PARTICIPATORY MULTIPLE OBJECTIVE DECISION MAKING PROCESSES: Emerging approaches with new challenges.

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Introduction

For effective watershed management, data, technology and science need to be integrated with social, environmental and economic elements while recognising spatial and temporal variability. In Queensland, Australia, the direction in natural resource management is towards transparent, multi-objective, multi-stakeholder partnerships between government, industry and community groups for the allocation and use of watershed resources. This means holistic, transdisciplinary approaches to the sustainable, multiple use of resources are required, and that the process of engaging watershed stakeholders is both effective and efficient.

The move towards a systems-based approach to evaluate management options has been facilitated by the development of multiple objective decision support systems (MODSS) to evaluate trade-offs between numerous and possibly conflicting objectives. However, the implementation of such tools requires a methodology to maximise participation by stakeholders and to ensure the decision making process is equitable, constructive and effective.

This paper describes the process and initial outcomes where a multi-stakeholder, participatory decision making approach is used to evaluate and prioritise proposed water infrastructure developments in northern Queensland, Australia. The study examines four possible dam sites, each with three spillway heights, and is promoted by the Queensland Department of Natural Resources (QDNR). What emerges from this study is that the outcomes are dependent on the process of facilitation as much as the utility of a multiple objective decision support system. In addition, there is a better opportunity for the stakeholders to identify a “consensus” option when they are involved early in the process, and there is sufficient time to allow the stakeholders to explore scenarios in order to satisfy their concerns and preferences.

Stakeholder Involvement

Australia has a number of participatory programs for undertaking natural resource management. Nationally, natural resource decision making is influenced by the release of a National Strategy for Ecologically Sustainable Development (NSESD). This document establishes the guiding principles to promote "development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends." (Australian Commonwealth, 1992). The strategy is applicable for the sustainable development in agriculture, fisheries, forestry, urban planning, tourism and energy by the public sector. Within this broad context, the NSESD provides protection for biological diversity, ecological processes, intergenerational equity and enhancement of the economic well-being of individuals and community groups. Despite the broad policy statement, the NSESD provides a framework for the development of public and community based processes for decision making in natural resource management.

Landcare is perhaps one of most successful community-based programs for natural resource conservation within Australia. It is closely associated with "grass roots" community involvement and based on the notion that participatory decision making and remedial works by those who "own" the problem is fundamental to defining and implementing solutions (Campbell 1994). This approach is seen as being far more effective than seeking isolated government help. Typically, Landcare groups would form based on issues, and not necessary from geographical locations. Together, the members of the Landcare group would lead towards increased awareness and changes in attitudes towards on-farm practices and interactions between land and water resources. Rickson et al.(1995) suggest the national Landcare program is one of the world's largest community-based resource management initiatives in terms of participation and government funding. Certainly, there is widespread awareness by farmers, with a survey in 1994 indicating more than 90% of country's farmers are aware of the Landcare movement (Mues et al., 1994). Currently, there are in excess of 3000 Landcare groups across the country.

In support of the national Landcare program, each State in Australia has developed approaches towards watershed planning and management. In 1991, the Queensland State Government initiated the Integrated Catchment Management (ICM) strategy. This strategy recognises the connections and balanced use of land, water and biological resources, and promoted the use of a hydrological catchment as the basis for planning (Dawson 1993). The recognition of downstream impacts of land use practices was an important shift in focus from the on-farm activities undertaken within Landcare. In addition, the ICM strategy provided a coordinated approach for government agencies, catchment community groups and industry sectors to undertake within a catchment. The success of ICM within Queensland is mixed. While the approach has achieved better coordination of resource management activities, the success of many ICM groups is somewhat dependent on the catchment coordinator for information, funds and activities. Further, in a survey of ICM groups in Queensland, McDonald and Shrubsole (1996) found that many groups preferred less government intervention, and that there was no universal approach towards the integration of social and political considerations with biophysical resources to support decision making by catchment groups. Currently in Queensland, there is no legislative support for ICM plans, although this is not the case in all other States.

Participatory Decision Making

There is a need for structured, non-interventionist and efficient approaches towards participatory decision making. Through this process, stakeholders become empowered to explore options that are feasible and within their capacity to change. In addition, the process integrates stakeholder perspectives, and ensures all participants see the problem in the same way. This is particularly important when the problem to be resolved involves a considerable amount of technical information.

