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Identifying Opportunities for Decision Support Systems in Support of Regional Resource Use Planning: An Approach Through Soft Systems Methodology

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ABSTRACT / Regional resource use planning relies on key regional stakeholder groups using and having equitable access to appropriate social, economic, and environmental information and assessment tools. Decision support systems (DSS) can improve stakeholder access to such information and analysis tools. Regional resource use planning, however, is a complex process involving multiple issues, multiple assessment criteria, multiple stakeholders, and multiple values. There is a need for an approach to DSS development that can assist in understanding and modeling complex problem situations in regional resource use so that areas where DSSs could provide effective support can be identified, and the user requirements can be well established. This paper presents an approach based on the soft systems methodology for identifying DSS opportunities for regional resource use planning, taking the Central Highlands Region of Queensland, Australia, as a case study.

Australia's regional landscapes provide both environmental (e.g., greenhouse sinks, pollutant purification) and sociocultural (e.g., indigenous spiritualism, wilderness qualities) services. Multiple service demands at the regional level for Australia's natural resource base have raised the profile of resource management conflicts in Australia since the 1970s. These services are increasingly in conflict with the traditional extractive / developmental economic services of extensive and intensified agriculture, exploration, and mining. These conflicting demands for natural resource services underpin a number of sustainability problems in regional Australia, including land degradation and pasture change, biodiversity loss, and the declining viability of some rural communities. Regional approaches to resource use planning have been proposed as one mechanism that could contribute to the solution of these problems (Foran and others 1990, DITRD 1993, Sattler 1993, RAC 1993, OCS 1993, Holmes 1996).

Following a review of regional approaches to resource use planning across Australia, Dale and Bellamy (1998) found that successful approaches are those that promote capacity building within and equitable negotiations among key regional stakeholders. They consider that this requires the use of and equitable access to appropriate social, economic, and environmental information and assessment tools to assist planning conducted by regional stakeholder groups (RSGs). The institutional arrangements within which planning occurs needs to facilitate the structuring, operation, implementation, and monitoring of planning in ways that support effective planning within and negotiation among these stakeholder groups.

To improve the planning capacity of RSGs, quick and easy access to relevant information about the present situation and the possible effects of proposed policy changes is needed. Information and the relationships between pieces of information form the basis of effective and equitable decision making (Sarokin and Schulkin 1991). Fortuitously, in the 1990s, the information technology (IT) revolution has increased the amount, availability, and accessibility of information. We also have witnessed computer systems shifting from storing and reporting data to more intelligent utilisation of available information and knowledge. Decision support systems (DSS) represent computer-based applications for the decision-making process. They help decision makers efficiently and effectively utilize data, information, and knowledge available to solve their problems. DSSs in environmental and natural resource management provide a mechanism for organizing information in a way that allows resource managers to analyze management strategies, evaluate policy alternatives,

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and integrate their own values and perceptions within the planning process (Stuth and Smith 1993). Numerous DSSs have been developed to address particular environmental and natural resource management issues and help make decisions (for examples, see Loh and Rykiel 1992, Nijkamp and Scholten 1993, Stuth and Lyons 1993, Longstaff and Cornish 1994, Fedra 1995, Bellamy and others 1996, Gauthier and Neel 1996, Hastings and others 1996, Smith and others 1997, Hipel and others 1997, Zhu and others 1996). No doubt, DSSs can play a role in resource use decision-making processes by allowing decision makers to: (1) navigate large amounts of information quickly; (2) explore interrelationships between factors that may influence their decisions; (3) facilitate understanding, learning, and negotiation; and (4) improve the basis of interactions among regional stakeholders.

However, the usefulness of DSSs is less a function of the technology itself than of the way in which they are applied (DeSanctis and Poole 1994). The requirements of a DSS for regional resource use planning depend on the specific nature of the planning problem, the mission and objectives of the RSGs involved, environmental (social, cultural, and political) constraints, and institutional arrangements. Therefore, effective DSS development must take into account human and organizational factors. They must perform their tasks well according to set standards, but they also must be acceptable and friendly to the end users, interlink with other information systems, and fit seamlessly into the planning structures and processes as a whole.

Effective DSS design requires explicit attention to the action or task the DSS serves, and to its relevance to particular groups of users in particular situations. Regional resource use planning is increasingly viewed as a political process involving negotiations and trade-offs among key RSGs with an interest in natural resource use outcomes (Dale and Lane 1994). Perceptions and meanings, and hence tasks, involved in this process are often problematic. Therefore, DSS development has to start with an understanding of the planning system. DSS developers need to understand the perceptions of RSGs and find out the meanings they attribute to the flux of events and ideas encompassed within the regional resource use planning process. As such, this paper explores and evaluates the application of soft systems methodology (Checkland 1981) to understand and model complex problem situations in regional resource use planning and to identify DSS opportunities to support the planning process. This approach is described through a case study in the Central Highlands Region of Queensland, Australia.

Soft Systems Methodology and DSS Development for Regional Resource Use Planning

The activity of problem solving often involves first finding out about the situation in which there are perceived problems, and then, through some analysis, leading to decisions about what to do and taking actions to alleviate those problems. Soft systems methodology (SSM) is developed primarily as a general problem-structuring methodology for examining problem situations in a way that would lead to decisions on actions (Checkland 1988, Checkland and Scholes 1990, Wilson 1990). By highlighting major issues and allowing different views in the problem situation to be explored, SSM helps those involved to learn their way toward appropriate actions.

