View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by University of Queensland eSpace

17. A Critical Appraisal of the MODSS Process as Applied to Forestry in South-east Queensland and the Hodgson Creek Catchment

Ian Jeffreys and Paul Lawrence

This chapter provides a critical appraisal of the MODSS methodology. The application of MODSS for forestry applications is reviewed in general terms, drawing on the experience of this study. A critical appraisal of the success of MODSS in this study, and suggestions as to how the methodology could have been improved, are then provided. The chapter also defines the related techniques MODSS and MCA and discusses their relative strengths.

17.1 A Critical Appraisal of MODSS for Forestry Applications in General

MODSS and MCA have been variously defined in overlapping terms to include a broad collection of techniques to support decision-making. For the purposes of this study, MODSS is defined as a process comprising the whole systems approach of integrating stakeholder and expert inputs while satisfying the economic, environmental and social objectives of the various stakeholder groups. MCA, on the other hand, has been defined in the limited view taken by RAC (1992) and Janssen *et al.* (2001), as the analysis techniques of aggregating the effects table, and including weighting and aggregation techniques – essentially a subset of MODSS. This distinction between MODSS and MCA may appear to be somewhat subtle to the casual observer; however, the difference is important in terms of application and communication of outcomes. The differences between MODSS and MCA are explored further in the following section to highlight their respective strengths, weaknesses and future possibilities.

The strengths of the MODSS process as applied to farm forestry decision support

The MODSS process is currently one of very few available methods for integrated analysis of economic, environmental and social considerations. Other commonly used analysis techniques are mono-criteria techniques that prioritise a range of options according to the extent to which they meet a maximum (or minimum) score. Economic analyses, for example, are predominately based on the achievement of economic maximisation with possible costs and benefits largely reduced to dollar terms. Whilst maximizing 'net present value' may maximize aggregate benefits to the community, some individuals may become better off and some worse off. The Kaldor-Hicks criterion for a project to be beneficial is that those who gain are potentially able to compensate those who lose and still be better off, although the compensation may not actually take place. In other words, such mono-criteria approaches fail to take account of distributional effects on incomes. Whilst some MODSS techniques maximise aggregate utility and do not explicitly consider the equity of benefit distribution, distributional impacts can be considered as one of many criteria.

Choosing between farm forestry options is inherently a multi-objective problem and hence lends itself to the application of MODSS and MCA. The type of trees and style of planting and management are infinitely variable, as are the combination of forestry purposes desired, e.g. native mixed species and extensive management for conservation or exotic single species and intensive management for production. Many of the benefits (and costs) are not easily expressed in economic terms.

The MODSS process and the MCA technique assume a complex and multi-faceted system and allow multiple factors to be aggregated. Normalising all data to single dimensionless utilities allows aggregation of multiple factors[1]. In this way, the integration provides a platform to apply a 'triple bottom line' to decision-making. Issues often treated as 'externalities' can be reflected in terms of decision criteria and incorporated into the decision-support process.

A MODSS provides a transparent process to decision-support. Increasingly, community and industry groups are requiring greater accountability and participation of process and the incorporation of science for realistic and defensible alternatives. The MODSS process achieves these requirements through an inclusive, participatory and responsive process. For example, participants are able to suggest decision criteria that are used in the evaluation of the options within an *effects table* (a matrix of options, decision criteria and values). Using a process involving facilitated workshops, the stakeholders can suggest an importance order of the *decision criteria* that reflects their preferences and concerns. The results of these analyses can be displayed almost instantly for further discussion and greater stakeholder ownership of the outcomes. This approach was used extensively throughout this project. The findings of the MODSS process are consistent with those from the other analyses in this report.

Weaknesses of the MODSS process as applied to farm forestry decision support

Perhaps one of the most contentious issues associated with MODSS is the assignment of weights to decision criteria in association with the effects table (as summarised in Chapter 4). This issue arises for two reasons. First, it is assumed that stakeholders can articulate their concerns and requirements in the form of performance criteria and an importance ordering of the criteria. Within the MODSS approaches, the most important criteria are allocated the highest weighting. Stakeholders who are not familiar with this approach to decision-support may have difficulty in identifying and ranking performance criteria. Second, scenarios describing the perceptions of various stakeholder groups are generated through their distinct sets of importance orders of the criteria. These importance orders or rank orders, and the subsequent weightings of the criteria, are a subset of all possible rank orders of the criteria set. It is important for the representative stakeholders to consider the relative value of economic impacts, environmental impacts and social impacts within the problem being addressed. If the MODSS process is to be used and supported by the wider community, then some consensus with the community needs to be secured so that the relative weights reflect the longer-term community aspirations.

A problem common to all integrated analyses approaches, particularly when using economic evaluation methods (for example, cost-benefit analysis, choice modelling, benefit transfer methodology) is the extent to which social and environmental effects are artificially forced to be measured as a single dimensionless unit, usually dollars. Both single dimensionless utilities and dollars are constructions of their social environment and have no intrinsic significance. They only obtain meaning when placed in a specific context, i.e. a dollar coin has no intrinsic value (other than that of the metal from which it is constructed); it gains a perceived value when it is offered in exchange for goods or services. A single dimensionless utility has no value until a stakeholder choses to trade it for other utilities, e.g. an increase in environmental utilities for a reduction in economic utilities. Therefore, relative value of economic, environmental and social utilities depends on the perspective of the decision-maker at the particular moment in time. For the analyses applied to farm forestry, economic, environmental and social perspectives are combined, allowing each to be non-dominating. In addition, the outcomes from each analysis are presented from an economic, environmental and social perspective, allowing the stakeholders to attach their own value to these perspectives. This is illustrated in Figure 16.1, in the form of four histograms. The first presents the combined analysis, the second the economic analysis only, the third the environmental only and the forth the social only.

