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The multiple criteria analysis tool (MCAT): A new software tool to support environmental investment decision making

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ABSTRACT

This article describes a decision support software system referred to as the multiple criteria analysis tool (MCAT). MCAT identifies a portfolio of decision options that return a maximum aggregated benefit under a constrained budget. Benefits scores of decision options – which we will refer to as projects – are computed using multiple criteria analysis whereas in a subsequent step, binary combinatorial optimisation is employed to identify the combination of projects that return a maximised aggregated benefit subject to a constraint. MCAT has primarily been developed to be used in natural resource management contexts. Though we illustrate MCAT through three Australian natural resource management case studies its use is explicitly not restricted to environmental decision problems. Wherever multi-criteria analysis (MCA) is regarded to be a suitable approach to evaluate decision options subject to a budget constraint, MCAT can be applied. We therefore believe that MCAT has potential for widespread application. It can help improve the transparency, analytic rigour and auditability of investment decisions.

Software availability

Name of software: Multi-criteria analysis tool (MCAT)
Developer: Oswald Marinoni, CSIRO Sustainable Ecosystems
Contact information: 306 Carmody Road, St Lucia QLD 4067
Tel.: +61 7 3214 2649
E-mail: oswald.marinoni@csiro.au
First available: 2008
Hardware required: Windows 9x/XP
Software required: None
Program language: .Net 2005. Program size: 5.1 MB
Availability and cost: Download of the latest beta version from www.toolkit.net.au

1. Introduction

Most, if not all, environmental investment decisions depend on multiple criteria and are subject to one or more constraints. The solution to optimisation problems taking into account multiple constraints is not new and there is a variety of literature in the field of operations research available that comprehensively discuss this issue (e.g. Martello et al., 2000; Drexl, 1988; Higgins, 2003). Investment decision problems are inherently optimisation problems where it is aimed to maximise the return or benefit for a given investment. To quantify returns economists have traditionally used benefit cost analysis (BCA), however, BCA requires that all benefits need to be given in Dollars units which is difficult if intangibles like ecological, cultural or social issues are involved (Acreman, 2001). This problem has long been realised and there are a variety of methods available that aim to "translate" intangible values into monetary units, e.g. contingent valuation (CV) or choice modelling (CM), however, the reliability of these approaches is still subject to debate (Hajkowicz and Collins, 2007).

A wider decision making framework that does not require a transformation into monetary units is multi-criteria analysis (MCA). However, MCA, too, requires the assignment of a numeric value to intangible issues which can be done on a qualitative ordinal scale. This can provide a practical way forward (Hajkowicz et al., 2007c) especially if methodological or ethical problems are encountered in the application of CV or CM. The broad applicability of MCA can be monitored through a wide range of applications and publications across disciplines. Since it is beyond the scope of this paper to give a comprehensive induction to MCA just a few very recent references are given here where MCA is applied to cover energy issues (Nobre et al., in press; Afgan et al., 2008), environmental emergency management (Geldermann et al., 2009), site selection (Zucca et al., 2008) or social investment in the mining sector (Esteves, 2008).

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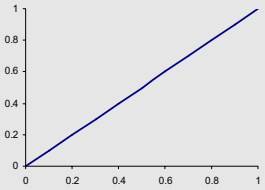
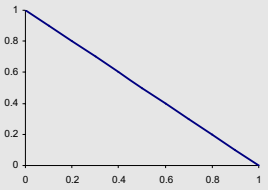
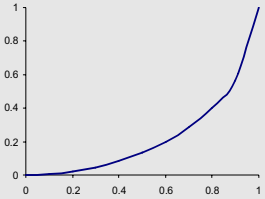
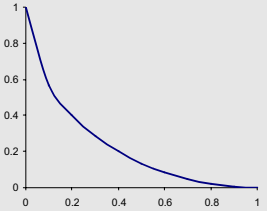
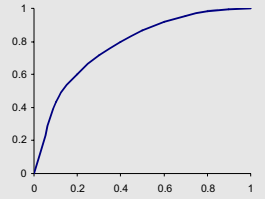
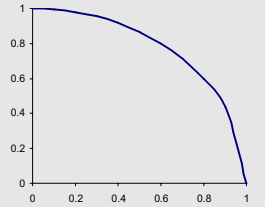
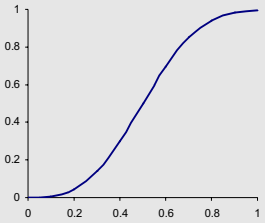
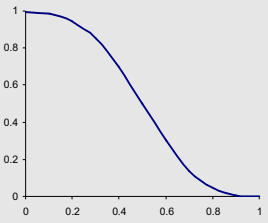
Table 1
Transformation functions embedded in MCAT (further explanations in text)

Transform type	Largest criterion value is best bottom axis: g_{ij}, left axis: partial utility score u_{ij}	Smallest criterion value is best bottom axis: g_{ij}, left axis: partial utility score u_{ij}	Formula for transformation t	Remarks/applicable situations
Linear			$t_1 = (1 - g_{ij})$	Criteria scores are linearly transformed. Utility scores increase/decrease as a function of this transformed value.
Convex			$t_2 = 1 - \sqrt{1 - (g_{ij} - 1)^2}$	E.g., criteria representing contamination values (smallest value is best (right graph)) get a higher score for low values. An increase in contamination values leads to a rapid decrease in utility scores.
Concave			$t_3 = \sqrt{1 - g_{ij}^2}$	E.g., a proximity score where the effect of a criterion on a water way changes non-linearly with distance. The greater the distance the better (left graph), the smaller the distance the better (right graph).
Sigmoidal			$t_4 = \left(e^{(\log_e(0.5)\times g_{ij}^d)/m^d}\right)$ with m = 0.5 and d = 3	E.g. population number of a specific species. A low population returns a high utility (right graph) whereas a population increase leads to a steady decrease in the utility score.