SSM involves systems thinking, where the concept of "system" embodies the idea of a set of elements connected together that form a whole, showing properties that are properties of the whole and are meaningless in terms of the parts which make up the whole (Checkland 1981). The "system" here has within it activities and structures concerned with communication and control, and also has the potential for survival in a changing environment. If such a system expresses a set of human activities so linked as to form a purposeful whole, it is regarded as a "human activity system" (Checkland 1981, Wilson 1990). Human activity systems can be manifest only as perceptions by human actors who are free to attribute meaning to what they perceive. There will never be a single account of a human activity system, only a set of possible accounts all valid according to particular points of view (Checkland 1981). Therefore, human activity systems are notional systems. They are not descriptions of actual real-world activity, but intellectual constructs for use in a debate about possible actions that might be introduced into a real-world problem situation. Systems thinking in SSM is consciously organized thought that makes use of the idea of the human activity system. It is conducted to set some constructed abstract wholes, often called "systems models," against the perceived real world in order to learn about it. SSM is developed as a systematic process of inquiry that makes use of systems models.

A systems model of a human activity system is based on an explicit recognition of the *Weltanschauung*, or worldview, of some interested party (Checkland and Scholes 1990). It is the *Weltanschauung* that makes the definition of a human activity system meaningful. SSM selects some human activity systems relevant to taking purposeful action in a problem situation and builds a number of systems models of them based on the

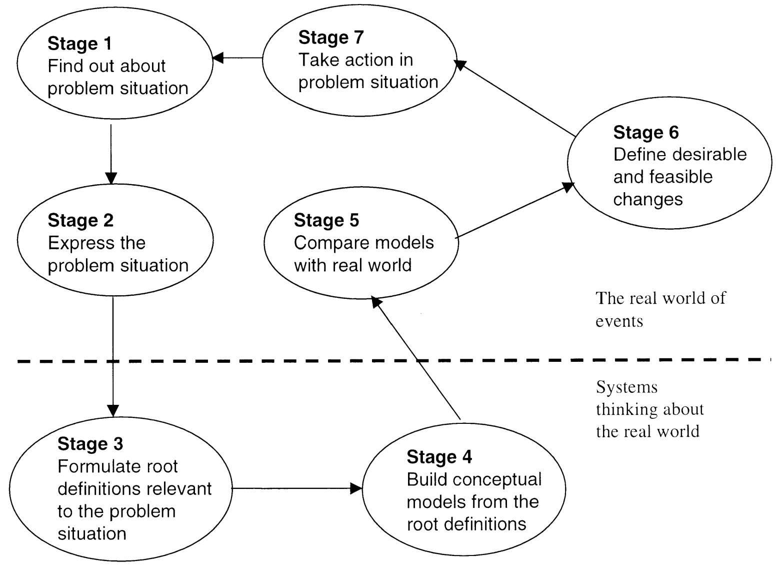

Figure 1. Soft systems methodology (adapted from Checkland 1985).

different *Weltanschauung*. A purposeful action means a deliberate, decided, or willed action by an individual or by a group. There are potentially as many systems models of a human activity system as there are interested parties. The models are not models of real-world activity, but accounts of some ways of perceiving it. They are models to be used in the problem situation to provide structure to a debate about what to do.

SSM can be described as a seven-stage process of analysis (Figure 1). The first two stages are concerned with understanding the situation, in which there is perceived to be a problem. The objectives are to find out what makes the situation problematic and to obtain some basic facts about it.

In stage 3, the problem situation is viewed in ways that will produce or improve insight about the problem. This is achieved by producing root definitions of relevant human activity systems. A root definition is a concise description of a human activity system, which states what the system is. It incorporates the point of view, transformation process, and environmental constraints that make the activities and performance of the system meaningful (Smyth and Checkland 1976). It is here that the *Weltanschauung* is made explicit. For example, a root definition of a human activity system in regional road planning could be: A system owned by the Department of Main Roads for identifying road demands of the public in a region, formulating and implementing the road investment plan to satisfy those demands in order to improve regional economic development while ensuring the appropriate balance with social justice, safety and environmental sustainability. A root definition should consist of the six elements, listed in Table 1, acronymized as CATWOE (Smyth and Checkland 1976). Table 1 explores the CATWOE elements relevant to the root definition above.

Stage 4 is concerned with the logical expansion of the root definition into the activities that the system must carry out. This leads to conceptual models consisting of those minimum necessary activities connected together. A conceptual model elaborates what a human activity system does. Only activities that could be directly carried out should be included. Conceptual models are constructed using a structured set of verbs. Arrows are used to connect the activities, which indicate logical dependencies. More details about how to build conceptual models are described in Checkland (1981). Figure 2 shows a conceptual model built from the root definition described above.

In stage 5, comparison of the conceptual models with real-world perceptions and happenings is undertaken. The purpose of this comparison is to generate a debate with interested parties in the problem situation. The debate aims to disclose the different constructions people in the problem situation place on the happenings and to find some kind of accommodation between different, sometimes conflicting constructions.

The purpose of stage 6 is to identify possible changes and actions, which could be introduced in the problem situation, from those recommended through the debate conducted in stage 5. The discussion of changes should be with interested parties in the problem situation. The changes should be both arguably desirable and culturally feasible given the people involved, prevailing attitudes, shared experiences, and prejudices (Checkland 1985).

Once desirable and feasible changes are defined, actions are taken in stage 7 to improve the problem

Table 1. The definitions of CATWOE elements (adapted from Smyth and Checkland 1976)

Consideration	Amplification	Example for regional road planning
C—Customer	Client (of the activity), beneficiary or victim of the transformation process(es)	The public
A—Actor(s)	The agents who carry out, or cause to be carried out, the transformation process(es) or activities of the system	The Department of Main Roads (DMR)
T—Transformation	A transformation process carried out by the system; assumed to include the direct object of the main activity verb(s)	From perceived demands on roads to satisfaction of those demands
W—*Weltanschauung*	The (often unquestioned) outlook or taken-for-granted framework, which makes this particular root definition a meaningful one	A road investment plan must create a road system that can improve regional economic development
O—Ownership	Ownership of the system, control, concern or sponsorship; a wider system that may discourse about the system	DMR
E—Environmental and system constraints	Environmental impositions, elements outside the system which it takes as given	Social justice, safety, environmental sustainability

situation. This involves the implementation of the changes, which in fact defines a new problem situation. In this new problem situation, the whole process can begin again.