[1] The theoretical justification of this process has been provided by Keeney and Raffia (1976).

The perception that the MODSS process and MCA techniques are a subjective methodology is another issue to be considered. The MODSS process is as subjective as the scores in the effects table. In the Burnett water infrastructure development study (Eisner *et al.* 2000) the effects table was evaluated using a mix of subjective and measured data. Alternative analyses are also subjective however, and carry an undefined uncertainty into the analysis. For example, the assigning of discount rates in the AFFFM and other financial models is highly subjective. The discount rate may be regarded as the required rate of return of the investor, which depends – among other things – on their judgment of the performance of alternative investments and their attitude to risk. Changing the discount rate greatly affects the outcome of the analysis. This is the reason why several discount rates are usually included in a sensitivity analysis. In practice, the discount rate is another method of weighting criteria, although it is not explicitly recognized as such. High discount rates weigh current benefits to be more important than future benefits. Hanley and Spash (1993, pp. 144-145) asserted that the discount rate assigned reflects the decision-maker's view on intergenerational equity and is a political choice and therefore open to subjectivity. Similar subjectivity exists in the choice of criteria and their relative weights in MODSS. It must be recognised that all techniques for evaluation of natural resource use options, including MODSS, are highly subjective and are an abstraction of a perceived reality.

A further consideration in the use of MODSS is the validity of using the opinions of experts to quantify the impacts of the alternatives on the decision criteria. The effects table in this study were scored using the considered expert opinion of the members of the Technical Reference Group. This approach was adopted for expediency within the constraints of time and budget. These opinions could have been supported by dynamic, spatial modelling and confirmation of the expert opinions using an alternative advisory group. With more available resources and a longer timeframe, access to more science would have provided greater rigour in identification of the impacts of the alternatives.

Opportunities for future development and application of the MODSS process

A distinguishing feature of the MODSS process is that it is a participatory approach. When well facilitated, MODSS becomes an action-learning process that allows users to learn through their involvement, creating an opportunity for the process of 'learning by doing' (Janssen 1991, p. 10). This is particularly useful when dealing with emotive and polarised stakeholder perspectives. The process of action learning allows users to better appreciate the concerns of other stakeholders.

Multi-criteria analysis (MCA) as applied using the MODSS process can provide a transparent framework for integrating economic, environmental, social and other considerations. This allows a broader perspective to be incorporated into the analysis (Lawrence *et al*. 2001). For these reasons, the MODSS tool can be used for the process of 'triple bottom line' accounting, as supported by the principles of *ecological sustainable development*. In Europe and Canada, MCA is widely used for providing decision-support in relation to the allocation of resources and environmental planning (Janssen 1991; Gambardella *et al*. 2000; Gameda *et al*. 2001).

17.2 A critical appraisal of the MODSS process as applied in this study

This section provides a critical appraisal of the MODSS and MCA application to farm forestry in southern Queensland and specifically in the Hodgson Creek catchment on the eastern Darling Downs. Possible shortcomings of this application of MODSS and MCA are examined, on the basis of experience gained in the study. Measures by which the process could be refined and improved are discussed. The study provides insights into the applicability and usefulness of these techniques for evaluating farm forestry practices in other locations.

Identifying the decision issue

In this study the issue was rigidly defined before approaching stakeholders. The issue statement itself was initially quite broad; *to address the uncertainty regarding the suitability, sustainability and profitability of alternative forestry options in relation to regional agricultural systems.* However, it was progressively narrowed by incorporation of expert defined options, criteria and subsequent analysis. Maintaining a broader or fuzzy issue definition would have allowed the stakeholders to develop this in a direction that more closely suited their needs. Increased landholder involvement in the definition of the issue and formation of options and criteria would aid ownership by landowners of the whole process. This would in turn increase the possibility of uptake of some of the options, if only within the landholder groups represented at the meeting.

Identifying the performance criteria

A number of observations may be made concerning identification and definition of decision criteria.

Limiting the number of criteria

It has been observed (in this study and elsewhere) that, when stakeholders are asked to identify criteria by which they may judge the performance of an option, they often produce a long list of items. The number of items may be too great for modelling purposes; this is known as 'criteria blow-out'. The number of criteria identified rapidly increases as criteria representing increasingly specific goals and issues are identified. These criteria are often interdependent and are judged by the stakeholders as individually having low relative importance. Criteria of low importance create a dilemma for the analyst; a trade-off has to be made as to whether the increased in robustness of the analysis is justified by the increase in time required to evaluate low importance criteria. In the stakeholders meeting for the Hodgson Creek study, 41 criteria were defined. The technical reference group then scored these criteria, which was a time consuming and laborious process, with 656 individual scores being defined. The analysis in southern Queensland defined a more manageable 28 criteria. An ideal number of criteria would be 15 to 21, or 5 to 7 for each broad category (economic, social and environmental).

Highly correlated criteria were investigated further applying a correlation analysis technique to the resulting effects table (details of which are provided in the appendices to Chapter 17). This revealed that criteria were in many cases measuring similar effects, and criteria which were essentially duplicates were remove from the analysis or combined and re-evaluated. For example, the economic criteria of *forestry revenue – growth, forestry revenue – royalty*, and *critical mass* are highly correlated (pairwise r-values of 0.98 to 0.91) and they are all concerned with the viability of a forestry industry. These criteria should be combined to form a new criterion, *Industry viability.* The removal of criteria will affect the results generated by the MODSS analysis, and therefore should only be undertaken in consultation with the stakeholder group and the technical reference group. The information regarding correlations and the possible interdependences can be used to define an improved set of criteria. This set would be presented initially to the stakeholder group and subsequently to the technical reference group. Changes accepted by the stakeholders would require re-evaluation and would create a further iteration of the process.

