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O.R. Applications

Application of the analytical hierarchy process to establish health care waste management systems that minimise infection risks in developing countries

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Abstract

This paper focuses on the application of the analytical hierarchy process (AHP) technique in the context of sustainable development to establish and optimise health care waste management (HCWM) systems in rural areas of developing countries. This is achieved by evaluating the way in which the AHP can best be combined with a life cycle management (LCM) approach, and addressing a main objective of HCWM systems, i.e. to minimize infection of patients and workers within the system. The modified approach was applied to two case studies: the sub-Saharan African countries of South Africa and Lesotho. Quantitative weightings from the AHP are used to identify alternative systems that have similar outcomes in meeting the systems objective, but may have different cost structures and infection risks. The two case studies illustrate how the AHP can be used (with strengths and weaknesses) in environmental engineering decision support in developing countries.

Keywords: OR in developing countries; Decision support systems; AHP; Life cycle management; Health care waste management systems

1. Introduction

This paper focuses on the application of the analytical hierarchy process (AHP) to address a specific sustainable development problem in developing countries, i.e. to minimise infection risks of health care waste management (HCWM) systems. Therefore, the AHP technique is introduced shortly with its strengths and weaknesses, and the application thereof is considered in the context of sustainable development and HCWM, to clarify the specific objectives of the study.

The AHP (Saaty, 1980, 1990) is a known multi-attribute weighting method for decision support (Madu, 1994). As such, the AHP has been used for solving complex decision-making problems in

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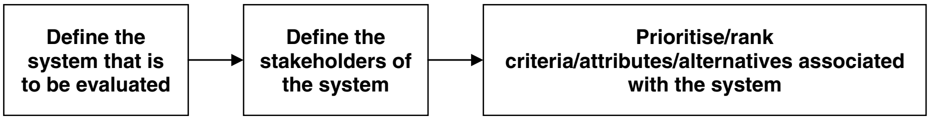

Fig. 1. A schematic diagram of the AHP process.

various disciplines, e.g. public policy (Kurttila et al., 2000), strategic planning (Bititci et al., 2001), viability determination (Alidi, 1996), forecasting (Carmone et al., 1997), and project management (Kamal, 2001). The AHP, which follows an approach of pair-wise comparison, provides a way for calibrating a numerical scale, particularly in new areas where measurements and quantitative comparisons do not exist. The process is summarised in Fig. 1.

A number of benefits and limitations have been noted with the AHP process in general as a multi-criteria decision analysis (MCDA) technique (Morrissey and Browne, 2004):

- It allows a systematic approach to evaluate policy options and helps understanding of the problem.
- A mixture of quantitative and qualitative information can be incorporated. MCDA goes beyond the evaluation of purely economic consequences and allows non-economic criteria to be assessed on an equal basis, i.e. MCDA techniques offer a level of flexibility and inclusiveness that purely economic based models tend to lack.
- Account can be taken of the preferences of the various stakeholder groups with conflicting objectives (Bana et al., 1997; Qureshi et al., 1999).
- MCDA methods do not produce the 'best' solution, but a set of preferred solutions or a general ranking of all solutions. Solving such a multi-criteria problem is, therefore, a compromise and depends on the circumstances in which the decision-aiding process is taking place.
- There is a need for personal judgement and experience in making the decisions.
- MCDA techniques are sometimes very cumbersome and unwieldy (Beynon et al., 2000).
- The allocation of weights to each criterion is subjective. Changing the weights could lead to a different result, i.e. rank reversal (Dyer, 1990).

In particular, specific limitations, associated with the application of the AHP to decision-making problems, have been expressed in terms of

- Its inadequacy to define complex systems, i.e. the hierarchical approach may be inappropriate for a specific system (Hokkanen and Salminen, 1997); and
- Inconsistencies[1] between stakeholder prioritization of attributes for a defined system, whereby weights can be calculated. For example, individual stakeholders may be subject to judgemental errors in the pair-wise comparisons (Laininen and Hämäläinen, 2002) or may find it difficult to consider a set of pair-wise comparisons as a whole (Aguaron et al., 2003). As a result, these stakeholders may perceive intransitive relationships in the pair-wise comparisons (Bodin and Gass, 2003). Alternatively, a group of stakeholders may find it difficult to reach consensus on a single or a set of pair-wise comparisons (Lai et al., 1999). Indeed, it has been argued that there is no consistency in actual choices (Hughes, 1990).

1.1. Application of the AHP to sustainable development systems

The concept of sustainability and sustainable development[2] can be understood intuitively, but it remains difficult to express it in concrete, operational terms (Briassoulis, 2001). However, many agree that sustainable development is about achieving environmental, economic, and social welfare for present as well as future generations (Azapagic and

[1] Consistency is a statistical measure of the extent to which an individual's decision structure, i.e. set of assessment judgements, is closer to being logically related than randomly chosen. The consistency of judgements reflects the extent to which the decision-maker(s) understands the problem, is knowledgeable of the decision variables involved, understands the assessment process, and is able to make a series of logically related judgements based on uncertain and often incomplete information (Noble, 2004).

[2] Sustainable development has been defined as – development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Bruntland, 1987).