The outcome of the SSM analysis is never an optimal solution to a problem; rather it is a learning that leads to choice of purposeful action. SSM studies are always multivalued, with many relevant and often conflicting values to be explored (Checkland 1981). With this nature, SSM provides a useful framework to explore the problem situation in regional resource use planning in order to define appropriate DSS development strategies to support the planning process.

Regional resource use planning aims at sustainable resource use in a region. Sustainable regional resource use depends on the regional management perspectives of key RSGs, their capacity to achieve their management objectives, and the response of the physical resources to particular regional management decisions. Figure 3 describes the key elements in achieving regional resource sustainability. It is characterized by multiple stakeholders with conflicting and multiple perspectives involved in resource management issues. Therefore, DSS development in support of regional resource use planning is a difficult process of inquiry. It must start with a sound understanding of the planning system and purposeful actions involved in it. Having obtained that understanding, we can analyze the regional resource use planning system as a set of interrelated human activity systems, which consist of sets of purposeful planning activities to deal with planning and monitoring the use of regional natural resources. Conceptual models of the human activity systems can be built. They are used to conduct an open inquiry that orchestrates a debate among the key RSGs. By posing different ways of looking at the situation in regional resource use and management, SSM helps get them to reflect on those views, thereby coming to some insight as to changes they would like to make.

After several cycles of SSM analysis, models that accommodate the views of different RSGs and that are widely agreed to be relevant in the planning situation evolve. These models are then used to elicit the DSS needs by asking about each activity in the planning system: How is this activity currently carried out? What information is required to perform this activity? The answers to the two questions then take us into the analysis of what DSS can contribute to this activity, hence identification of activity-specific DSS opportunities.

Figure 4 illustrates the process of identifying DSS opportunities in regional resource use planning through SSM. This process has been used in our case study in the Central Highlands of Queensland, which is discussed in the following sections.

Understanding the Problem Situation

Queensland's Central Highlands region comprises five shires (Figure 5). It is one of those rangelands regions in Australia where the environment has come under increasing pressure from the frequently conflict-

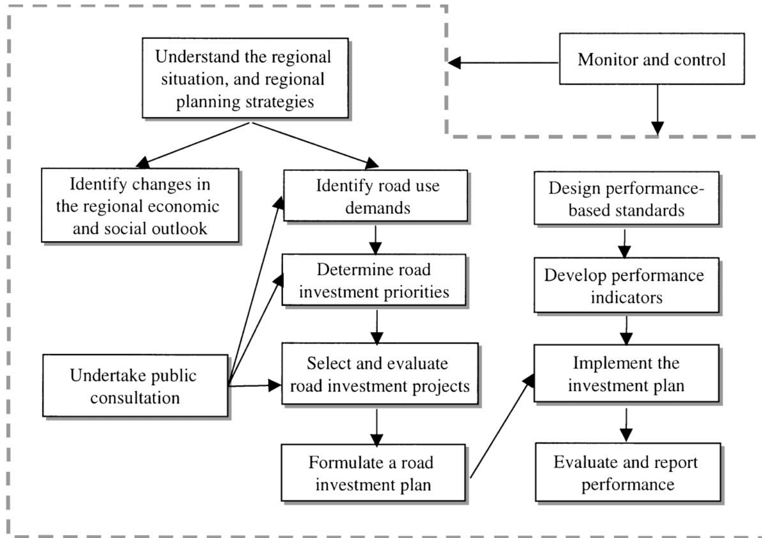

Figure 2. An SSM conceptual model for regional road planning.

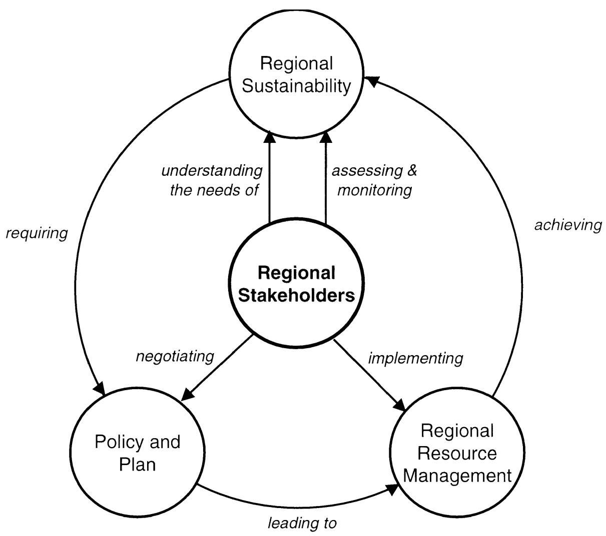

Figure 3. Key elements in achieving regional sustainability.

ing demands of agricultural intensification and growing mining development.

The main RSGs with an interest in natural resource management in the Central Highlands include: (1) state and federal government agencies; (2) local governments; (3) economic development organizations; (4) community-sector human services agencies; (5) the mining and exploration industries; (6) conservation interests; (7) pastoralists and meat processors; (8) Aboriginal groups; (9) broad-acre grain growers; (10) horticultural producers and cotton irrigators; (11) land care and catchment groups; (12) research and education organizations; (13) commercial service providers; (14) recreational fishing interests; (15) timber producers, millers, and harvesters; and (16) bee keepers. Different RSGs perform their own planning activities. Although the region is increasingly being valued for its environmental and cultural qualities, there has not been an integrated regional effort to apply effective resource use planning in the past. This has led to a number of regional problems, including land degradation, pasture change, the spread of weeds and feral animals, declining rural community populations and social support services, and increasing farm debt. There are greater demands for the protection of regional resources and the environment, and the maintenance of regional sustainability.