Criteria can also be judged according to their relative position in the importance order. Criteria at the lower end of the importance order receive low weights and therefore have little impact on the overall performance of the options. For example, in the economic group of criteria using the landholder defined importance order, the joint lowest ranking criteria *forestry revenue – growth* received a weight of 0.6% in the economic analysis and 0.2% in the overall analysis. In contrast, one of the most important criteria (joint first), *profit – farm*, received 18.0% weight in the economic analysis and 6.0% overall. That is not to say that the lower ranking criteria should be arbitrarily removed, but the analyst should inform the stakeholder and technical reference groups that one criterion has many times (30

times, in this example) the influence of the other on the result, and it may be expedient to remove the one with a trivial weight.

Criteria definition and relevance of specific criteria to this application

The performance criteria should be generally applicable to all the options, i.e. it should be possible to evaluate each option against each criterion. For example, the economic criteria *forestry revenue – growth* and *forestry revenue – royalty* are not applicable to all the options. These criteria are dependant on the establishment of a forestry industry; therefore current land-use where there is no forestry cannot be evaluated against these criteria. The option *current land-use* always received the lowest possible score, for these criteria. These criteria should be replaced or included in a general revenue criterion that encompasses all farm revenue. These criteria were also ranked as least important from the landholder and local government perspective, and on these grounds they may warrant removal. However, state government extension officers ranked both relatively highly and therefore redefined versions of these criteria have been retained in the analysis. Other criteria appeared to be placed in the wrong group. For example, *shelter effects* was classed as an environmental criterion, but was defined as only having an impact on productivity and therefore was in effect an economic and not environmental criterion. This criterion has been transferred from the environmental to economic group of criteria in the construction of an improved set of criteria (see below).

An improved set of criteria – initial version

In light of these discussions, two new possible sets of criteria are proposed in this section. Before any changes to the analysis could be made, the proposed changes should be presented to the stakeholder group for feedback. Unfortunately, stakeholder contact was limited to a single one-day workshop, so it has not been possible to carry out such reappraisal in this case. The first alternative criteria set would be constructed by combining correlated criteria and removing unimportant criteria (as defined by the stakeholders). The second would be constructed by combining correlated criteria and keeping only the highly important criteria (as defined by the stakeholders). In both cases, criteria would only be assessed relative to the other criteria in the same group, i.e. within the economic, environmental and social groups. The two revised lists are presented below.

An improved set of criteria – first version

Combining correlated criteria and removing criteria regarded by stakeholders as unimportant leads to the following list:

Economic criteria

Industry viability. Currently, this criterion is *forestry revenue – growth, forestry revenue – royalty*, and *critical mass*. These were highly correlated and all were related to the economic viability of an option. Therefore, they have been combined. The definition of the criterion has been broadened to include any agricultural industry and not only the forestry industry, thus making the criterion applicable to all the options.
Cash flow. Previously this criterion was *cash flow – upfront costs* and cash flow – debt servicing, both were highly correlated and therefore combined.
Infrastructure costs (community). Unchanged
Regional impact. Unchanged
Regional output. Unchanged
Profit (farm). Unchanged
Property value. Unchanged
Risk profile. Unchanged

Flexibility of land use. Unchanged
Liquidity of assets. Unchanged

Environmental criteria

Soil resource quality. Unchanged
Water quality and salinity control. This arises from combining two of the current criteria, namely 'water quality' and 'salinity control'. These were highly correlated and both related to water quality and water movement through the catchment.
Biodiversity (local native) and habitat quality. Currently this criterion comprises of two criteria, namely *'habitat quality'* and *'biodiversity'*. These were highly correlated and both related to abundance of local native species and conduciveness of the habitat for these species. *Water quantity*. Unchanged
Cumulative impacts. Unchanged
Pest habitat- Unchanged
Displacement of existing native bio-systems. Unchanged
Air quality (spraying of agricultural chemicals). Unchanged. This criterion is highly correlated with displacement of existing native bio-systems, but is clearly measuring a different effect. Both are included in this list, and are likely to be independent[2]. The high correlation appears to be accidental.

Social criteria

Aesthetic amenity. Unchanged
Change management requirements (including reskilling). Unchanged
Consistency with local state fed government regulation/policy. Unchanged
Maintaining services and employment. This criterion was previously two criteria, namely *maintaining services* and *net employment*. These criteria were highly correlated and equally important.
Community capacity. Unchanged
Community cohesion and acceptance. This criterion was previously two criteria, namely *community cohesion* and *community acceptance*. These criteria were highly correlated and equally important, and are likely to be interdependent.
Population turnover. Unchanged
Equity. Unchanged
Community health. Unchanged
Health effects on family. Unchanged

An improved set of criteria – second version

Combining highly correlated criteria and culling all but the most important criteria leads to the following list:

Eeconomic group

Industry viability
Infrastructure costs (community)
Profit (farm)
Cash flow
Risk profile
Liquidity of assets

[2] It is possibly to check for independence using the test outlined in Chapter 13, Section 13.2, proposed by Keeney and Raffia (1976, pp. 299-301).

Environmental group

Soil resource quality
Water quality and salinity control
Water quantity
Cumulative impacts
Pest habitat
Displacement of existing native bio-systems
Air quality (spraying of agricultural chemicals)

Social group

Aesthetic amenity
Change management requirements (incl reskilling)
Consistency with local state fed government regulation/policy
Maintaining services and
Community health
Health effects on family

In the economic criteria the cull was relaxed slightly to include the six highest-ranking criteria because only a few criteria received the absolute highest ranking. These criteria could be used as the basis for building a future MODSS for evaluating farm forestry in another catchment.

