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Building designers are increasingly concerned about the environmental impact of building projects. Coupled with this is the heightened demand of client organizations for environmentally 'friendly' buildings. Commercial buildings are often the most tangible expression of an organization's values; values it wishes to convey to employees and customers. The complexity of issues influencing a building's 'greenness' does present a problem for the designer. To address this problem the Building Research Establishment (BRE) produced an assessment framework entitled the Building Research Establishment's Environmental Assessment Method (BREEAM). The purpose of this method is to monitor designs and raise the awareness of designers to environmental issues. It is not intended for use as a comparative basis for competing designs. Instead, it provides technical guidance on the issues which need to be addressed in an environmental assessment. The author considers that this framework should be extended to assess explicitly the values of the client and the priorities of the environmental community.

The methodology advocated in this paper is based on multi-attribute utility theory (MAUT). This allows the combining of information obtained from experts, with values elicited from the eventual building users and owners. It provides a tool to assist the designer in the briefing stage as a negotiation mechanism, and at the proposal stage as a device for advocacy.

Keywords: environmental assessment, appraisal, risk, green buildings

Introduction

The purpose of this paper is to describe a decision model which can be used to establish an index of environmental merit for building designs. Any decision analysis approach relies on viewing a problem as an assemblage of individual features rather than holistically. The problem is decomposed into components, each of which is subject to evaluation by the decision maker. The individual components are then recomposed to give overall insights and recommendations on the original problem. In this way the problem is transformed from an opaque problem (one that is difficult to comprehend and evaluate) into a transparent problem by undertaking a sequence of transparent steps.

One complicating feature of an environmental assessment model is the presence of competing (and often conflicting) objectives. Therefore, a design which is superior with respect in one environmental issue may be inferior in another. Given the limitation of financial resources and design time, which objective should be pursued most avidly? At what point do the environmental benefits of an environmental improvement become marginal for the client? How are the environmental issues reconciled with non-environmental design issues?

Environmental assessment inevitably involves subjective assessment. Objective or

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technical information can be given with regard to the possible environmental implications of a given design. Furthermore, objective advice can be given in relation to the technical solutions which can be applied to eliminate or reduce unfavourable outcomes. These two areas are comprehensively addressed in the BREEAM report. Nevertheless, subjective assessment invariably requires two further elements:

1. Environmental community values: global environmental priorities remain unresolved in the scientific community. Even though experts are informed about various environmental impacts, there is considerable disagreement about the relative significance of each issue. Is air quality a more pressing issue than the conservation of resources or global warming?
2. Client values: the importance attributed to particular enviromental objectives also depends upon the *individual* client and their respective value systems. The concept of a green design has no meaning in any absolute sense, representing different things to different people and organizations. It reflects people's deeply felt views about the quality of life necessitating ethical trade-offs such as current returns *vs* benefits to future generations. These issues do not fall in the domain of objective scrutiny.

The following section describes the characteristics and limitations of the BREEAM approach as a comparative tool. The remainder of the paper then describes a decision model which develops some of the ideas in the BREEAM report in order to define a single measure of environmental merit for a building design.

The BREEAM approach

The Building Research Establishment's Environmental Assessment Method (BREEAM) is a certification method designed to promote good design practice in relation to environmental consequences. The method was formulated in order to raise the awareness of designers about possible local and global consequences at the design stage. This is achieved by forcing designers to consider how many of the listed issues have been addressed. In its current form it allows designers to assess the merits of alternative designs on the basis of individual issues. However, for designs that are superior in one respect and inferior in others, the problem of establishing the overall merit of a design remains.

One feature of this methodology is the avoidance of any weighting scheme. In its present form it does not attempt to represent the economic concerns and values of the client. The emphasis is on sound technical advice. This approach does not, however, allow the designer to prioritize environmental issues or to reconcile environmental issues with other competing issues. The justification for this omission in the report is that 'it is believed that a relative weighting scheme is not possible today because of the great difficulty in putting an economic cost to the long term effects of environmental issues'. By implication, the client is thus required to make an informed assessment of their significance.

The BREEAM environmental assessment method is based on a credit scoring approach, such that designs which satisfy particular constraints or objectives are awarded credits. No common scale is used so that credits cannot be assumed to be of equal value. However, the total number of credits obtained provides a general indication of the environmental friendliness of the building design.