Resource use planning in this region was a largely centralized process, focusing on the development of regional structure plans used by centralized authorities (i.e., single-purpose agencies) to regulate land use. It has been recognized that such planning is not effective in either reaching binding agreements between RSGs or in managing conflicts when megadevelopment proposals are presented for assessment by regulatory agencies (Dale and Lane 1994). In order to improve regional planning, facilitate and coordinate planning activities undertaken by the RSGs, a regional coordinating committee (RCC) was established. The main role of the RCC is to provide project direction, coordination, and cross-region communication. Representatives from each major RSG undertaking planning are involved in the operation of the RCC. The RCC members do not make decisions for RSGs, but facilitate negotiation and coordination among them. Regional planning is now moving toward an equitable negotiation and bargaining process that involves mediation of a complex range of perspec-

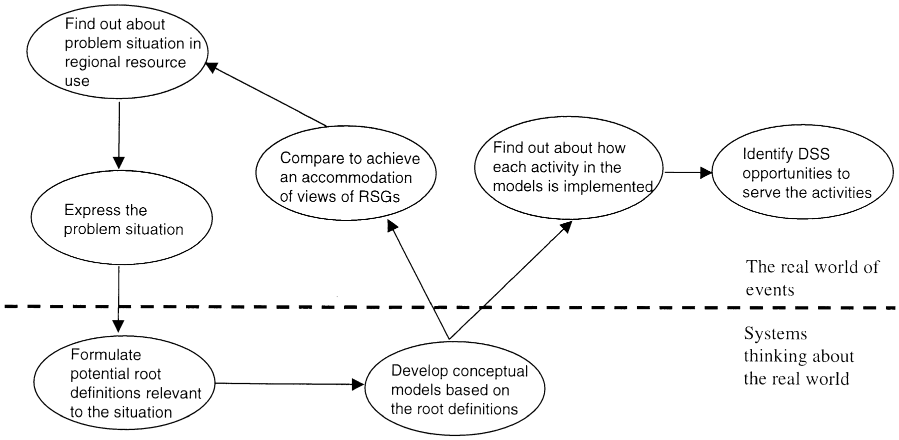

Figure 4. Process for identifying DSS opportunities through SSM.

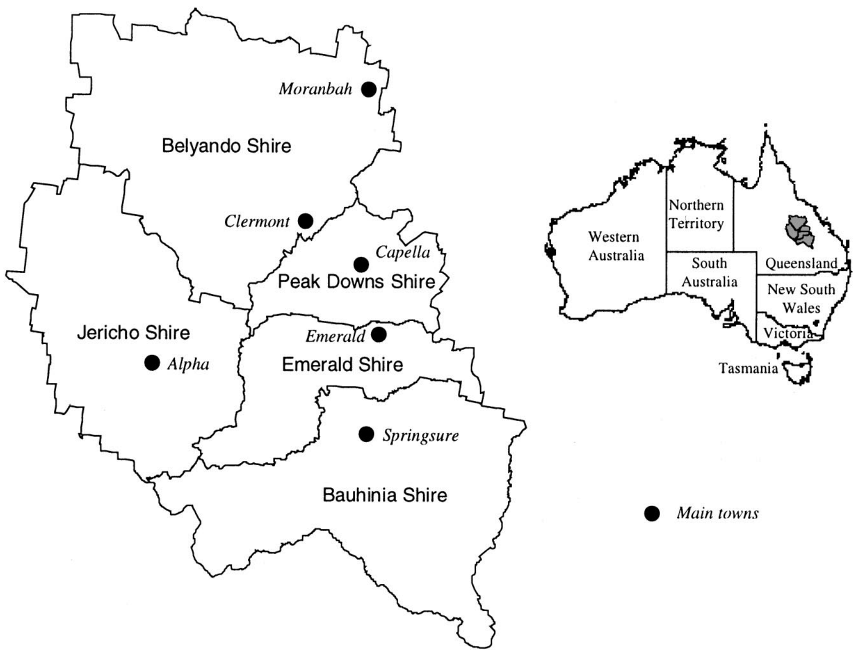

Figure 5. The Central Highlands Region in Queensland, Australia.

tive involved in regional resource management issues from the RSGs.

A major research project, the Central Highlands Regional Resource Use Planning Project (CHRRUPP) is currently exploring ways to facilitate improved planning within these RSGs and equitable negotiations among them (Dale and others 1998). It seeks to:

- apply accepted and technically sound social, economic, and environmental assessment methods to underpin the planning and negotiation processes;
- set up appropriate institutional arrangements to facilitate effective negotiation; and
- establish mechanisms to build the capacity of stakeholder groups involved in regional resource use and management (Dale 1998).

CHRRUPP considers equal access to information and information technology to be crucial for the success of negotiated regional resource use planning in the Central Highlands. However, at present, there is a limited use of information technology for regional planning in this region. Large RSGs, such as government agencies and R&D institutions deal with large amounts of data. They have developed some DSSs for processing, managing, and analyzing the data. But these

DSSs simply help the agencies to understand resource management issues from the technical perspective and support the planning processes of single agencies. Information is equally important to small RSGs, but very few of them have the resources needed to build or buy their own data management, modeling, and DSS tools. This greatly limits their ability for information access, management, and analysis. In response to this situation, development of DSS was initiated as part of the CHRRUPP to help build the planning capacity of the RSGs and support negotiated regional resource use planning process.

Since different RSGs have different perceived information and decision support needs, DSS development in CHRRUPP aims to provide decision support tools for the tasks and processes that are widely agreed by the key RSGs to be relevant to the negotiation and capacity building in regional resource use planning. Those tasks and processes need to be identified so that DSS requirements can be defined.