The limitation of defining only discrete forestry options

Most evaluation techniques including MODSS, MCA, cost-benefit analysis and environmental impact assessment require discrete and mutually exclusive options. All the decision-support techniques proposed in this report including the AFFFM require discrete options. MODSS and MCA are less flexible in this example compared to the financial modelling in the AFFFM because the value for each criterion is obtained by expert opinion rather than calculated using an equation. In the Burnett water infrastructure study (Eisner *et al.* 2000), many criteria were evaluated using objective value functions with the score for the individual criterion determined according to other attributes of the options. For the current study, determining such objective value functions would have been a time-consuming task and potentially would have added little to the analysis, because of the lack of data suitable for deriving objective estimates. Objective value functions do not currently exist for a large number of the criteria identified in this study. In the interest of expedience, analyses using objective value functions can sometimes exclude factors that cannot be quantified. In fact, one of the major strengths of MODSS is that it is inclusive and integrates all factors that influence a decision – whether objective functions exist for them or not. In the absence of defined objective value functions, options evaluated using expert opinion have to be defined within discrete limits. Whilst in an ideal situation a MODSS would include continuously variable options, it is currently not possible to include all the relevant factors in such an analysis. In the place of continuous options, discrete categorical options placed at logical intervals on this continuum must suffice.

Evaluation of options against criteria

The technical experts described the two workshops in which they evaluated the options for the Hodgson Creek study as highly stressful, rushed and laborious. Experts noted that there was too much work for the two days allowed. Whether this was a result of the options and criteria lacking adequate definition or the demanding nature of the scoring process was unclear. The experience of the technical reference group in the southern Queensland study, for which members of the technical reference group had been instrumental in developing options and criteria, and in development of the definitions, boundaries and baselines, was however quite different. It is hypothesised that the additional stress was

a consequence of the technical reference group having no input prior to the evaluation workshops for the Hodgsons Creek study.

In future MODSS applications, this type of problem would be alleviated somewhat by inviting the technical reference group to observe the stakeholder meeting, although care must be taken not to overwhelm the stakeholder group with technical experts and government officers. Another possible solution would be to remove the evaluation process from the workshop environment. The first workshop would take the form of a general discussion of the options and criteria, clarifying any points of information and adding to and refining the descriptions of the options and criteria. The technical reference group members would then complete the evaluation of the options against the criteria in their own time. The analyst could then combine the data and highlight differences of opinion. The analyst should only highlight differences and not try to resolve them. The second meeting would then discuss any differences in opinion as to the scores for individual criteria and seek consensus on these scores. In this way the areas where there is broad consensus need not be discussed.

A number of additional aids may be useful in the workshop process, including maps and other visualisation tools. In the Hodgson Creek study, maps detailing the hypothetical position and extent of the forestry options within the catchment were produced, although these were not available to the technical reference group until the first workshop. These maps could have proven a useful aid to the technical reference group, if the group were given sufficient time to study the maps. Other visualisation tools may include photographs of similar farm forestry options in other catchments, or composite photographs or an artist's impression of the change in visual appearance of the landscape after implementing a forestry option. The latter of these may prove prohibitively expensive. With the development of advanced computer visualisation tools, it will become increasing possible and affordable to recreate a 'virtual' catchment from GIS data, as a visualisation device by which the stakeholders and experts can explore and view possible land-use changes.

The two-stage iterative process

The MODSS process is an iterative process, whereby options and criteria are developed and refined progressively. This study was limited by the amount of contact possible with stakeholders. Stakeholders were introduced to the process after experts had completed the first round of analysis. On reflection, consulting the stakeholders and producing a quick and simple analysis may have proved a more productive use of the stakeholders' time. The inclusion of the stakeholders at this stage of the process allows them to gain insights into the issues surrounding farm forestry, by 'playing with the problem' (Janssen 1991, p. 10). By presenting the south-east Queensland study to the stakeholder group at the workshop, the workshop was limited to assessing and making changes to these options.

By removing the initial analysis, the technical reference group can build directly from the stakeholder defined options and criteria. Because the technical reference group is defining and scoring one study only, more of the group's time and energy can be placed in to the iterative development of this study. In this report; the south-east Queensland study is superseded by the Hodgson Creek study.

Defining the time periods for the analysis

Any forestry option is a very long-term investment. The impact, of the farm forestry options on the performance criteria is likely to change dramatically over the lifetime of the option. To reflect this, the Hodgson Creek MODSS was analysed at two timescales, namely the *transitional period* and the *steady-state period*. The transitional period – defined as the period during which a farm forestry industry is being developed in the catchment – is also defined as the cost period, and extends from years 0 to 10. The second time period – idefined as the steady-state or equilibrium period – is the period when a forestry industry has been developed in the catchment, plantings have matured and a rotation of felling and replanting has been established, typically from year 30 or 40 onwards.

This appears to exclude the period from year 10 to year 30 from the analysis. This apparent gap could be filled in two ways. First, the transitional period could be redefined to include the complete interval from the first plantings to the first harvest, i.e. year 0 to approximately year 30. Second, a third time period could be defined. This would involve separating the current transitional period into an establishment period and a new transitional period. The establishment period would be the period when the forest industry is being established, including the cost period during which trees are planted and farm infrastructure is upgraded. Then the redefined transitional period would be the period during which the trees mature. Little silvicultural activity would continue in this latter period.

This is unlikely to reflect the way a forestry industry and individual plantations would be established, since plantings are likely to occur incrementally over the first 30 to 40 years. Both methods would require some re-evaluation of options. In the first method, the scores would need to be revisited to check their applicability to this redefined timescale. In the second method, the two new timescales would require a complete re-evaluation. The first method of redefining and clarifying the extent of the transitional period is preferable because it is more likely to reflect the nature of forest industry development.