The issues identified in the model fall within a continuous spectrum from entirely direct effects to entirely indirect effects or externalities. For the client the advantages of reducing direct effects such as indoor health hazards are clear: it is less evident what the benefits are with respect to indirect effects such as global warming. An important motive may be the need to be seen dealing with environmental issues. Figure 1 illustrates the issues considered in the report. The report emphasises measures which produce 'little or no additional life-cycle cost

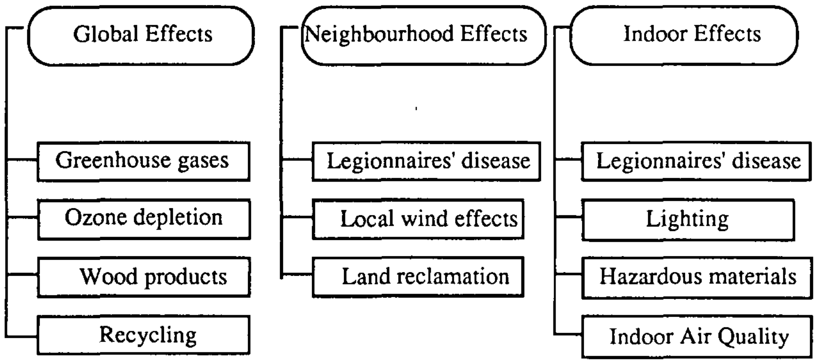

Fig. 1. Issues considered in the BREEAM model.

impact'. Despite this effort to minimize additional costs, it is clear that many of the targets may conflict with other economic design objectives. Perhaps the most pervasive cost associated with 'green' design is that associated with innovation, often resulting in addition design time, uncertain performance and space constraints.

The issues identified in the report can be assigned to one of three categories:

1. *Designing constraints* – these are targets which either are or are not satisfied. They typically use guide-lines which are easy to implement and are based on good design practice.
2. *Conflicting design objectives* – an objective, unlike a constraint can be satisfied to varying degrees. An example of conflicting objectives is indoor air quality and energy efficiency, with increased ventilation rates demanding greater energy for heating and cooling.
3. *Reinforcing design objectives* – these objectives are consistent with other design objectives. An example of a reinforcing objective is CO_2 emission reduction which is consistent with energy efficiency.

The three limitations of the BREEAM approach as a decision model are:

1. There is no formal method for establishing trade-off values between competing objectives. This is likely to lead to a less defensible basis for comparative assessments.
2. The absence of a common scale of measure which further compounds the difficulties in making trade-offs.
3. The difficulty in assessing subjective critieria on a rigid credit scoring scheme.

Modelling multiple objectives

Extending the ideas propounded in the BREEAM report the author describes a decision model which assimilates the information provided by the expert on each alternative and combines this with the pertinent values of the non-expert, the client. It is intended that the assessment would provide a key mechanism for dialogue between the designer and client during the briefing stage. When the client is represented by a number of stakeholders (including building owners, users, maintenance engineers and customers) the model allows each of their views to be expressed. It is envisaged that a formal encoding process, using a computer programme, would be used to elicit the views of these stakeholders. This would identify inconsistencies in value statements.

Multi-attribute utility theory is particularly suited to multiple objective decisions overcoming some of the deficiencies of the BREEAM method. Rather than increasing the amount of information available to the decision maker, it provides a means of making a more effective use of existing information. Having considered relevant attributes 1 to n, which have variable performance levels $x_1, x_2 \ldots x_n$, the analyst attempts to produce a function, the overall utility function $u(x_1, x_2, x_3 \ldots x_n)$, which reflects the relative desirability of an option. The objective is to maximize the utility function. The following discussion looks at a particular form of utility theory and the principles involved in its application. A summary of mathematical notation used is shown in Table 1.

Table 1. List of mathematical notation

i	Attribute number
n	Total number of attributes considered
x_i	Scalar performance level for attribute i for a given option
X_i	Most likely performance estimate of attribute i for a given option
k_i	Scaling factor for attribute i
$u(x_i)$	Single utility function for attribute i
$u(x_1, x_2, \ldots x_n)$	Total utility function of n attributes
$v(x_1, x_2, \ldots x_n)$	Total value function of n attributes
$V(X_1, X_2, \ldots X_n)$	Total expected value function of n attributes
r	Real discount rate (net of inflation)

Specifying the utility function

Every option in a decision situation can be described by a collection of attributes with performance levels $x_1, x_2 \ldots x_n$. These attributes should reflect the desired objectives of the decision maker. Provided that the attributes can be represented by a scalar value or performance level, it should be possible to identify the combination of performance levels which most satisfies the decision maker. The objective of the analysis is to obtain an overall utility function $u(x_1, x_2 \ldots x_n)$ which provides a utility index or measure of worth for a given set of options. A suitable utility function should capture the total preference structure of the decision maker. The decision maker will thus choose the alternative which maximizes this function.

