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A Multi-Criteria Decision Framework for Animal Welfare Policy

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Abstract

Policy decisions aimed at improving farm animal welfare involve balancing several competing objectives. Not only do such decisions involve tradeoffs between social, ethical, economic and welfare considerations, animal welfare itself is a multi-dimensional concept and some husbandry practices may satisfy some welfare needs but fail to satisfy others. Multi-criteria decision analysis is a decision theoretic tool that has been used to inform decision making in fields such as environmental policy, urban and regional planning, and biosecurity – all of which are characterised by competing goals and multiple stake-holders. This paper presents a preliminary multi-criteria framework for the analysis of animal welfare policies at the national level using indoor housing options for layer hens as an empirical example. Preliminary results are presented, but major emphasis is placed on highlighting the information needed to make such a framework both transparent and tractable.

Keywords: Animal welfare; multi-criteria decision analysis; decision analysis; decision support

1. Introduction

A range of issues influencing the welfare of farmed animals have generated considerable public debate over the past few decades, and interest continues to intensify. Recent examples of animal welfare controversies have included the use of dry sow stalls, the induction of premature birth of dairy calves and schicita slaughter without pre-stunning. The 'external' and ethical implications of various widely-used production systems have lead countries around the world to conclude that the government has a vital role to play in the regulation of farm animal welfare. In New Zealand the main piece of legislation governing animal welfare outcomes is the Animal Welfare Act 1999 (the Act).

In addition to establishing general core obligations that people have towards animals, the Act provides for the issue of specific codes of welfare that establish minimum standards for the care and treatment of animals and promote best practice for people in charge of animals. While recommended best practices are not legally binding, minimum standards do carry the force of law. They provide the details of specific actions that people need to take in order to meet the obligations of the Act. If the minimum standards are not met, people are at risk of prosecution. Thirteen Codes of Welfare have been issued by the Minister of Agriculture and four more are under development. Some of the Codes relate to specific species (e.g. Pigs, Dogs and Companion Cats) and others relate to broad activities that involve live animals (e.g. Rodeos, Circuses, Export and Transport).

While anyone with a vested interest in animal welfare can draft a code of welfare, in practice the Codes are written by groups of stakeholders. The National Animal Welfare Advisory Committee

(NAWAC), a ministerial advising committee established under the Animal Welfare Act, has a high degree of responsibility with respect to codes of welfare. One of NAWAC's main functions is to advise the Minister of Agriculture on the content of the Codes, and part of the established protocol for producing a Code of Welfare includes submitting the final draft to NAWAC for consideration.

Once it receives a draft code, NAWAC assumes responsibility for it because, under the Animal Welfare Act, NAWAC is responsible for consulting the public and subsequently for recommending that the Minister of Agriculture issue the code. When formally considering a potential code, NAWAC has a statutory obligation to consider a range of issues that are relevant to the welfare of the animals as well as the people that are affected by the content of the Code. At present, the list of factors that must be considered includes:

- animal welfare outcomes based on scientific knowledge;
- practical experience and available technology;
- good practice;
- practicality of making changes;
- international trends;
- societal values; and
- economic implications for those concerned.

NAWAC is also required to consider animal welfare in terms of the so-called 'five freedoms' that are set down in the Act as the physcal healthand behavioural needs of animals:

1. proper and sufficient food and water:
2. adequate shelter:
3. opportunity to display normal patterns of behaviour:
4. physical handling in a manner which minimises the likelihood of unreasonable or unnecessary pain or distress:
5. protection from, and rapid diagnosis of, any significant injury or disease,

Determining the extent to which the content of a particular code satisfies this complex list of objectives is a challenging task that lends itself naturally to multi-criteria decision techniques.

The primary objective of this paper is to explore the possible application of multi-criteria decision making techniques to help mange this complexity.

2. Methodology

Multi-criteria decision making techniques are being applied with increasing regularity to facilitate decisions that are characterised by conflicting and multiple objectives. Such techniques have been used in such widely diverse fields as the regulation of ocean fisheries (Innes and Pascoe, 2010), the management of sustainable community forests (Balana, BB; E Mathijs and Muys, 2010), energy planning (Pohekar and Ramachandran (2004), solid waste management (Cheng, Chan and Huang, 2002) and landfill site selection (Sener, Suzen and Doyuran, 2006). Broadly speaking, multi-criteria decision analysis (MCDA) is a general decision making tool designed to accommodate multiple objectives that may often conflict. While decision support models have been developed at the farm level to assess pig welfare (Bracke, MBM, BM Spruut, and HGM Metz, 1999a, 1999b, 1999c; Bracke MBM, B. M. Spruijt, J. H. M. Metz and W. G. P. Schouten, 2002; Bracke MBM, J. H. M. Metz , B. M. Spruijt and W. G. P. Schouten, 2002) and ectoparasite control strategies (Milne, Dalton and Stott, 2008), applications of MCDA to support animal welfare policy at the national level appear to be limited to date.