Further, there is a better opportunity to resolve problems and reach consensus when stakeholders are involved early in the planning phase.

The Queensland Department of Natural Resources, Resource Sciences and Knowledge (QDNR-RSK) has developed a generic approach for undertaking a multi-stakeholder, multi-objective decision making in natural resource management. The approach involves a process of stakeholder engagement throughout the entire decision making phase. The process supports the principles of group decision making, and allows individuals to express their concerns and preferences. This process is schematically shown in Figure 1. The components within the process involve:

- A statement of the issue to be resolved
- Identification of the stakeholders who need to be involved
- Defining the feasible resource management options
- Defining the decision criteria to evaluate the options
- Establish an issues matrix to quantify the impact of each option
- Allow stakeholders to assemble the decision criteria into an order of importance
- Undertake MODSS analyses based on stakeholder scenarios
- Prioritise the options for further discussions

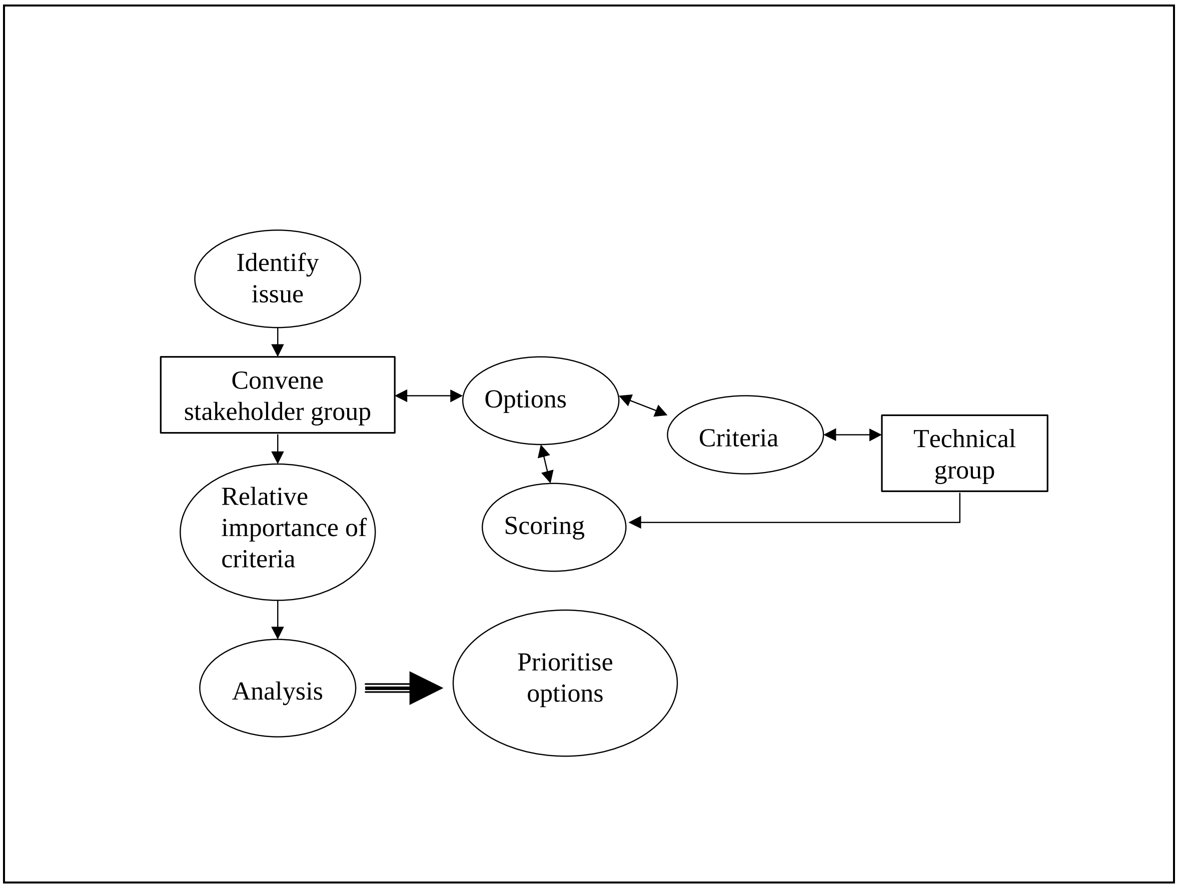

Figure 1 Schematic presentation of participatory decision making process.