A useful simplifying assumption is that the overall utility function $u(x_1, x_2 \ldots x_n)$ can be obtained from the utility functions of the individual attributes. That is

$$u(x_1, x_2 \ldots x_n) = f(u(x_1), u(x_2) \ldots u(x_n)) \tag{1}$$

One form of this is the additive case

$$u(x_1, x_2 \ldots x_n) = \sum_{i=1}^{n} k_i u_i(x_i) \tag{2}$$

A value function $v(x_1, x_2 \ldots x_n)$ represents a special form of utility function which is assessed under conditions of certainty. This avoids having to consider preferences for hypothetical lotteries involving the attributes with no uncertainty, as would be the case with the conventional utility function. Sensitivity analysis can subsequently be used to investigate the significance of any uncertainty which exists. The additive relationship can be expressed in the form

$$v(x_1, x_2 \ldots x_n) = \sum_{i=1}^{n} k_i v_i(x_i) \tag{3}$$

The expression $v_i(x_i)$ represents a single attribute value function for attribute i with performance level x_i (a single attribute value function describes the relationship between the performance level and the value to the decision maker). The scaling constants k_n reflect the weighting assigned to each attribute: each scaling constant, k_i lies between 0 and 1, with the sum of all the scaling constants equalling unity.

Keeney and Raiffa (1976) have shown that such additive decompositions are appropriate when the condition of mutual preferential independence is satisfied. An attribute x_1 is preferentially independent of an attribute x_2 if the preferences for the specific outcome of x_1 are not dependent upon the value of x_2. If, correspondingly, the preference for x_2 is not dependent upon x_1, they are described as having mutual preferential independence. One contrived example of this would be the site of a new building and the size of the car parking facilities. Let x_1 be an outcome variable which would denote either an out-of-town location or an inner city location and x_2 an outcome variable denoting either a small car park or a large car park. The value of x_1, namely whether the building is sited out of town or in town, will inevitably affect your preference for a large or small car park, reflecting the kind of parking provision required in each location. Preferential dependence can be assessed by a pairwise consideration of all the environmental attributes. Any dependencies which appear, will necessitate a redefinition of the attributes concerned. A further discussion on mutual preferential independence is given by Bunn (1984).

The Environmental Utility Model

Formulation of the proposed environmental model involves the following steps:

1. List all environmental constraints and attributes which characterize the building design.
2. Specify the utility function for each attribute i, including:
   (a) the trade-off constants (k_i),
   (b) the single dimension value functions $v_i(x_i)$.
3. Estimate the environmental merits of each proposed design, including the effects of uncertainty: these encompass both objective and subjective assessments obtained from appropriate specialists.

4. Evaluate the design options using an overall utility function, using sensitivity analysis to identify potential changes in rank ordering.

Step 1 – Identifying constraints and attributes. Several of the measures identified in the BREEAM report represent direct design measures, or constraints. These are listed in Table 2. In order to satisfy environmental requirements any design which does not satisfy these constraints is rejected or modified to accommodate the requirement. Issues which represent objectives rather than constraints are then addressed. The decision maker seeks to maximize or minimize these in the initial design. A suggested list is shown in Table 3 although the eventual inclusion of objectives will reflect the concerns of the individual client.

Table 2. Constraint table

No.	Constraint	Effect
1	Sustainable wood products used	Global
2	Air conditioning heat rejection design satisfies CIBSE (1987) TM13	Neighbourhood
3	Domestic hot water temperature satisfies CIBSE (1987) TM13	Indoor
4	Fluorescent lighting uses high frequency ballast	Indoor
5	No lead paint used	Indoor
6	No asbestos used	Indoor
7	Urea formaldehyde conforms to British standards or substitute is used	Indoor