MCDA models are structured so that a pre-determined number of alternatives can be evaluated against a set of criteria or attributes. Specific criteria indicators may be either quantitative, or qualitative in nature, but categorical criteria must be coded in at least an ordinal manner for incorporation into the analysis. Each of the pre-determined alternatives receives a set of 'performance scores' (a_{ij}) which reflects the performance of alternative i against criterion j. The objective of the analysis is to select the 'best' alternative according to a specific decision rule. Among the first steps in specifying a MCDA model, therefore, are the careful specification of the alternatives, and the selection of appropriate criteria. Within the current context, the alternatives would involve various housing specifications for laying hens, and broad criteria would include animal welfare, economic, ethical and social considerations.

2.1 Decision rules

2.1.1 Weighted sum method (WSM)

One of the most common decision rules in the applied MCDA literature involves calculating a simple weighted average of all of the performance scores for each alternative (equation 1). Assuming that all criteria are defined in terms of 'benefit' (higher scores indicate better performance), the alternative with the highest average score is the 'best'. Accordingly, a 'preference weight' must be assigned to each criterion (w_j) that reflects the relative importance of that attribute to the decision making process. A range of methods can be used to derive these weights, the most straightforward

of which involves the subjective judgement of a single decision maker. A more participatory method involves a structured process of group ranking, which will be described in more detail in Section 2.2.2.

(1)

Note that when the criteria are defined in different units (dollars versus cortisol levels), a normalising process must be used so that the scores can be added.

2.1.2 Weighted product method (WPM)

As the name implies, the WPM involves multiplication to arrive at a final score, instead of addition. As with WSM, the specification of this decision rules assumes that higher attribute scores are more preferred. In order to compare the alternatives A_K and A_L, the following product is calculated:

(2)

Where K and L are two of the N alternatives, a_{ij} are the performance scores and wj is the preference weight of the j^{th} criterion. If , then alternative K is more desirable than alternative L. The best alternative is better than or equal to all other alternatives. The main advantage of the WPM is that the ratios eliminate any units of measure, so no normalisation is required.

2.2 Ranking

2.2.1 Single 'expert opinion'

By far the simplest way to assign relative importance to each of the criteria is to seek the opinion of a single recognized expert. This is the approach taken by Milne, et al (2008), and is clearly better suited to multi-faceted decisions at the farm level, which are typically made by the farm owner/operator. National-level policy decisions, by contrast, involve multiple stakeholders and the decision process tends to be more inclusive. Regardless of the ranking process, the weights generally exhibit the following characteristics: . In general, group procedures such as the ranking procedure described below are preferred to using a single expert for policy-level decisions, but this approach can be taken at a preliminary stage to see how sensitive the results are to the assignment of weights.

2.2.2 Group ranking techniques

One widely used group ranking procedure involves asking everyone in a stakeholder group to assign a 'rank' to each criterion depending on how important they perceive that particular decision

element. An average rank or weighting is then calculated for each criterion, based on the individual scores of the stakeholders. The ranking procedures generally involve an ordinal likert scale where 1 corresponds to weakly important and the top of the scale (7 or 9) corresponds to extremely important.

Suppose that there are k experts or stakeholders involved in the ranking procedure, each assigning a rank to j criteria. If r_{k1}, r_{k2}, … r_{kn} represent the ranking that respondent k assigns to each of the criteria, then the relative weight for the jth criterion can be calculated as follows:

(3)

Because the resulting weight is an arithmetic average, it may be unduly influenced by 'outliers' on either end of the likert scale. As a result, some researchers advocate discarding the top and bottom rankings when developing the average weight for each criterion .

Another commonly used group ranking procedure involves a one-to-one pairwise comparison of each criterion against all of the others. Existing studies suggest, however, that problems can arise with respect to the transitivity of the ranking that results. Empirical applications of MCDA that have developed criteria weights using both group ranking and pair-wise comparisons suggest that the resulting weights are fairly robust to the method used to generate them, and therefore the overall decision rule is not particularly sensitive to the choice of method for assigning priority weights to each criterion (Balana, Mathijs and Muys, 2010).