Choice of MODSS Software packages

The MCA completed in this study used the software package Definite (Janssen *et al.* 2001). This is high-level MODSS package and includes MCA using various weighting and aggregation techniques, CBA, and sensitivity analyses of the MCA and CBA. It has a high degree of functionality, a consequence of which is that the user interface is relatively complicated, and the tool is not suited to inexperienced users. Definite is also commercial licensed software and has to be purchased from the developer. The result of this is that this study could not be easily reproduced in any other catchment without a reasonable amount of funding and persons with technical expertise in the use of this MODSS tool.

One of the other tools considered in this study was the MODSS tool Facilitator (DNR *et al.* 1999). Facilitator is a considerably simpler tool in both the analysis and the user interface. It is available without charge and can be downloaded from the Internet. This tool was developed specifically for use by catchment management and Landcare groups. This study could have been undertaken using Facilitator but would then have lost depth of analysis due to the simpler functionality of Facilitator.

The Definite package is suited for an in-depth analysis of farm forestry options. It is suited to groups that require a detailed and robust analysis, and is especially suited for policy analysis. The Facilitator package is more appropriate for small-scale and local use applications. Because Facilitator is simple to use, problems can be developed and analysed with greater ease and more quickly, and it is therefore more suitable in a workshop situation. The output of Facilitator is a simplified version of that produced by Definite. However, the effects table for both systems can be imported from spreadsheets and data can be transferred between the packages.

17.3 Conclusions

The use of a simple MCA tool (such as Facilitator), to develop options, criteria and importance orders in a participatory group setting, can be useful for action-learning. This would allow stakeholders to ‘play’ or experiment with the decision problem, identifying relationships between the various components of the problem and the outcomes. The MODSS process provides a useful framework for workshops to discuss issues surrounding farm forestry.

The MODSS study into farm forestry on the Darling Downs identified a number of options that are worthy of further consideration and excluded options that would not be feasible in this area. The options identified for further consideration are the same as those identified from the landholder survey

(Chapter 6). The MODSS analysis, the case studies using the AFFFM and the survey results support and complement each other, providing validation of the conclusions of each study.

The MODSS process is one tool in a kit for evaluating natural resource and land-use management issues, including farm forestry. MODSS is highly useful in combining data and knowledge in a clear and transparent framework. Currently, MODSS suffer from the 'black box' problem. The processes applied although relatively simple are unseen, being hidden in software packages. This has aroused suspicions as to the nature of the analysis, although acceptance of these methods will increase with greater exposure to them.

Currently the MODSS process using stakeholder and technical input combined with MCA tools, is the best available method for integrating economic, environmental and social analyses, to produce a holistic analysis of natural resource and land-use management issues, including farm forestry issues. Its utility will be further increased with additional work to generate quantitative means to score options, improved means of visualizing options and simpler and more robust means of determining and assessing decision criteria.

References

Department of Natural Resources (DNR), Agricultural Research Service, USDA and Netstorm Pty Ltd. (1999), *Facilitator 1.2.17 Beta, A Multi-Objective Decision Support System,* presented at the 2nd International Conference for Multiple Objective Decision Support Systems for Land, Water and Environmental Management (MODSS'99), Brisbane.

Eisner R., Lawrence P. and. Jeffreys I. (2000), *Use of MODSS (Multi-Objective Decision Support System) in the Burnett River Catchment Study*, Project report, Department of Natural Resources, Brisbane.

Gambardella L.M., Rizzoli A.E., Fornara N., Alessandrini A., Epifani C. (2000), *The use of simulation in the socio-economical evaluation of the management of an intermodal terminal*, HMS2000, Maritime and Industrial Logistics Modelling and Simulation, 5-7th October, Portofino, Italy.

Gameda, S., Huffman, T., Yang, J., Junkins, B. and Gill, R. (2001), 'Integration of economic and biophysical models for assessing agricultural policy impacts on water quality at a regional scale', *MODSIM 2001 Proceedings of the International Congress on Modelling and Simulation*, The Australian National University, 10-13 December, pp. 1189-1194.

Hanley N. and Spash C. (1993), *Cost-Benefit Analysis and the Environment*, Edward Elgar, Aldershot.

Janssen R. (1991), *Multiobjective Decision Support for Environmental Management,* Kluwer Academic Publishers, Dordrecht.

Janssen R., van Herwijnen M. and Beinat E. (2001), *DEFINITE (version 2) DEcision support system for a FINITE set of alternatives*, Institute for Environmental Studies, Vrije Universiteit, Amsterdam.

Keeney R. and Raffia H. (1976), *Decisions with Multiple Objectives,* Cambridge University Press, Cambridge.

Lawrence, P.A., Robinson, J. and Eisner, R. (2001), A Decision Environment: going beyond a decision framework to improve the effectiveness of decision making in natural resource management. MODSIM 2001 Proceedings of the International Congress on Modelling and Simulation, 10-13 December, The Australian National University, Canberra, pp. 1613-1618.

Resource Assessment Commission (RAC) (1992), *A Multi-criteria Analysis as a Resource Assessment Tool*, Research Paper No. 6, Resource Assessment Commission, Canberra.