Table 3. List of environmental attributes

Attribute	Least desirable	Most desirable	Units
(x_1) LCC (AE)	3.2	2.5	£ $\times 10^6$
(x_2) Innovation risk	5	0	subjective
(x_3) Ozone depletion	>0.06	No a–c	ODP
(x_4) Greenhouse gases	120	0	kg/m^2/yr
(x_5) Indoor air quality	80	0	%
(x_6) Land reclamation	0	4	subjective
(x_7) Recycling provision	0	3	subjective

Two further objectives are considered in the model: 'life cycle cost' and innovation risk'. Life cycle costs are expressed as the annual equivalent, which represents the annuity which, over the life of the project, yields the same net present value as the net present value for the project. Expressed in this form, the client is able to make sense of how project costs will impact on the annual expenditure of the firm, allowing comparison of options with unequal lives.

The total life cycle cost is perhaps the most pervasive of environmental issues to consider. It requires an explicit consideration of the future costs of a design decision. Central to this concept, is the discount rate **r** which reflects the time value of money. The value of the discount rate **r** determines the level at which future costs are discounted. A high discount rate will reduce the significance of costs which occur in the more distant future. A corollary of this is that options which are justified on the basis of future cost savings such as energy efficiency, durability and ease of maintenance are undervalued. Short-time horizons used in the costing will also militate against long-term solutions. If costs are expressed in constant prices, the real discount rate should be based on the long-term cost of borrowing in the market place, net of inflation (see Flanagan and Norman (1984) for a further discussion on the choice of discount rate). In the following example, a Test Discount Rate of 6% consistent with HM Treasury's (1982) recommended rate for public sector projects is applied.

Having identified the attributes, the decision maker must then identify intervals between the least acceptable and most desirable level of each attribute. These are shown in Table 4.

Table 4. Definition of ranges and intervals

Attribute	Measure and Intervals
(x_1) LCC annual equivalent	Annual equivalent life cycle cost in £ × 10^6 including maintenance costs using the test discount rate of 6%
(x_2) Innovation risk (adapted from Chang and Lutz (1988))	(5) a full scale version has been constructed (4) a commercial installation-exists (3) more than ten such installations exist (2) the innovation has been accepted in a building code (1) the design has been used in environmental conditions similar to that proposed (0) the design has been used successfully in the past by the design team
(x_3) Ozone depletion	Ozone depletion potential relative to R11 = 1
(x_4) Greenhouse gases	Carbon dioxide emission $kg/m^2/yr$
(x_5) Indoor air quality	Percentage recirculated air
(x_6) Land reclamation	(0) Use of premium or green field site (1) reclamation of land with light surface debris (2) reclamation of land containing bulky sub-surface debris (3) reclamation of land containing low level contamination
(x_7) Recycling provision	(0) No provision for recycling of waste (1) space provision for storage of recyclable waste (2) loading bay for easy removal of recyclable material (3) segregation of waste materials at source

Step 2 – defining the utility function. The definition of a utility function in the form expressed in Equation 3 involves

1. Establishing trade-offs using scaling constants k_1 to k_n.
2. Establishing single attribute value functions $v_i(x_i)$.

This two-stage process is described in the following steps 2a and 2b.

Step 2a – Ranking attributes using scaling constants. At this stage, trade-offs between competing objectives are assessed. These trade-offs are expressed in terms of the scaling constants k_i. To calculate the value of these constants the decision maker must first rank the attributes in order of importance by considering the question 'Given that all the attributes are at their least desirable level, choose the attribute that you would most prefer to move from its least desired to its most desired level?' This question is repeatedly addressed, removing the chosen attributes each time until a ranking order of importance is achieved. The ranking order appears on the second column of Table 5. In this example the ranking order of these attributes suggests that the relative magnitude of the respective scaling constants is

$$k_1 > k_3 > k_5 > k_6 > k_2 > k_4 > k_7$$

Table 5. Calculation of scaling factors k_n

Attribute	Ranking	Probability value	Scaling factor
(x_1) LCC	1	0.40	0.26
(x_2) Innovation risk	3	0.26	0.17
(x_3) Ozone depletion	5	0.15	0.10
(x_4) Greenhouse gases	6	0.12	0.08
(x_5) Indoor air quality	2	0.28	0.19
(x_6) Land reclamation	4	0.20	0.13
(x_7) Recycling provision	7	0.10	0.07
		$\Sigma = 1.51$	$\Sigma = 1$

Having ranked the trade-off values k_1–k_n, specific values for each constant must then be obtained. This is achieved by using the interview question shown in Fig. 2. in which the interviewee has to select a probability P for which he is indifferent between the reference system, which will occur with certainty, or the best and worst system which will occur with probability P and 1-P respectively. The reference system is one in which all attributes are at their lowest acceptable level except for the attribute of interest, which is at its highest level. The worst system is one in which all attributes are at their lowest acceptable level, whilst the best system is one in which all attributes are at their highest desirable level.