3 A MCDA of Indoor Housing Options for Layer Hens

MCDA is a logical framework for animal welfare policy decisions because of the existence of multiple objectives. Housing alternatives that are more acceptable to the general public come at a cost to the industry, and many industry participants believe that they also involve compromises with respect to other facets of welfare for the hens if stockmen are not highly skilled. MCDA tools allow decision makers to explicitly consider a wide range of objectives in a transparent and defensible manner.

There are two broad welfare issues surrounding the use of cages. The first has to do with physical health issues, and the second (related) concern has to do with the fact that traditional cage systems offer hens very little opportunity to display a wide range of behaviours. Health issues include such conditions as cage layer osteoporosis, which is exacerbated by a combination of high calcium demand for egg production and a lack of exercise. However, it is the behavioural effects of keeping

hens in cramped and barren conditions that is the main concern of both animal welfare organizations and animal scientists studying animal welfare.

Traditional methods of layer farming such as free range also have welfare problems, such as higher disease incidence, increases in cannibalism and injurious pecking. A broad conclusion of many who oppose the use of cages is that the negative welfare impacts of alternative systems can be reduced with appropriate management. The behavioural deprivation, on the other hand, is an inherent characteristic of battery cage systems.

3.1 Alternative indoor housing options for layer hens

Application of the weighted sum and product methods requires the formal and explicit identification of a range of potential alternatives. Within the current context, a variety of housing options must be identified for layer hens, and subsequently ranked against a range of decision criteria. For this preliminary application, three distinct housing alternatives were considered: colony systems, aviaries or percheries, and deep litter systems. All of these alternatives will be compared to the status quo, which involves the use of conventional battery cages.

3.1.1 Battery cages

Battery cages are small enclosures with a sloping floor to facilitate egg collection. Food and water are provided for the birds, but otherwise the environment is very barren. A common size for commercial cages is 50 cm x 50 cm, so that when fully stocked with 5 birds each bird has 500 cm^2. In practice floor space per hen for battery cages ranges upward from 300 cm^2 per bird. In New Zealand, hens are required to have at least 450 cm^2 per hen. In the European Union, standards introduced in 2003 called for at least 550 cm^2 per hen. In the US, the current recommendation by the United Egg Producers is 67 to 86 in^2 (430 to 560 cm^2) per bird. Various States are taking independent action, however, and in California an initiative was passed that banned the commercial use of battery cages in that state by 2015.

3.1.2 Colony systems

Given the welfare issues with battery cages, substantial design effort has gone into the creation of housing systems that retain the production advantages of traditional cages but allow the hens more space as well as the opportunity to display a wider range of natural behaviours. One example of such attempts is the colony system. This management system involves the use of enriched cages that provide more space (both height and floor area), perching and nesting facilities. Some designs also

include area for dust bathing and claw shortening. Most design variants of these systems offer each bird approximately twice the floor area of conventional cages.

3.1.3 Aviaries and Percheries

Several alternatives to cage systems have been developed, mostly in Europe and the UK, over the past 30 years. Both aviaries and percheries are examples of such systems, which do not involve the use of cages. These systems may be restricted to one level, or they may be designed to take advantage of the full height of a barn / shed, and therefore incorporate two or three levels. In aviary systems, multiple levels are achieved mainly via platforms to prevent birds on upper levels fouling those below, whereas in percheries the varying height is achieved via the use of perches, usually timber rails located in such a way that birds can fly between them but not foul lower levels. Most of the systems involve more than one level, interconnected by ladders. Stocking densities vary in these systems, but average around 20 birds / m^2 – which gives each hen approximately the same space they have in many of the cage systems.

3.1.4 Deep litter systems

As the name implies, these systems involve the use of substrate such as shavings, chopped paper, straw or sand. They are usually limited to one level, although perches may be provided to allow the hens to roost. Variants of this system have been adopted in Northern Europe, and generally allow far more space per bird. At stocking densities of 7 – 11 birds/m^2, each bird is allocated approximately 900 - 1400 cm^2.

