Decision Environment approach lends itself to community actions and involvement, particularly where there is a desire to have a merger of "top-down" and "bottom-up" approach to strengthen ownership and longevity of preferred options. In Zimbabwe, organisations such as CAMPFIRE in partnership with regional district officers of agricultural extension agencies, can use the decision environment approach to bring about improved planning within the financial capacity of rural farmers.

5. CONCLUDING REMARKS

This paper presents the concept of a Decision Environment which recognises a higher-order framework to improve the effectiveness and efficiency of decision making in natural resource management. The seven key elements are: planning opportunity; strategy development; facilitation; information sourcing; decision analysis; the decision outcome and implementation with adaptive management and policy. These seven key elements represent points of consideration in a holistic, semi-structured decision process, yet are continuously reviewed and revisited as part of an iterative process.

In practice, the Decision Environment identifies a hierarchy of decision frameworks for enhanced planning and resource use. This broader construct enables further refinement of each element to reflect the planning opportunity being addressed, so that additional information or particular issues can be included. Once this process is completed, it would be possible to construct a functional software tool that would serve as an information storage, presentation and reporting facility for catchment groups or planning agencies.

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7. REFERENCES

Chaloupka, M., J. Robinson and J. Asafu-Adjaye, Addressing water quality problems through the integration of ecological and economic modelling, Proceedings of the MODSIM 2001 Congress, Canberra, 10-13 December, 2001.

Cramer, L. A. Links between community of place and the commercial fishing community in the Pacific North-West, Abstracts of the International Symposium on Society and Resource Management, The University of Queensland, Brisbane, July 7-10, 1999.

Hajkowicz, S.A. An evaluation of multiple objective decision support for natural resource management. PhD thesis, The University of Queensland, 2000.

Lawrence, P.A., R.J. Shaw, L.J. Lane and R. Eisner, Participatory multiple objective decision making processes: emerging approaches with new challenges. Proceedings of the Watershed Management and Operations Management Conference, *American Soc. Civil Engineering*, Fort Collins Colorado, USA, 20-24 June, 10pp. 2000.

Simon, H.A. The New Science of Management Decision. Harper and Row, New York, 1960.

Thwaites, R.N., C.L. Claridge, P.L. Norman and P.A. Lawrence, A participative action-research model for decision-making in sustainable land use planning for tropical savanna woodlands. In: Rural livelihoods, empowerment and the environment, Proceedings of the 15th International AFSR-E Symposium, Pretoria, RSA, 29 November - 4 December 1998: 337-346, 1998.

Zhu, X. and A.P. Dale, Identifying opportunities for decision support systems in support of regional resource use planning: an approach through soft systems methodology, *Environmental Management,* 26(4): 371-384, 2000.

X. Zhu, J. McCosker, A.P. Dale and R.J. Bischof, Web-based decision support for regional vegetation management, *Computers, Environment and Urban Systems*, 25(6): 67-89, 2001.