Appendix 17.1
Correlation Analysis of Effects Table

Figure 17.A1 to 17.A3 and Tables 17.A1 to 17.A3 present the correlation analysis for the economic, environmental and the social groups of criteria, respectively. Figures 17.A1 to 17.A3 are graphical representations of a Pearson's correlation analysis. In these figures correlated criteria are grouped using extended square brackets. A Pearson's correlation coefficient of 1 indicates perfect positive correlation, 0 no correlation and –1 perfect negative correlation. The degree to which the square brackets are extended represents the value of the correlation co-efficient. These highly correlated groups are subsequently grouped with diminishing levels of positive correlation. The correlation coefficient all the pairwise comparisons of criteria are displayed in Tables 17.A1 to 17.A3. Highly correlated criteria have similar scores and often the same scores for same options. Highly correlated criteria may be measuring the same effect using two different names. For example the social criteria of *maintaining services* and *net employment* are perfectly correlated; this pairwise comparison has a correlation coefficient of 1. These criteria were combined to form the new criterion of *maintaining services and employment*. A second example is the economic criteria of *forestry revenue – growth, forestry revenue - royalty* and *critical mass,* these are highly correlated; the pairwise comparison of these criteria have correlation coefficients of 0.9806, 0.9384 and 0.9123 respectively. These criteria were combined to form the new criterion of *industry viability.*

Figure 17.1. Correlation analysis of the economic group of criteria

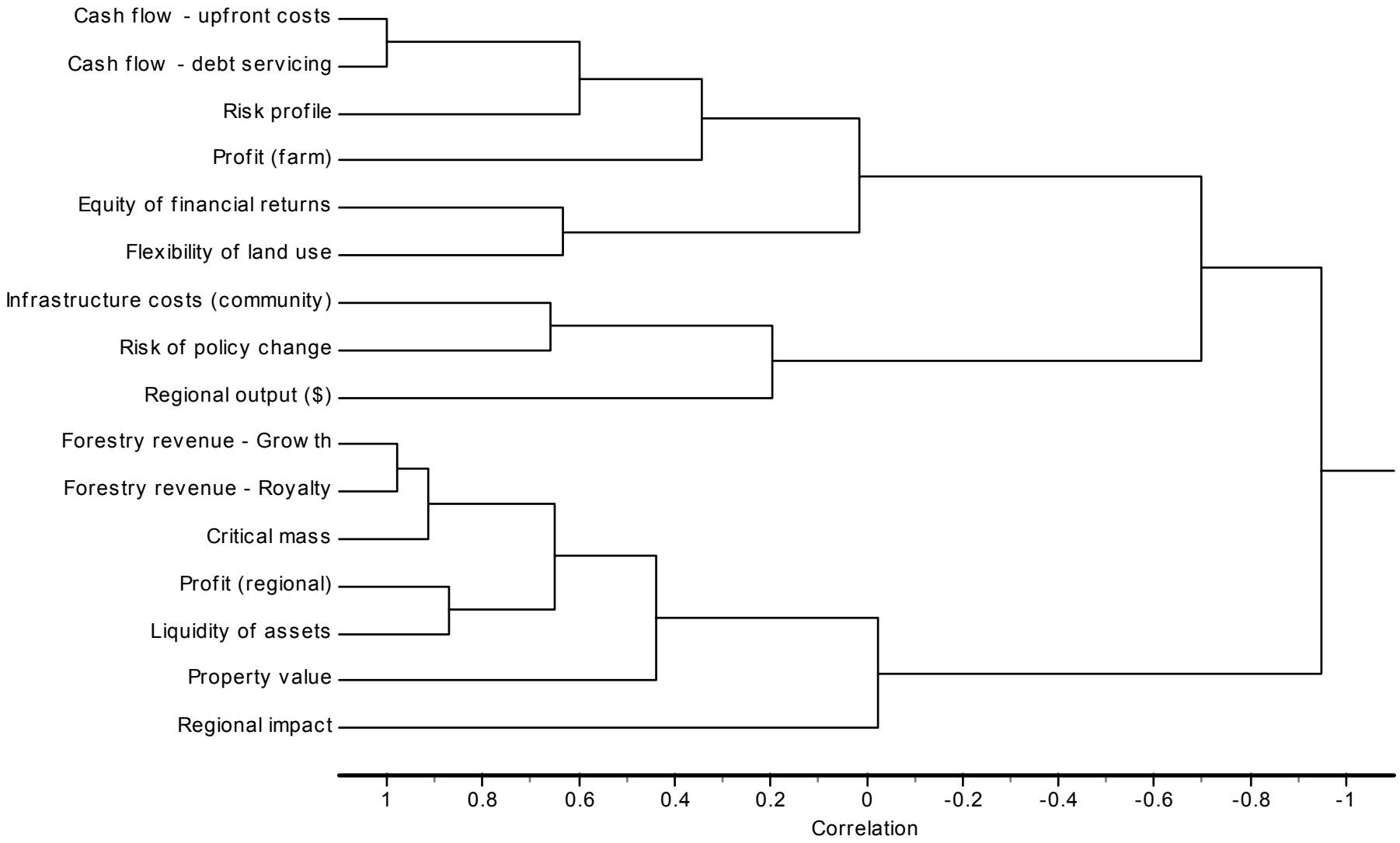

Table 17.1. Pearson's correlation co-efficient for the Economic group

Economic criterion	Forestry revenue – royalty	Infrastruct-ure costs (community)	Regional impact	Regional output ($)	Profit (regional)	Profit (farm)	Property value	Risk profile	Risk of policy change	Equity of financial returns	Cash flow – upfront costs	Cash flow – debt servicing	Critical mass	Flexibility of land use	Liquidity of assets
Forestry revenue – growth	0.9806	-0.5872	0.3004	-0.6344	0.6843	0.3385	0.4581	0.2788	-0.8102	-0.4356	0.733	0.733	0.9364	-0.5023	0.778
Forestry revenue – royalty		-0.4801	0.2677	-0.6476	0.6523	0.3576	0.4500	0.2924	-0.7678	-0.4012	0.7382	0.7382	0.9123	-0.5027	0.7573
Infrastructure costs (community)			-0.3608	0.1984	-0.5304	-0.0231	-0.2229	-0.0335	0.6581	0.4336	-0.2972	-0.2972	-0.5906	0.226	-0.4948
Regional impact				0.1525	0	-0.5589	0.3311	-0.2707	-0.3428	-0.9489	-0.2142	-0.2142	0.4461	-0.5434	-0.0228
Regional output ($)					-0.1762	-0.2508	0.1616	-0.6178	0.5547	-0.0367	-0.6961	-0.6961	-0.5551	0.0743	-0.4209
Profit (regional)						0.5506	0.4397	0.2335	-0.6452	-0.1006	0.5364	0.5364	0.6536	-0.1165	0.87
Profit (farm)							0.4328	0.3418	0.0345	0.4442	0.4933	0.4933	0.1592	0.0221	0.7036
Property value								-0.2617	-0.0723	-0.4397	0	0	0.4962	-0.7183	0.5269
Risk profile									-0.2807	0.1832	0.597	0.597	0.16	0.4461	0.4415
Risk of policy change										0.4107	-0.5592	-0.5592	-0.8321	0.1841	-0.5972
Equity of financial returns											0.1002	0.1002	-0.5791	0.6351	-0.1237
Cash flow – upfront costs												1	0.5146	0.0135	0.6177
Cash flow – debt servicing													0.5146	0.0135	0.6177
Critical mass														-0.6202	0.6893
Flexibility of land use															-0.1341