Figure 2. shows the systems considered in the assessment of scaling constant for attribute x_6, land reclamation. In the reference system, all the attributes are at their lowest level except for land reclamation which has a maximum value of 4. A probability P of 0.20 is chosen as the point of indifference between the reference system and the gamble. This probability value is

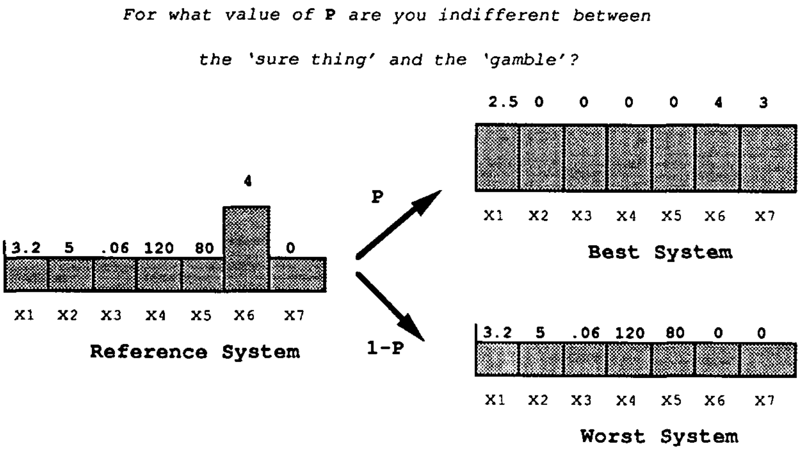

Fig. 2. Establishing trade-off values using a hypothetical gamble.

entered in Table 5 together with the probability values elicited for the other reference systems. The values of P chosen for each attribute reflect their relative importance. Since the sum of the scaling factors must equal unity, the values of P must be normalized by dividing through by the total, to provide the respective scaling factors k_i.

Step 2b–Assessment of single attribute value functions. The decision maker must next consider the individual value functions of attributes x_1 to x_n. Table 6 shows how value scores are calculated for the 'land reclamation' attribute (x_6). The top line identifies the limits of the acceptable range of land conditions for the client.

Table 6. Calculation of value scores

Level	0		1		2		3		4	
Order of importance		4		3		1		2		
Magnitude of importance		×1		×1.5		×4		×2		$\Sigma = 8.5$
Value	0		$\frac{1}{8.5}$		$\frac{2.5}{8.5}$		$\frac{6.5}{8.5}$		1	

The intervals are rank ordered according to preferability. In other words, the decision maker must '. . . identify the interval change for which he/she is prepared to pay the largest amount of money, the second largest amount and so on'.

For land reclamation the decision maker selected the interval 2 to 3 as the change for which he/she would pay the most money as shown in Table 6. That is to say, the decision maker values most highly the jump from land which originally contained only bulky subsurface debris to land which also possessed a level of localized contamination (see Table 3). In addition, the interval 3 to 4 was perceived as being more important than the interval 1 to 2 which in turn was perceived as being more important than the interval 0 to 1 (the least important interval). This order of importance is entered in the boxes directly below the range in Table 6.

Having rank ordered the intervals, the decision maker should then indicated '. . . how many times as much money they are prepared to spend to increase the performance of each interval compared to the least valued interval change'.

The decision maker in this example is prepared to pay four times as much money for the transition from 2 to 3 compared to the interval leap 0 to 1; will pay two times as much money for the transition from 3 to 4 compared to the interval 0 to 1: and will pay one and a half times as much money for the transition from 1 to 2 compared to the interval 0 to 1. These magnitudes of importance are then tabulated in the appropriate box. By summing up these magnitudes, we obtain a total, which in the example is equal to 8.5 as shown in Table 6. This figure is then used to normalize the values between 1 and 0. Values are thus assigned to each point along the scale, where $v_i(x)$ is the value of the attribute i at interval x normalized between the intervals 0 to 1.