The process involves two working groups, namely a stakeholder advisory group and a technical reference panel. The stakeholder advisory group typically involves representatives of farmers, graziers, commodity sectors, local shires, environmental and conservation council, indigenous groups, and state agencies. Within the process, stakeholders are encouraged to identify and define both the feasible options and the decision criteria which will be used to evaluate the options. This part of the process allows stakeholders to communicate their perspectives and express any concerns. An important component in the process is the articulation of the intent and definition of the decision criteria. Consistent with the NSESD, the decision criteria should embrace environmental, economic, social, cultural, technological and policy considerations. This step in the process may require several iterations of discussions, and may involve input from the technical reference group (Figure 1).

Within the participatory process, stakeholder representatives also rank the relative importance of the decision criteria. In this way, stakeholders can express their preferences for the relative significance of the decision criteria, which is used to assign weights and identify a possible course of action. A methodology for defining weights based on the preference order of the criteria is provided below.

The primary roles of the technical reference panel are to quantify the effect of the options on the decision criteria and to assign scores based on these assessments. The membership of the technical reference group would be determined by the type of decision criteria, and may be drawn from specialists within the universities, national and state agencies and research authorities. Quantification may rely on measured data, simulation models, expert judgement, or a combination of all these information sources. In this way, the issues matrix is populated based on the best available science in an objective way. The actual process of assessing the impacts may be undertaken by all members of the technical group or by the individual specialists, however the former would capture greater interactions when assessing the impacts.

The participatory decision making process is designed to be iterative, and relies on constructive facilitation through both the stakeholder advisory group and technical reference panel.

The DNR-MODSS

The Department of Natural Resources in Queensland has produced a software tool to assist the process of multiple stakeholder involvement where there are tradeoffs to be made in natural resource management decision making. The tool, known as *Facilitator*, is a generic decision support system designed to be "built" by the stakeholders and technical specialists through the process of involvement (Lawrence and Shaw, 2000). The software followed the development of a prototype decision support system (P-DSS) by the USDA Agricultural Research Service in Tucson Arizona (Lane et al., 1991; Yakowitz et al., 1992). The DNR multiple objective decision support system is designed to identify a preferred option when there are multiple objectives to be satisfied. The underlying assumption of the MODSS is that the problem to be resolved can be formulated as a matrix, in which the decision criteria represents one axis, and the choice of feasible options represents the other axis. Access to the software can be obtained through the webaddress www.modss.org.

A feature of the *Facilitator* decision tool is the incorporation of a hierarchical arrangement of the decision criteria (Yakowitz et al., 1997). Under the assumption of an additive value function, this approach permits stakeholders with different viewpoints to define either an ordinal or a branched hierarchy of the criteria without explicitly assigning weights to the criteria. However, it is possible to obtain all possible variations in weights that are consistent with the importance order to compute a maximum and minimum composite score. An example of a hierarchical decision criteria structure is shown in Figure 2.

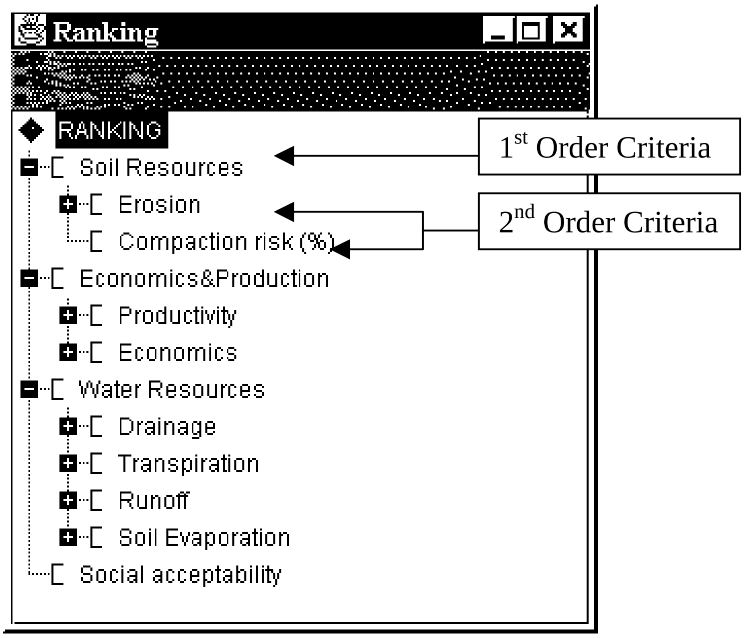

Figure 2 An example of a hierarchy decision criteria, showing Soil Resources, Economics, Water Resources and Social Acceptability as first order criteria.