Developing Conceptual Models of Human Activity Systems Relevant to Negotiated Regional Resource Use Planning

Regional resource use planning involves negotiation, discussion, evaluation, and analysis, all aimed at resolving underlying conflicts and uncertainties and at forming a shared understanding of regional problems and possible solutions. The RCC regularly hosts regional coordination conferences to allow RSG representatives to meet and discuss issues of importance to the region. These representatives come from a variety of backgrounds and have different values. From these regional coordination conferences and other interactions with the major RSGs, many ideas for human activity systems relevant to regional resource use planning emerged, including:

- A system to facilitate interaction among and between RSGs toward the negotiation of regional resource use strategies and priorities in order to achieve regional sustainability.
- A system to provide resources to enable RSGs to build planning capacity, improve the understanding of the constituents of major RSGs regarding the significant resource use and sustainability issues, and respond to and operate under evolving conditions.
- A system to explore the common themes in regional resource use and expose and resolve conflicts through social debate.
- A system to address interrelationships between biophysical, human, and economic factors relevant to regional resource use and management.
- A system to carry out social impact and environmental assessment of regional resource use plans.
- A system to make trade-offs among a broad range of resource use options in the region and maximize agreement among RSGs.
- A system to monitor and coordinate planning activities in the region.
- A system to bargain and negotiate individual plans developed by each RSG within the constraints of law.
- A system to allocate limited resources among RSGs.
- A system for deciding the optimal location of key regional infrastructure.

After accommodating different views from the key RSGs and based on priorities within the planning process, we selected two relevant human activity systems for investigation of DSS opportunities. The two human activity systems are regarded as most relevant to the situation in regional resource use planning in the region. Their root definitions and corresponding conceptual models were built. The two root definitions are presented in Table 2.

Figure 6 shows the conceptual model derived from Root Definition 1 in Table 2. It is concerned with collaborative decision making among key RSGs in regional resource use planning, coordinated by the RCC. The conceptual model based on Root Definition 2 is shown in Figure 7. It is concerned with possible changes in regional resource use, and subsequent impacts on individual RSGs. The model is relevant to RSGs with an interest in regional natural resource management. These RSGs also interact with the external environment and make decisions to respond to the likely changes in regional resource use and management.

After the models were built, we used them to find out how the activities from each model are currently carried out and what information they require. Tables were used to list the activities from the models, current practice for undertaking these activities and their information requirements.

Tables 3 and 4 were created for the two models represented in Figures 6 and 7. The second column in each table presents our findings regarding how the activities in the two models are undertaken in the real world and what information they possibly need. These provided a basis for the debate among the relevant members of the CHRRUPP team on how DSS can contribute to those activities. The third columns of the

Table 2. Two root definitions relevant to regional planning systems in the Central Highlands

Consideration	Root definition 1	Root definition 2
Definition	A system owned by the RCC. It identifies and evaluates the options for resolving natural resource management issues, the conflict of interests among RSGs, and seeks to formulate negotiated resource use and management strategies to achieve regional sustainability.	A system owned by an RSG. It provides information to decision makers in the RSG for identifying and evaluating possible regional resource use issues likely to impact on them. It proposes likely responses to those issues, with minimum conflicts with the interests of other RSGs and the general public.
C—Customer	Decision makers from participating RSGs.	Decision makers in the RSG.
A—Actor(s)	The RCC members and external experts.	Decision makers and other personnel in the RSG.
T—Transformation	From regional resource use issues and conflicts to negotiated regional resource use management agreements.	From regional resource issues to determining the impacts of these issues on the RSG and likely responses.
W—*Weltanschauung*	Regional resource use planning must be based on equitable negotiations among key RSGs. There is a need to maximize consensus on regional resource use and management, promote regional development and social equity, and at the same time maintain regional resource sustainability.	The RSG needs to respond and operate under evolving conditions.
O—Ownership	The RCC.	The RSG.
E—Environmental and system constraints	Institutional arrangements and the constraints that come from having due regard for the regional resource base, and the interests of all RSGs and the general public.	Institutional arrangements and the constraints that come from having due regard for the interests of other RSGs and the general public.

tables list potential DSS contributions as the outcome of the debate.

Identifying Opportunities for DSSs in Support of Regional Resource Use Planning

By analyzing Tables 3 and 4 derived from the SSM study described above, we found that quick and equitable access to information and knowledge by all RSGs is important for all activities involved in negotiated regional resource use planning. A number of decision support tools to address specific issues are needed and must be easily accessible to all RSGs. In addition, decision making in regional resource planning is a shared process among the RSGs. It requires a focus on group work rather than one-to-one contact. Therefore, there is a need for a DSS to provide support to group tasks including the generation and exchange of ideas and opinions among group members.

Based on this understanding, we decided to develop an overarching DSS with various decision support functions through the use of the World Wide Web and Internet technology. This led to the development of the CHRRUPP Regional Planning Information Service (http://chris.tag.csiro.au/chrrupp/). The service can be regarded as a Web-based overarching DSS that provides all RSGs with easy and equitable access to relevant information, knowledge, and several decision support tools. The Web has the easy-to-use interface and places minimal constraints on users' hardware and software environment while allowing them to use DSS products residing on different kinds of computing platforms. The Web browsers are available for all the major computing platforms and their installation at client sites is relatively easy. The CHRRUPP Regional Planning Information Service is maintained at one site (currently hosted in CSIRO Tropical Agriculture). Therefore, all RSGs do not need resources and expertise to maintain the information and decision support tools.

The decision support functions, which have been included and are to be included in the CHRRUPP Regional Planning Information Service, are defined by prioritizing the ideas listed in Tables 3 and 4. They range from information provision and knowledge-based support to analytical modeling and group task support.