Using the five known points, the value function can then be represented graphically. This is shown in Fig. 3 for the three subjective attributes, innovation risk (x_2), land reclamation (x_6) and recycling provision (x_7). The polynomial expressions obtained by curve fitting, provide explicit functions that can be used in the computation of single value scores. Third order polynomials are obtained for innovation risk and recycling provision whilst the land reclamation attribute fits a fourth order polynomial as shown in Fig. 3.

The four functions measure on an objective scale, including life cycle cost, ozone depletion, greenhouse gases and indoor air quality were assumed to have linear value functions. See Kirkwood (1982) for further discussion of this assumption concerning the linearity of the cost value function. The value function for the variable x_i for each of these functions is calculated from the expression:

$$v_1(x_i) = \frac{x^{**} - x_i}{x^{**} - x^*}$$

where x^* is the most desirable level and x^{**} is the least desirable level. Using these continuous functions it is possible to calculate values obtained from intermediate performance levels.

Step 3 – Estimating the performance level of options. The penultimate step requires the estimation of performance levels for each option including levels of uncertainty. To illustrate this stage consider three hypothetical design concepts which are mutually exclusive and are characterized by various technological solutions.

Option 1: *the open system* – this building design minimizes energy consumption with the effective use of ambient energy. It utilizes a natural ventilation system, thus demanding an out-of-town location. Electric heat pumps provide heating and cooling using local ponds as heat sinks. A green field site would be required for this option. Option 2: *the closed system* – this design minimizes energy consumption by minimizing energy loss. This entails the use of high U-value materials and sophisticated demand based controls including occupancy sensors and CO_2 sensors. Four pipe fan-coil units provide the heating and cooling requirements. High levels of recirculation and heat recovery are used to optimize the reuse of space heating. HCFC 123 is used as the refrigerant (ODP = 0.02). Option 3: *the reclamation system* – this design focuses on the use of derelict urban land. A VAV air-conditioning system is proposed which uses a thermosyphon cooling system to exploit ambient energy. HCFC 22 is used as the refrigerant (ODP = 0.05).

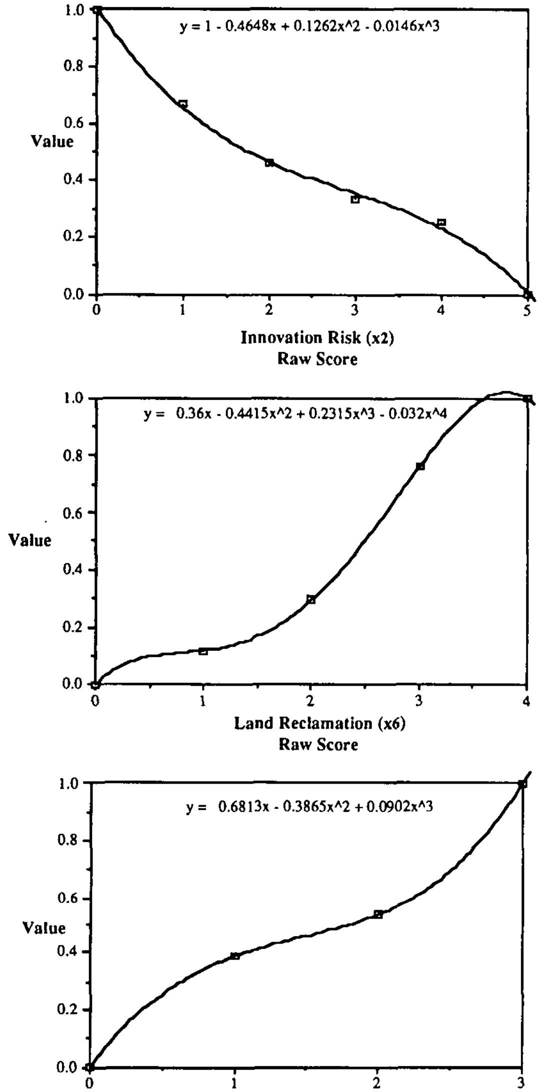

Fig. 3. Plot of raw score *vs* value.

Listed in Table 7 are the most likely performance level estimates X_i for each of the three options. As well as the most likely estimate, X_i, low estimates X_i^L and high estimates X_i^H should be identified for each option.