The additive value function is of the form:

$$V(w,v) = \sum_{i=1}^{m} (w_i \cdot v_{i,j})$$

Where *i* ranges over the base criteria in each branch in the hierarchy, *v* is the score assigned to the alternative with respect to each base criteria element, and *w* is the weight consistent with the hierarchy and normalised such that all weights add to 1.0. Essentially, the composite score V is a function of the individual scores for each option and the weights of each criteria.

The algorithm for assessing the full range from best to worst composite score commences for the base criteria within each branch of the hierarchy. The best and worst additive values are calculated for each element using the solution of two linear programs that maximise and minimise *V* at each branch over all weights consistent with the importance order. For an importance order with *m* criteria, the weights *w*, have the relation:

$$w_1 \geq w_2 \geq w_3 \geq \ldots \geq w_m.$$

Therefore, for a given importance order and score values for an option *j*, the best (worst) composite score that option *j* can achieve is determined by solving the linear programs:

Best (Worst) additive value:

$$\text{Max (min)} \;\; V_j = \sum_{i=1}^{m} (w_i \cdot v_{i,j})$$

Subject to:

$$\sum_{i=1}^{m} w_i = 1$$

and $w_1 \geq w_2 \geq w_3 \geq \ldots \geq w_m. \geq 0$

The difference between the maximum and minimum additive scores is a reflection of the sensitivity of the outcome to the importance order of the criteria. Further details of the algorithms, dominance issues and the hierarchy are described by Yakowitz et al. (1993, 1997).

Application for prioritising water infrastructure developments

The participatory decision making process was used to identify and prioritise water infrastructure developments in the Upper Burdekin Sub-Basin in far north Queensland. The Burdekin River Basin has a drainage area of 130,000 km^2 and a main stream length of 732 km. Mean annual precipitation is 670mm although highly variable. The studies are a Queensland Government initiative to diversify regional development and to underpin economic security for areas impacted by declining prices in mining, the cattle industry and limited employment opportunities in regional towns. Future water development in the basin would also support existing industries in horticulture, sugar cane and vegetables. Population within the Basin is 23,400 (1991). Environmentally, the Burdekin Basin lies adjacent to the Wet Tropics World Heritage Area, and the Burdekin River drains into the Great Barrier Reef to the east. The Burdekin River has one of the most diverse fish populations of all Queensland, and it is recognised that future developments must consider the fish populations from an ecological viewpoint and as a recreational resource.

This is a first-phase analysis in which the locations for possible structural developments are prioritised. The participatory process commenced during 1997 with the formation of the Burdekin Basin Water Panel Advisory Committee (BBWPAC). This group numbered 25 and comprised sugar cane farmers, graziers, three shire mayors, community citizens, representatives from the Queensland Conservation Council, and the Indigenous People, and state agency representatives from the EPA, DNR and State Development. The Committee was chaired by Executive Director, Water Infrastructure and Planning, QDNR. Meetings for the BBWPAC occurred approximately every 2-3 months.

For the upper portion of the Burdekin Basin, four potential dam sites were identified, namely Mt Foxton, Hell's Gate, Mt Fullstop and Greenvale. At each location, three design spillway heights were evaluated. The capacity of the dam and the area of inundation increased with spillway height. These options for water development were identified by the Department's water infrastructure development staff, with subsequent assessments by private consultants. The BBWPAC also inspected the potential sites during the course of their meetings.

The evaluation of the impacts of the potential dams was conducted by the Burdekin Basin Technical Assessment Panel (TAP). Membership of this group was assembled from the CSIRO, EPA, James Cook University, Great Barrier Reef Marine Park Authority, Australian Institute of Marine Science, DNR, EPA, DPI.