3.2 Decision criteria

Selection of pragmatic but meaningful criteria is a critical step in any MCDA, as the criteria enable decision makers to compare the alternatives in a transparent and systematic way. Formulation of the criteria should be primarily motivated by the principle objectives of the policy, but may be constrained by data availability and reliable measurement tools. A logical starting point for the formal development of decision criteria for animal welfare policy is the range of factors that NAWAC is statutorily obligated to consider when making a recommendation on a Code of Welfare. These are:

- the submissions made and the consultations undertaken by the Committee,
- good practice and scientific knowledge in relation to the management of the animals to which the code relates,
- available technology, and
- any other matters considered relevant by the National Animal Welfare Advisory Committee.

In addition If NAWAC is recommending a change from existing practices the Act requires the committee to have regard to:

- the feasibility and practicality of effecting a transition from current practices to new practices and any adverse effects that may result from such a transition,
- the requirements of religious practices or cultural practices or both, and
- the economic effects of any transition from current practices to new practices.

Over the last ten years of application these requirements have become interpreted as:

- animal welfare outcomes based on scientific knowledge;
- practical experience and available technology;
- good practice;
- practicality of making changes;
- international trends;
- societal values; and
- economic implications for those concerned.

For this application eleven specific criteria were selected (Table 1); five are related to animal welfare outcomes (C1 – C5), one is related to practical considerations of the affected industry such as available technology and qualified staff (C6), two are related to the international environment and societal expectations (C7 – C8), and three are related to the economic impact on the affected industry (C9 – C11).

For this preliminary analysis the eleven criteria were normalised by assigning a seven-point scale to assess each.

3.3 Scoring the alternatives

This preliminary scoring has been undertaken by a single 'expert' (one of the authors), based on a general knowledge of the overall issues rather than on expertise in any particular field and will need to be subjected to a group ranking process such as that described above in section 2.2.2. For example, the members of NAWAC have been appointed to represent a broad range of relevant stakeholder expertise and would be a suitable group to score the alternatives. However, this preliminary approach provides at least a qualitative view that would probably be reasonably consistent with those of experienced practitioners. The rankings are displayed in Table 2.

Table 1. Criteria for evaluating indoor housing alternatives for hens

	Criterion	Description
C1	Animal Welfare A: Nutrition	7-point scale ranging from 1 = does not provide adequate access to food and water, to 7 = each bird can readily access food and water when required. (note that there may be health issues associated with too much food)
C2	Animal Welfare B: Housing	7-point scale ranging from 1 = does not provide protection from the elements, to 7 = provides for an ideal range of temperatures and humidity in all climactic conditions
C3	Animal Welfare C: Health	7-point scale ranging from 1 = exposes birds to a very wide range of health challenges, to 7 = all health and sanitary requirements are met.
C4	Animal Welfare D: Behaviour	7-point scale ranging from 1 = does not allow birds to display any normal patterns of behaviour at any time, to 7 = allows birds to freely express all normal behaviours at all times.
C5	Animal Welfare E: Distress	7-point scale ranging from 1 = birds housed in this environment typically display signs of distress, to 7 = birds housed in this environment seldom display signs of distress
C6	Management capabilities	7-point scale ranging from 1 = system requires a high level of management skill that is not currently present in NZ, to 7 = management skill required for this system is readily learned by the 'average' farmer
C7	International Trends	7-point scale ranging from 1 = does not comply at all with international trends in housing, to 7 = At the forefront of international trends
C8	Public Expectations	7-point scale ranging from 1 = system is not acceptable to the general public, to 7 = system is widely supported by general public
C9	Distributional Impacts	7-point scale ranging from 1 = significant cost to consumers anticipated, to 7 = likely to involve very little cost to consumers
C10	Industry structure	7 point scale: 1 = heavy impact with a high degree of exit anticipated – 7 = little impact with low cost of adjustment for farmers
C11	Economic Impact	NPV of policy alternatives .7 point scale: 1 = heavy impact with a major cost for famers – 7 = little impact with low cost of adjustment for farmers.

3.4 Relative priority weightings

The process for determining the priority weightings is preliminary and will also need to be subjected to a group ranking process. However, there are some imperatives for the weighting process. The first five criteria are the welfare needs taken directly from the Act and therefore cannot be prioritised against each other. Hence we have given them equal weights combining to 70% of the total. International trends and public expectations have been given lower, though equivalent weightings for different reasons. The Act does not require NAWAC to directly consider international developments or societal expectations but they are used as proxies for guidance on emerging good practice. (Note NAWAC distinguishes between public opinion, which can be ephemeral and societal expectations, which is more of an assessment of underlying values.) The Act also requires NAWAC to consider the practicability and economics of any proposed changes so these criteria have been assigned 24% of the weightings. Rankings are also displayed in Table 2.