Step 4 – Evaluating options. The final evaluation stage involves calculation of the overall value score. The value function for each option $v(x_1, x_2, x_3 \ldots x_n)$ can be calculated from Equation 3, using the scaling constants derived in Step (2a) and the value functions obtained in Step (2b). Table 7 shows the derivation of the total expected value scores $V(X_1, X_2, \ldots X_n)$, for each of the three options, using the most likely estimates X_i.

Table 7. Derivation of the expected total value for three options

	Option 1			Option 2			Option 3		
Attribute	X_i	$v(X_i)$	$k_i v_i(X_i)$	X_i	$v(X_i)$	$k_i v_i(X_i)$	X_i	$v(X_i)$	$k_i v_i(X_i)$
(x_1) LCC annual equivalent	2.7	0.71	0.19	2.6	0.85	0.23	3.0	0.28	0.07
(x_2) Innovation risk	3	0.35	0.06	2	0.46	0.08	1	0.65	0.11
(x_3) Ozone depletion	0	1.00	0.10	0.02	0.67	0.07	0.05	0.17	0.02
(x_4) Greenhouse gases	60	0.50	0.04	40	0.67	0.05	80	0.33	0.03
(x_5) Indoor air quality	0	1	0.19	80			60	0.25	0.05
(x_6) Land reclamation	0			0			4	1	0.13
(x_7) Recyling provision	3	1	0.07	0			0		
			$\Sigma = 0.64$			$\Sigma = 0.42$			$\Sigma = 0.41$

Sensitivity analysis is used at this point, to assess the effects of small changes in scaling factors, risk attitude constant, life cycle cost or any other uncertain variable, on the ranking order. Performance uncertainty is considered using the high X_i^H and low X_i^L estimates for each option. The effects of small changes on the eventual value function can be readily assessed if a spreadsheet program is used. If the position of the highest ranking alternative remains constant during such an analysis, then a superior alternative will have been identified.

Difficulties to address

The above example considered only seven environmental objectives. However, it may be necessary to incorporate other environmental objectives such as embodied energy used in the construction materials, visual impact and ease of maintenance. The ability to use subjective scales greatly increases the scope of issues considered in an assessment model. For objectives which are clearly hierarchical in character, the application of the analytical hierarchy process might be considered as an alternative to multi-attribute utility assessment (see Dyer (1990)). Many of the performance levels used in the assessment may not be known with certainty. Yoon (1989) has shown how probabilities can be explicitly incorporated in the multi-attribute utility model to assess the magnitude of this uncertainty.

The decision makers should be wary of misleading performance measures which may not truly reflect environmental impact. For example, kilowatts of energy required to manufacture a construction material, do not reflect the scarcity or polluting effect of the energy source. Aluminium is often cited as a material with an embodied energy content considerably higher than that of other materials. Despite this, it is commonly manufactured at hydro-electric plants which arguably have a much lower demand on scarce resources as well as a less significant greenhouse effect.

The extent of objectives considered under the umbrella term 'environmental' may be a subject of disagreement. Some of the issues identified in the BREEAM report are more accurately described as general design objectives. Included amongst these are ease of maintenance, wind effects and indoor air quality. It may be more appropriate to define a complete set of design objectives of which environmental issues form only a part. In this form the model can be used at the briefing stage to direct the whole process of value elicitation from the client.

Difficulties may arise when one performance measure, notably energy consumption, satisfies more than one objective. Energy saving has a twofold effect of reducing the consumption level of a scarce resource as well as reducing the polluting effect arising from carbon dioxide emission. Expressing a utility function which captures simultaneously the client's interest in preservation and pollution reduction may be somewhat involved. An alternative would be to consider these objectives separately.

The condition of mutual preferential independence may present problems in the formulation of the model. Careful pairwise assessment of attributes and redefinition will prevent this form of dependency which can undermine the validity of multi-attribute utility theory.

Conclusions

The purpose of the assessment model described in this paper is fundamentally different from that of BREEAM, and explains the differences that exist between them. Whilst the BREEAM model attempts to prompt and inform designers about environmental issues, the author's model provides a comparative model on an individual client basis. It is considered that the process of formulating the model as much as the product of the model will enrich the client and designers understanding of the green issues. This process is steered rather than driven by technical expertise, in a form which is consistent with the economic considerations of the client.

The time required to implement such assessments can be reduced using computer-based multi-attribute utility programmes. Such programmes should provide an open structure which allow structural changes as well as changes in data. An intelligent inquiry routine should form part of the programme, providing an aid in the value elicitation process.

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