Figure 17.2. Correlation analysis of the environmental group of criteria

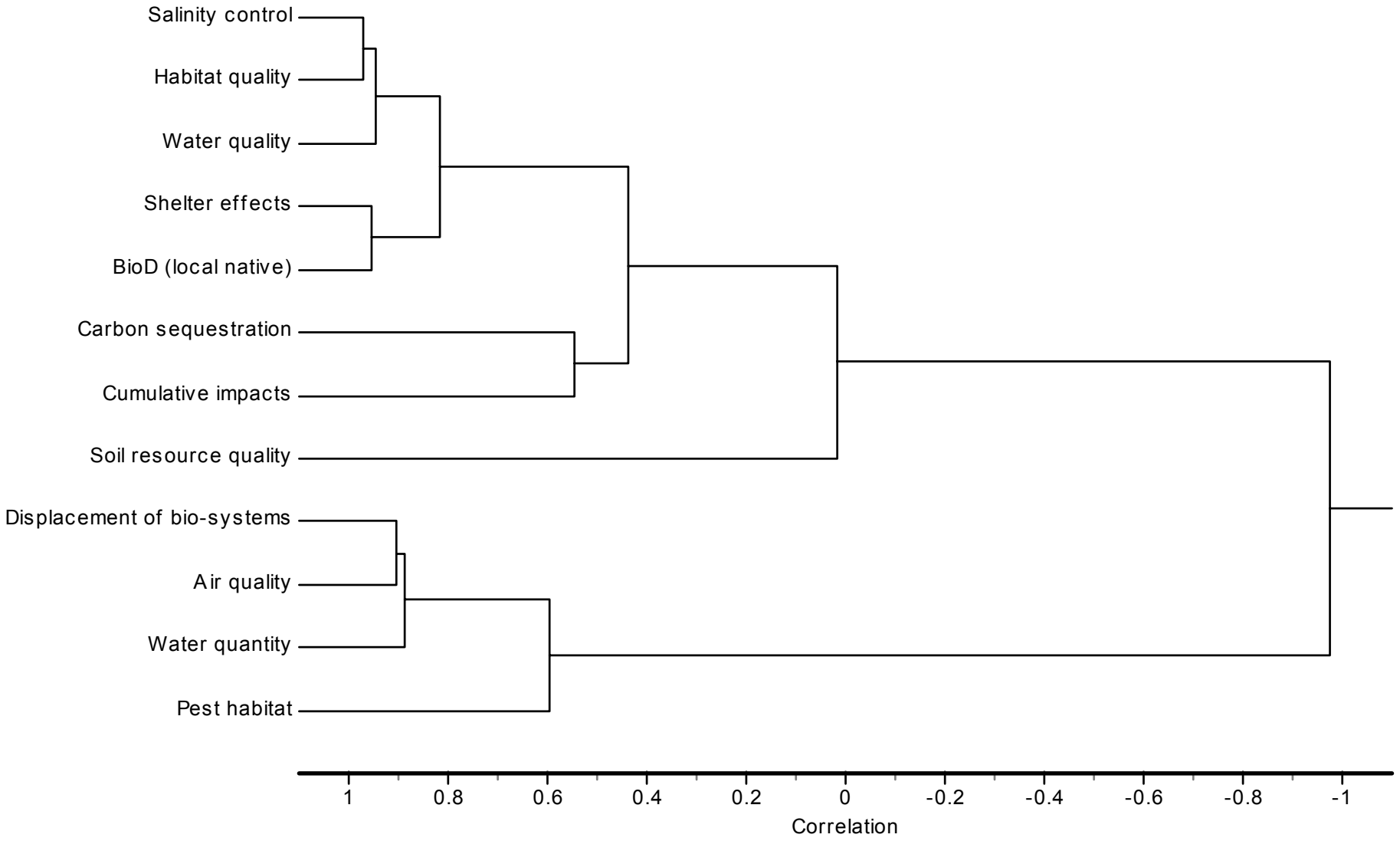

Table 17.2. Pearson's correlation co-efficient for the Environmental group

Environmental criterion	Soil resource quality	Carbon sequestration	Water quality	Salinity control	BioD (local native)	Water quantity	Cumulative impacts	Displacement of bio-systems	Habitat quality	Pest habitat	Air quality
Shelter effects	0.3724	0.6147	0.8584	0.8148	0.9556	-0.5048	0.4382	-0.8322	0.8439	-0.8474	-0.669
Soil resource quality		0.2355	0.4153	0.5828	0.4713	-0.1746	0.0167	-0.282	0.4578	-0.3116	-0.0755
Carbon sequestration			0.674	0.5479	0.5715	-0.973	0.5454	-0.9177	0.5037	-0.6084	-0.9425
Water quality				0.9451	0.9301	-0.627	0.4979	-0.8483	0.95	-0.942	-0.6346
Salinity control					0.9389	-0.5047	0.52	-0.7539	0.969	-0.8998	-0.4629
BioD (local native)						-0.4979	0.4795	-0.8193	0.9478	-0.9177	-0.562
Water quantity							-0.5197	0.8897	-0.4632	0.5969	0.8892
Cumulative impacts								-0.5331	0.4568	-0.4146	-0.413
Displacement of bio-systems									-0.7442	0.8421	0.9026
Habitat quality										-0.9471	-0.459
Pest habitat											0.605