3.5 Results

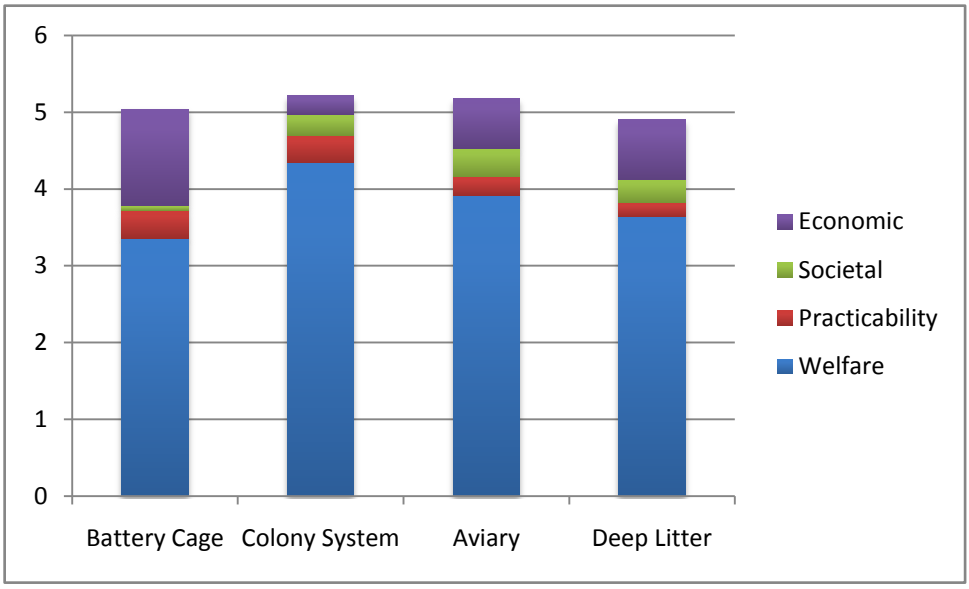
The results of this preliminary analysis using the weighted sum method are presented in Table 2 and are summarised in Figure 1.

Based on the assumptions made in this analysis, enriched colonies are marginally preferred to aviaries or battery systems with deep litter systems least preferred. The welfare component of the scores dominates for all housing types while the economic effects make a significant contribution to the scores of the battery systems and to a lesser extent the deep litter systems. Deep litter and aviary systems are the most difficult to apply (least practicable) but are the most favoured by society.

Table 2. Relative criteria weights and performance scores for housing alternatives

Criteria	Relative Weight	Battery Cage Performance Score	Colony System Performance Score	Aviary Performance Score	Deep Litter Performance Score
C1	0.14	7	7	6	5
C2	0.14	7	7	6	6
C3	0.14	7	7	5	4
C4	0.14	1	5	5	5
C5	0.14	2	5	6	6
C6	0.06	6	6	4	3
C7	0.03	1	6	7	6
C8	0.03	1	3	5	4
C9	0.06	7	2	4	3
C10	0.06	7	1	4	5
C11	0.06	7	1	3	5
Decision Score		5.04	5.21	5.18	4.90

Figure 1. Aggregate scores for housing alternatives



3.6 Sensitivity analysis

This section highlights the factors that have a particularly heavy influence on the resulting decision.

3.6.1 Choice of Criteria

Other criteria such as consistency in application of requirements based on the way other farming systems are regulated or with international good practice were considered but the Act provides a significant constraint on the range of criteria that can be considered. One criterion that we considered but rejected for this preliminary analysis was ethical considerations. Inclusion of this criterion would have favoured non-battery systems.

3.6.2 Impact of relative ratings

Relative weightings can clearly have a major impact on the final score. We chose a rating system that assigned 70% of the weight to welfare and 30% to other criteria, including economic considerations. Reducing welfare considerations to 50% of the weight would shift the overall score significantly in favour of battery systems with enriched colonies then having the lowest score of the four housing types.

3.6.3 Impact of scoring procedure

Changes in individual scores under each criterion had only minor effects on the overall final score and did not change the relative rankings of the alternative housing systems. However, the use of a

common ranking system to normalise comparisons between criteria has not been carefully evaluated and needs further consideration.