Information Provision

The CHRRUPP Regional Planning Information Service provides RSGs with equitable access to regional information (Bischof and others 1999). This includes

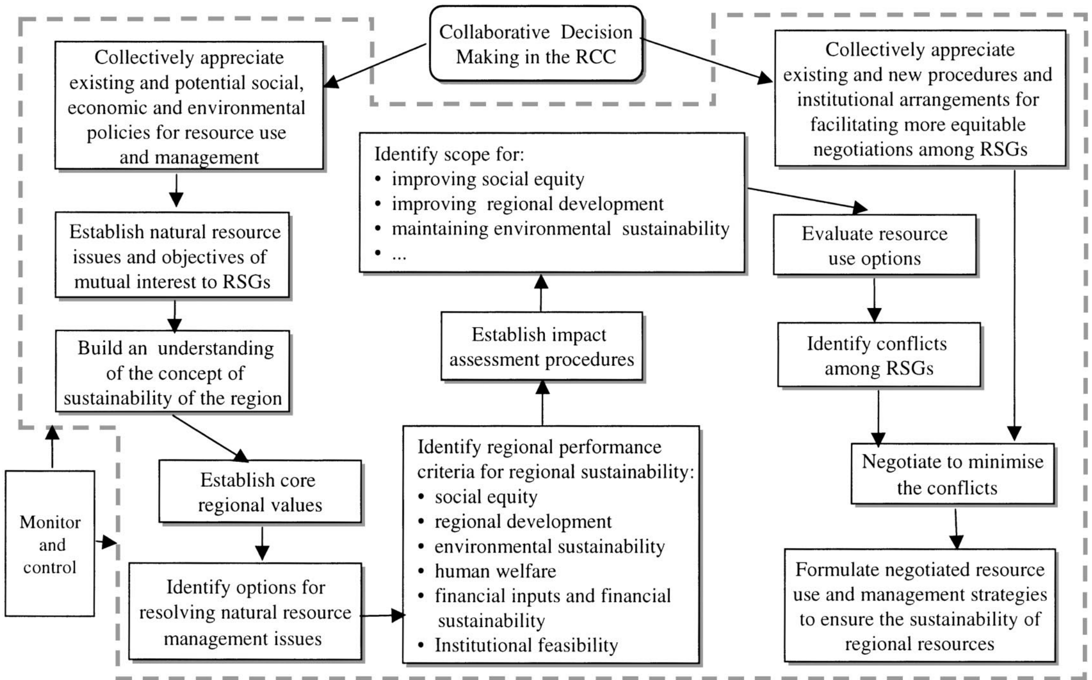

Figure 6. An SSM conceptual model derived from root definition 1 in Table 2.

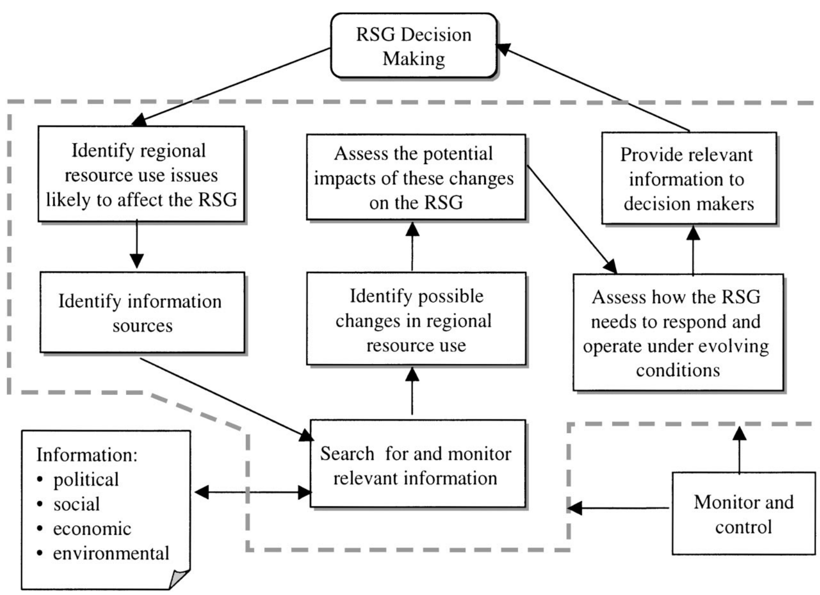

Figure 7. An SSM conceptual model derived from root definition 2 in Table 2.

the regional resources available with their current state and trends, the institutional arrangements and government policies for capacity building, information about individual RSGs, funding opportunities, facilitatory and technical services, data and information directory and sources, relevant research projects and planning activities, and so on. Most of the information is stored and maintained in a database. The system provides easy navigation and search of the information. A Web-based map browser, WebMap (http://chris.tag.csiro.au/webmap/), was developed to provide mapping and query of spatial or map-based information.