The decision criteria were defined and refined following an iterative process between the BBWPAC and the TAP. A total of 36 criteria were identified under the broad categories of environmental, economic and social and cultural (Table 1). Once the type and definitions for the criteria were finalised, the TAP proceeded to rate the impacts of the locations and spillway size against these criteria. The impacts were judged using a scoring system of 0 (maximum negative impact) to 10 (maximum positive impact), where a neutral impact received a rating of 5. Most of the economic criteria were assessed using complex economic and hydrologic models, however for the majority of criteria, the TAP defined the score based on their experiences and ensuing discussions. In this way, the TAP provide the best available technical information based on their professional experiences or interpretations from simulation models without constant on-going studies. In addition to the scores, the TAP produced a statement of justification which was presented to the BBWPAC in December 1999.

The December meeting of the BBWPAC yielded positive feedback on the participatory approach. Prior to the meeting, the committee had requested that laptop computers be available so that they could adjust the order of importance for the decision criteria. One stakeholder installed the files and software on his laptop for further investigations. These initial reactions suggest that the process of integrating stakeholder involvement and technical input from the TAP was constructive and useful.

Although this work is still in progress, the outcomes for three preliminary scenarios are available. Figure 3 shows the 12 developments ranked on the average of the maximum and minimum composite scores. If only economic criteria are considered, the Greenvale site with a spillway 439m above sea level and smaller option with a spillway 430m asl are the most preferred. The smaller spillway developments at Mt Foxton (365 m asl) and Hell's Gate (365 m asl) and the largest development at Greenvale (445 m asl), are less preferred. The large developments at Mt Foxton (364 m asl) and Mt Fullstop (385 m asl) are the least preferred. From an environmental only perspective, Figure 3b shows that the Greenvale 430m option dominates all the other water development options. There is only a marginal difference between the developments at Mt Fullstop 365m, Greenvale 439m and Hell's Gate 365m to address the environmental criteria, however these options are less preferred to the Greenvale 430m option. Finally, Figure 3c shows that the

Greenvale 430m option best satisfies the requirements expressed by the social and cultural decision criteria.

Table 1 Environmental, Economic and Social Decision Criteria to evaluate impacts

Environmental Criteria		
Net biodiversity	Rare & threatened species	Resilience of impacted ecosystems
Ecological processes	Fluvial dynamics	Capacity to manage impacts
Uniqueness of impacted area	Downstream effects	On-farm effects
Aesthetics		
Economic Criteria		
Ability to meet needs	Net present value	Internal rate of return
NPV/ML water	Contribution by users	Total capital cost per ML
Risk of commercial failure	Employment	Geology/construction risk
Impact on regional infrastructure	Time to reach full utilisation of supply	Tourism and recreation
Impact on ecosystem services	Impact on existing entitlements	
Social Criteria		
Impact on individuals within site	Impact on vulnerable populations	Impact on regional demographics
Likelihood of community support	Potential for community opposition	Impact on community access
Consistency with planning by governments	Impact on social / community infrastructure	Impact on equity of access to water
Impact on existing & potential economic activities	Local uptake of job opportunities	Capacity of local community to take advantage of opportunities

These preliminary results demonstrate the utility of examining the hierarchy decision criteria rather than just the overall ranking when using a multiple objective decision tool in a multi-stakeholder context. When used in a participatory way, stakeholders need to be convinced that outcomes will address all the necessary criteria, and not just individual, single criteria. The Greenvale 430 option appears to provide a possible compromise between environmental, economic, social and cultural factors. In addition, the results support the removal of the larger dam developments at Mt Foxton, Mt Fullstop and Hell's Gate on both environmental and economic grounds.

Concluding Remarks

The process and support software for engaging stakeholders can resolve issues of natural resource management when there are multiple and possibly conflicting objectives to consider. The framework described in this paper is appropriate to unite social, economic, environmental and political issues. Although the Facilitator software is generic, interactive and designed to accommodate involvement by stakeholders, the approach depends on a human element to deliver the process. Skills in group facilitation are a fundamental requirement for resource management field officers.

In this example, there is a dependence on expert opinions to evaluate the water infrastructure options. With improvements in watershed scale modelling, it should be possible to account for the dynamics of temporal and spatial variability into the decision support tool. To this end, links to interactive GIS, visualisation, and spatial models will enhance learning and adoption of outcomes.