4. Discussion and Policy Implications

This analysis marginally preferred enriched colonies above all other systems and least preferred deep litter systems. This result is more or less the opposite from societal expectations and reflects the very large economic impact of the change from battery egg-laying systems for relatively small welfare gains. Welfare in cage-laying systems is high for three of the five "freedoms", access to food and water, protection from climatic change and protection of physical health, but low for the ability to express normal behaviours and freedom form distress. Alternative systems provide for slightly lower levels of the first three freedoms but for much more of the latter two. Since all five freedoms are regarded as equal under the Act the overall welfare gain is not substantial. Certainly the cost of moving from battery systems is high, either because of very expensive new colony cages or the substantially higher building volume required to achieve comparable levels of production.

Including a specific criterion to score ethical considerations may have increased the scores of the non-battery alternatives but we considered at this preliminary stage that more work was required to objectively assess how ethical considerations could be incorporated into this type on analysis.

The result was highly sensitive to the relative weightings placed on welfare versus economic impacts. This dilemma is at the core of the requirements of the Act: the balancing of welfare gains and economic cost. NAWAC is required "only in exceptional circumstances" to recommend minimum standards that do not meet the welfare objectives of the Act and economic effects are only one of three criteria to be considered when making such a recommendation. This will continue to be an area of serious debate and may only be clarified when legally challenged.

Although this preliminary analysis was based on a simple form of weighted sum analysis, informed by a single 'expert' for weightings, the authors plan to explore whether more rigorous approaches to developing weightings and criterion scores will provide better decision support. Once we have this data we also intend to test the comparisons using the weighted product method to overcome any normalisation problems.

5. Conclusions

Multi-criteria decision making appears to have a useful place in supporting the consideration of contentious aspects of animal welfare codes. This preliminary analysis highlights the need for more robust data to inform weighting and scoring of the various criteria to be considered in each analysis but the actual set of criteria to be considered is probably appropriate.

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References

Balana, BB; E Mathijs and Muys (2010) Assessing the sustainability of forest management: An application of multi-criteria decision analysis to community forests in northern Ethiopia, ***Journal of Environmental Management***, v 91, pp 1294 – 1304.

Bracke, MBM, BM Spruut, and HGM Metz (1999a) Overall animal welfare assessment reviewed. Part I: Is it possible?, ***Netherlands Journal of Agricultural Science***, v 47 pp 279 – 291.

Bracke, MBM, BM Spruut, and HGM Metz (1999b) Overall animal welfare assessment reviewed. Part II: Assessment tables and schemes, ***Netherlands Journal of Agricultural Science***, v 47 pp 292 – 305.

Bracke, MBM, BM Spruut, and HGM Metz (1999c) Overall animal welfare assessment reviewed. Part III: Welfare assessment based on needs and supported by expert opinion, ***Netherlands Journal of Agricultural Science***, v 47 pp 279 – 291.

Bracke MBM, B. M. Spruijt, J. H. M. Metz and W. G. P. Schouten (2002) Decision support system for overall welfare assessment in pregnant sows A: Model structure and weighting procedure**, *J Anim Sci,*** vol 80 pp 1819-1834.

Bracke MBM, J. H. M. Metz , B. M. Spruijt and W. G. P. Schouten (2002) Decision support system for overall welfare assessment in pregnant sows B: Validation by expert opinion**, *J Anim Sci,*** vol 80 pp 1835-1845.

Cavallaro, F (2009) Multi-criteria decision aid to assess concentrated solar thermal technologies, ***Renewable Energy,*** vol 34, pp 1678 – 1685.

Cheng, S, CW Chan and GH Huang (2002) Using multiple criteria decision analysis for supporting decisions of solid waste management, ***Journal of Environmental Science and Health, A***, vol 37(6), pp 975 – 990.

Innes, JP and Pascoe, S (2010) A multi-criteria assessment of fishing gear impacts in demersal fisheries, ***Journal of Environmental Management***, v91(4), pp 932-939.

Milne, CE; GE Dalton and AW Stott (2008) Balancing the animal welfare, farm profitability, human health and environmental outcomes of sheep ectoparasite control , ***Livestock Science***, vol. 118 pp 20 – 33.

Pohekar, SD and M Ramachandran (2004) Application of multi-criteria decision making to sustainable energy planning – A review, ***Renewable and Sustainable Energy Review***, vol 8 pp 365 – 381.

Scientific Veterinary Committee, Animal Welfare Section (1996) "Report on the Welfare of Laying Hens", Commission of the European Communities Directorate-general for Agriculture, Brussels.

Sener, B; ML Suzen and V Doyuran (2006) Landfill site selection by using geographical information systems, ***Environmental Geology***, vol 49 (3), pp 376 – 388.