Figure 17.3. Correlation analysis of the social group of criteria

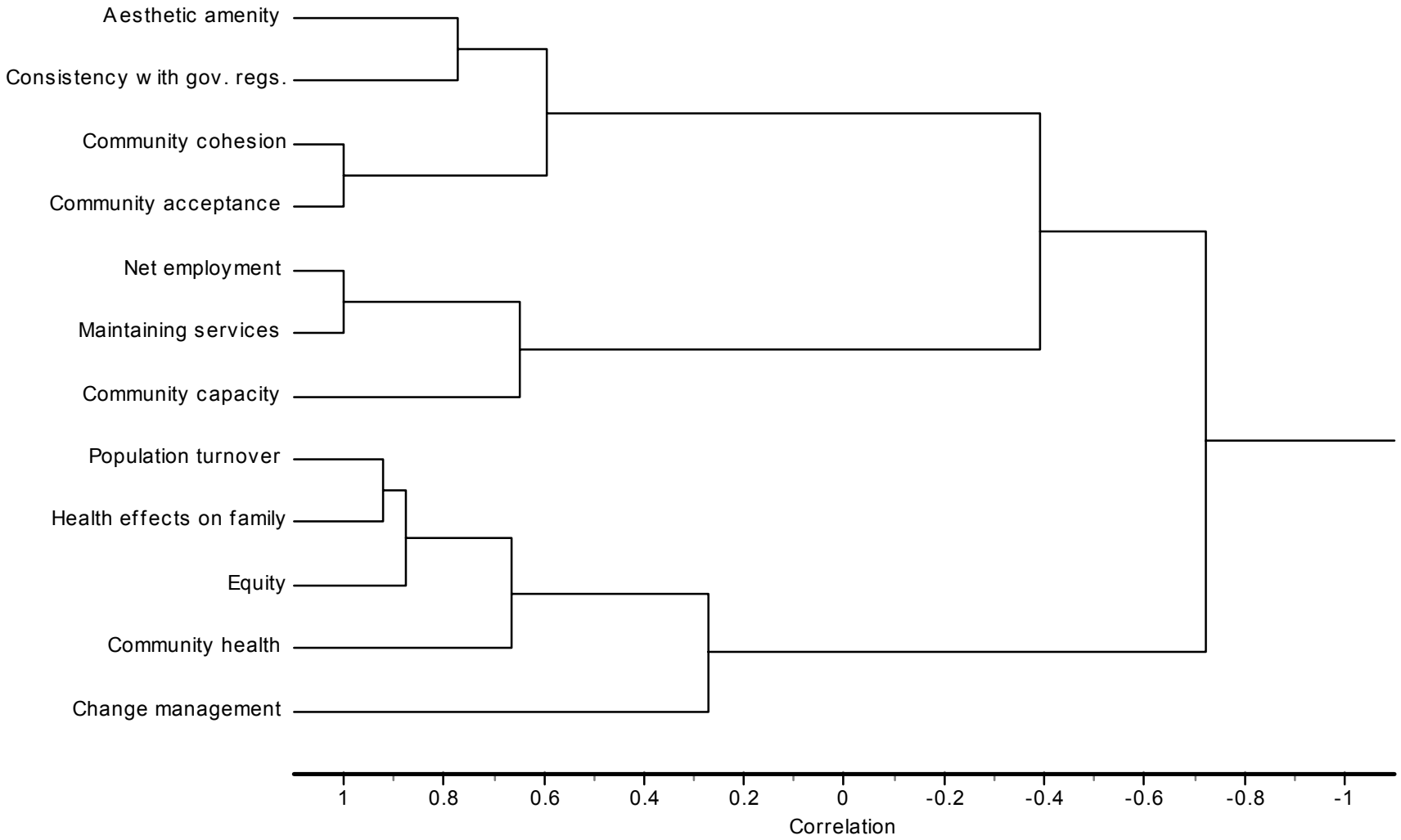

Table 17.3. Pearson's correlation co-efficient for the Social group

Social criterion	Aesthetic amenity	Change management	Consistency with government policy and regulations.	Net employment	Maintaining services	Community capacity	Community cohesion	Community acceptance	Population turnover	Equity	Community health	Health effects on family
Aesthetic amenity		-0.4638	0.7715	-0.1003	-0.1003	-0.3926	0.5966	0.5966	-0.0166	-0.1194	-0.5251	-0.0636
Change management			-0.4053	-0.3013	-0.3013	0.0154	-0.66	-0.66	0.3298	0.2815	0.4456	0.27
Consistency with gov. policy and regs.				-0.0738	-0.0738	-0.2123	0.6167	0.6167	0.2712	0.2809	-0.2756	0.1925
Net employment					1	0.6493	0.3185	0.3185	-0.696	-0.4234	-0.4097	-0.7242
Maintaining services						0.6493	0.3185	0.3185	-0.696	-0.4234	-0.4097	-0.7242
Community capacity							-0.1891	-0.1891	-0.3306	0.1221	0.2034	-0.1771
Community cohesion								1	-0.1301	-0.1567	-0.5908	-0.1978
Community acceptance									-0.1301	-0.1567	-0.5908	-0.1978
Population turnover										0.8744	0.6657	0.9222
Equity											0.7821	0.9036
Community health												0.7502
Health effects on family												