Knowledge-Based Support

The CHRRUPP Regional Planning Information Service provides several knowledge bases to support the

Table 3. Comparison of activities in the model from root definition 1

Activity	How currently performed	What DSSs could contribute
Appreciate existing and potential social, economic, and environmental policies for resource use and management	Limited structures for intergroup discussion. Some RSGs read relevant documents and discuss in group.	Provide document management. Allow for quick and easy navigation of documents in a collective environment.
Establish natural resource issues and objectives of mutual interest to RSGs	Discuss in group. Exchange ideas on specific issues, and comment on these ideas. Prioritize regional resource use issues.	Provide structured issue-based analysis for group discussion. Organize results of idea generation. Highlight key issues. Provide and maintain regional databases that hold statistic data on all sectors in the region, and other resource information, provide ability to link and scan databases, and help in accessing databases rapidly and efficiently. Allow information from external sources to be merged into the issue analysis.
Build an understanding of the concept of sustainability of the region	Workshops, formal and informal discussions. Identify key barriers to sustainability.	Provide information about industry, environment, culture, and heritage in the region.
Establish core regional values	Based on decision makers' experience and value judgments, and information on regional resource use situations. Discuss in group.	Elicit decision makers' value judgments, synthesize all the information.
Identify options for resolving natural resource management issues	Use decision makers' knowledge and expertise, and information on regional resource use situations. Discuss in group.	Provide and maintain knowledge bases for interpreting information, and rendering advice regarding the nature of the natural resource management issues, and possible options for resolving these issues. Provide and maintain databases that store large volumes of information across all sectors in the region. Allow for easy, quick, and efficient query and update of the databases. Link and scan databases.
Identify regional performance criteria for regional sustainability	Use decision makers' knowledge and expertise, information on regional resource use situations. Discuss and negotiate. Draw on expert knowledge and technical expertise from a wide range of disciplines (e.g., economists, hydrologists, ecologists, natural resource scientists, and planners).	Provide and maintain knowledge bases that hold expert knowledge and technical expertise regarding regional performance criteria for regional sustainability.
Establish impact assessment procedures	Based on decision makers' judgment, and data analyses. Draw on expert knowledge and technical expertise from a wide range of disciplines.	Provide problem-solving techniques, including analytical modeling (e.g., cost-benefit analysis, multicriteria analysis, optimization, risk assessment) and qualitative analysis (using heuristic expertise).
Identify scope for the regional performance criteria	Based on decision makers' judgment and preferences, experts' expertise, and information on new technology, management strategies, and new research results.	Elicit decision makers' preferences, integrate the preferences with expert expertise. Provide and maintain a database of information on new technology, management strategies, and new research results.
Evaluate resource use options	Based on decision makers' judgment, preferences, and experts' expertise.	Apply analytical techniques appropriate to the evaluation (e.g., multicriteria analysis). Provide knowledge bases and qualitative analysis (heuristic reasoning) mechanisms for the evaluation where analytical techniques are inappropriate. Provide advice on the suitability and feasibility of resource use options and on the likelihood of success of the selected options. Provide explanation and justification of evaluation results.
Identify conflicts among RSGs	Discuss in group.	Analyze data through modeling. Detect and highlight conflicts.

Table 3. (Continued)

Activity	How currently performed	What DSSs could contribute
Appreciate existing and new procedures and institutional arrangements for facilitating more equitable negotiations among RSGs	Read documents and discuss in group. There is no explicit structured institutional basis for structuring negotiation, and as such, there is no clear system for analysis of procedures.	Provide document management. Allow for quick and easy navigation of documents. Encourage formal consideration of appropriate negotiation structures.
Negotiate to minimize the conflicts	Discuss and negotiate. Design rules of negotiation. Each participant indicates views and preferences. A facilitator helps the participants reach an agreement.	Facilitate communication among participants. Help facilitate and integrate participants' views to build a joint problem representation. Provide access to data and models. Provide communication facilities for both participants and the facilitator.
Formulate negotiated resource use and management strategies to ensure the sustainability of regional resources	Discuss in group and build consensus. Jointly create a document that states regional resource use and management strategies.	Consensus seeking. Voting (recording all participants' votes, tabulating them, and displaying results for all to see). Report generation.

management of natural resources and infrastructure development planning in the region. A prototype of the regional vegetation management system, called VegMan (http://chris.tag.csiro.au/chrrupp/Plan/VegMan/), is accessible within the system. VegMan contains a knowledge base storing and managing regional vegetation information including the current situation, conservation status, retention requirements, and management recommendations for each vegetation community in the region. It also provides access to maps and photos of vegetation resources in the region and updated government policies and legislation regarding regional vegetation management.

Similar knowledge-based systems for pest and weed management are going to be developed and incorporated into the CHRRUPP Regional Planning Information Service. These systems aim to promote greater awareness by all RSGs of major resource use issues in the region and help them undertake their planning activities by taking these issues into account.

An integrated knowledge-based DSS for regional road infrastructure development planning is also under development. This system will initially help the local governments evaluate and prioritize transport infrastructure development projects on local government-controlled roads. The outcomes from the system will be used to justify and select TIDS (Transport Infrastructure Development Scheme) funding applications to the Queensland Department of Main Roads. The system will integrate knowledge-based systems technology with multicriteria analysis techniques to guide decision makers through the process of project evaluation, helps them gain a better understanding of the issues, factors, and criteria involved in the project evaluation. It aims to provide the local governments access to the same knowledge and information so that they are able to standardize the evaluation process and improve the consistency in decision making.

Analytical Modeling

Two analytical modeling tools have been developed for evaluation of resource use options, prioritization of resource use issues and planning projects, and allocation of resources. The first one is JavaAHP, a multicriteria analysis tool, which is now available within the CHRRUPP Regional Planning Information Service (http://chris.tag.csiro.au/JavaAHP/). It implements the Analytical Hierarchy Process (AHP). AHP is a methodology for multicriteria analysis and decision making (Saaty 1980). JavaAHP uses the AHP methodology to model a planning problem, evaluate relative desirability of alternatives, organize and synthesize the information and judgments used in decision making.

The second one is MOCA, which integrates JavaAHP and goal programming (Lee 1972). It adds the mathematical optimizing function to multicriteria analysis (Zhu 1999). MOCA can be used to assist in developing regional resource use planning strategies. The first prototype of MOCA is running as a standalone application. It will be migrated to the Web and incorporated into the CHRRUPP Regional Planning Information Service.