Stakeholder representativeness on advisory committees and the effective and efficient engagement of stakeholders in the process of meetings, is an emerging issue in the realm of participatory decision making. Stakeholders need to be satisfied that their input to the processes will yield returns. Solutions to these issues may lie within the discipline of social and citizen sciences, and their involvement will enrich the effectiveness of the participatory process. In addition, allowing stakeholders to access decision support tools via the Internet may reduce the number of meetings and encourage discussions between catchment stakeholders and their representatives to explore scenarios prior to advisory committee meetings. Finally, it is essential for participatory processes to develop a research methodology to evaluate the implementation of the preferred option, both in the short and longer terms.

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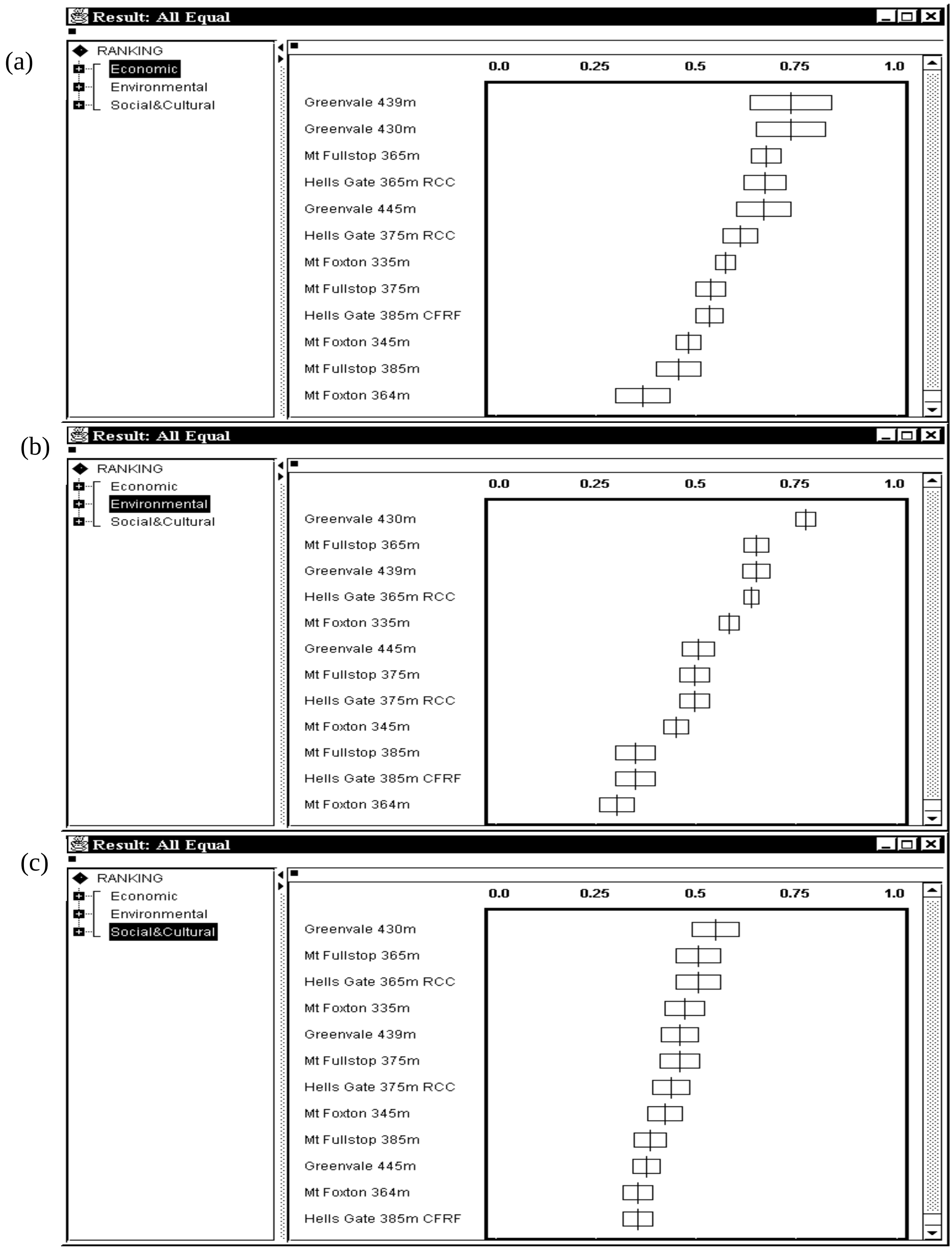

Figure 3. Preferred water development options (highest score) based on (a) economic criteria, (b) environmental criteria and (c) social and cultural criteria

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