Group Work Support

JavaAHP and MOCA can support both individual and group work. They use the AHP methodology to provide a framework for group participation. This can be achieved by allowing the conflicting groups to jointly structure the problem from the beginning and bring their judgments closer together through debating and bargaining. Both tools have the report generation function. The voting function, which records, displays,

Table 4. Comparison of activities in the model from root definition 2

Activity	How currently performed	What DSSs could contribute
Identify regional resource use issues likely to affect the RSG	Decision makers perform the activity based on intuitive judgment, the business objectives of the RSG, comparison with other RSGs business objectives, and past experience of events in the region. Dependent on knowledge and expertise of individuals or groups.	Provide, enhance, and maintain knowledge base of experience and expertise. Provide information about the region, the regional resource use issues, and information about what other RSGs have done in comparable situations. Highlight and bring out dependent and key regional resource use issues that are likely to affect the RSG.
Identify information sources	No common system of information management and dissemination exists. RSGs seek information in an ad hoc fashion from other RSGs including government agencies and research institutions, information suppliers, consultancy, experience, personal contact, etc.	Provide, enhance, and maintain a database of sources of information. Allow for an easy and quick search for relevant information sources.
Search for and monitor relevant information	No consistent system that facilitates information searching exists. Generally, subscribe for information, pay for / do research, run training or education programs, read information.	Provide and maintain meta-databases that enhance access to large volumes of information. Allow for easy, quick, and efficient query, and update of the databases. Link and scan external and internal databases. Provide continuous monitoring of both external and internal information.
Identify possible changes in regional resource use	Limited use of GIS and DSS technology to evaluate alternatives. Detailed investigations through scanning external and internal information, and communications with other RSGs.	Provide ability to scan and link external and internal databases. Analyze information quickly through quantitative modeling or qualitative analysis.
Assess the potential impacts of these changes on the RSG	Based on individual decision maker's judgment, and data analyses.	Perform impact assessment through quantitative modeling or qualitative analysis.
Assess how the RSG needs to respond and operate under evolving conditions	Based on individual decision maker's judgment, data analyses, and scenarios analysis. Prepare an action plan for the RSG to act.	Test different scenarios, identify the best or "good-enough" alternatives through "what-if," goal-seeking analyses, and risk assessment.
Provide relevant information to decision makers	Prepare reports by the RSG staff and present them to decision makers. Report elements may include summarization, comparison, prediction, and confirmation.	Generate reports. Provide quick and automated reporting.

and summarizes participants' votes, is going to be added to JavaAHP.

In addition, several email discussion groups are setting up for exchanging and archiving ideas and opinions regarding regional planning issues from the RSGs. It aims to promote the mutual understanding between them.

Discussion and Conclusion

Regional resource use planning aims to achieve regional sustainability. The complexity of natural resources and the diverse interests of RSGs make it a complicated process. To make an informed decision, all pertinent information must be collected, analyzed, integrated, and synthesized. DSSs offer capabilities for effective utilization and integration of information to support decision making. They can be viewed as supporting components within the planning process. As argued above, a DSS can only function effectively if it is properly integrated in the planning process and the problem situation in which it is operational. Identifying promising areas where DSSs can provide added value to the RSGs for decision making in regional resource use planning is the first step for effective DSS development. We found that SSM provided a useful framework for understanding the regional resource use planning system and the analysis of DSS needs.

One strength of SSM is that it provides a means of constructing a picture in models of purposeful activity that could be related all planning activities with DSS support. DSSs are designed to support planning activities through sophisticated information management. They must match work tasks of the RSGs in order to bring improvements in work effectiveness. Therefore, DSS development must be based on an understanding of the activities that the DSSs will serve and the structures for carrying out those activities. SSM conceptual models can provide an activity-focused view of a regional planning system. They show what major planning activities are involved and how they are related to each other, or at least how they should be arranged and connected logically. Therefore, they can serve as the foundation for a set of recommendations for introducing DSS technology.

A second strength of SSM is that it provides a basis for coherent discussion of the objectives, structures, and activities involved in the planning process and DSS needs. DSSs must be designed to serve the needs of the RSGs and must be developed on the basis of the RSGs' view of the problem situation. SSM describes a human activity system by using system definitions consisting of root definitions, CATWOE declarations, and conceptual models. A system definition represents a particular view about the problem situation. The conceptual models can serve as a communication tool. They provide a basis for discussion with the RSGs of what ought to be done to achieve the objectives specified in the root definition. The discussion and debate on the system definitions and comparing them with the real world situation may lead to widely agreed conceptual models from which the requirements of DSS can be identified.

In addition, SSM analysis focuses on the problem situation rather than a particular problem. It starts from thinking about the problem situation and moves to thinking about what can be done about the problem situation. This emphasis on the problem situation can help gain a better understanding of the relationship between DSS applications and the planning process, so that the DSS could be developed to improve planning decision-making process not just provide one-off solutions to a particular problem.

In this paper, we have presented an SSM approach to identify DSS opportunities to support the regional resource use planning process. DSS capabilities relevant to purposeful activities were defined by analysing SSM conceptual models and asking what activity model needs could be supported by DSSs. The research conducted on DSSs in relation to SSM modeling has been instrumental in defining and prioritizing the needs of DSS for regional resource use planning in the Central Highlands Region, leading to the development of a Web-based overarching DSS, the CHRRUPP Regional Planning Information Service. The service consists of various decision support functions ranging from information provision, knowledge-based support, analytical modeling, to group task support.

In the case of the Central Highlands Region, readers may think of human activity systems that are more relevant than those selected in this paper. As Checkland (1981) argued that there would never be a single account of a human activity system, only a set of possible accounts all valid according to particular *Weltanschauung*. The important point is that SSM facilitates the debate on ideas of relevant human activity systems, and makes the debate more open and explicit. The systems we selected have been shown to be highly relevant to the situation in our case study. This research also indicates the potential use of SSM in doing so in other regions.

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