Risk and its analysis in the sustainability assessment of the built environment

Citation for published version:

Link:
Link to publication record in Edinburgh Research Explorer

Document Version:
Publisher's PDF, also known as Version of record

Published In:
25th Annual ARCOM Conference

General rights
Copyright for the publications made accessible via the Edinburgh Research Explorer is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy
The University of Edinburgh has made every reasonable effort to ensure that Edinburgh Research Explorer content complies with UK legislation. If you believe that the public display of this file breaches copyright please contact openaccess@ed.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.
RISK AND ITS ANALYSIS IN THE SUSTAINABILITY ASSESSMENT OF THE BUILT ENVIRONMENT

Doug Forbes¹, Simon D Smith² and Malcolm Horner³

1 Whole Life Consultants Ltd, Dundee University Incubator, James Lindsay Place, Dundee, DD15JJ, UK
2 School of Engineering, University of Edinburgh, Edinburgh, EH9 3JL, UK
3 Division of Civil Engineering, University of Dundee, Dundee, DD1 4HN, UK

How to build sustainably is arguably the pre-eminent question of our time. The construction industry and the built environment which it creates have a substantial impact on a range of sustainability issues. Sustainability assessment exists to measure the impacts of sustainability. However, the existing range of assessment methods frequently fails to take risk in the process or the outcome into account. The purpose of the research presented in this paper is to present a generic approach to estimating risks in sustainability assessment for the built environment. This approach defines generic cases of the probability and consequence for risks in sustainability assessment. An outcome matrix has been created to define the severity of each risk based on the associated probability and consequence. Appropriate responses are proposed to then manage the risks. Using the context of sustainability assessment for housing, the specific risks associated with the Ecohomes assessment method are explored. This research demonstrates through applying risk analysis that there are unacceptably severe risks associated with the weighting mechanism, regional differences, fixed parameters and thresholds, the range of coverage of the indicators and the heavy data requirement. However, the analysis demonstrates that there are a number of in-built mechanisms which make Ecohomes resistant to specific risks, and there are also some risks which may not be severe for specific problem situations. The application of risk estimation allows novel insights into the sustainability assessment process and is transferable to other sustainability assessment methods for the built environment.

Keywords: BREEAM, Ecohomes, risk analysis, sustainability assessment.

INTRODUCTION

Sustainability and sustainable development are arguably the pre-eminent issues of our time. Many of the origins of current research and development in this area can be traced back to the Brundtland Commission’s Report, “Our Common Future” (WCED 1987). In the intervening years there has been debate as to exactly what sustainable development entails and how it can be achieved. There are many perspectives, but it is generally agreed that the aim is to achieve the goal of meeting current needs whilst preserving the ability of future generations to do likewise. In doing so it is generally appreciated that there are three dimensions. These three dimensions are social, economic and environmental (Parkin et al. 2003). Ultimately the goal must be to head towards being sustainable. Sustainability assessment is a vital tool in considering whether development is sustainable: that is whether changes are decreasing or

¹ doug.forbes@wlcuk.com
² r.m.w.horner@dundee.ac.uk
³ simon.smith@ed.ac.uk

increasing our ability to be sustainable (Pope et al. 2004). Effective, robust assessment of sustainability is therefore vital to take account of the complexities and interactions of the social, economic and environmental dimensions (UN 2007). This is particularly so in the assessment of the built environment. BREEAM (Building Research Establishment’s Environmental Assessment Method) is commonly referred to as the first simplified environmental assessment methods for buildings (Birtles 1997; Cole 1998). It is simplified because it allows projects to be readily assessed on a common framework without necessarily carrying out a detailed impact assessment for each one. BREEAM is a UK-based assessment and has been adapted for application to Canada, Hong Kong and Australia (UKGBC 2007). BREEAM is one of the most commonly used sustainability assessment methods for the built environment in the UK.

What are the risks in sustainability assessment?

The purpose of this research is to investigate how risks can be assessed in sustainability assessment and to develop a generic approach for doing so. This will use subjective probability and consequence and highlight where sustainability assessments are robust and where further investigation of the risks is required. If sustainability assessment is wrong or incomplete then the outcome will not be head towards the goal of sustainability. One of the problems in the standard approaches to sustainability assessment is that there is no published account of the uncertainties which exist. These uncertainties exist in two key areas: firstly the development of the methods and secondly the application of the techniques. Frequently the methods are provided as a ‘black-box’ type system which produces a deterministic outcome. It is therefore hard to make a judgement on how risk-prone a sustainability assessment method is.

The underlying risk in sustainability assessment is that the wrong outcome results from the assessment. There are obviously degrees to which it can be wrong. For example it could be fundamentally flawed, or it could be wrong in only one area. Applying the framework of risk management to analyse and respond appropriately to these risks allows the potential problems in sustainability assessment to be seen.

The objective of applying a risk management framework to sustainability assessment methods is to establish where the uncertainties exist in the process and where the risks which may result in a wrong assessment of sustainability lie (Blockley and Heslop 2001). Many of these risks will be hazards where the assessment can fail in its measurement. Sustainability assessment, and in particular sustainability assessment of the built environment, has failed to take due account of the risks associated with the estimate of sustainability (Roscelli and Bellomo 1997). The application of a risk management framework to sustainability assessment will allow these uncertainties and hazards to be understood in more depth. This will allow a further evaluation of high severity risks where they exist in the process. Sustainability assessment methods can then be modified to control and reduce the risks. This approach is designed to deal with the risks at the development stage of sustainability assessment tools. The analysis of risks in this way will guide and direct the development of the assessment and will produce guidance on how the tools should be applied.

RISK ASSESSMENT IN SUSTAINABILITY ASSESSMENT

Previous research has identified a comprehensive set of risks associated with sustainability assessment of housing (Forbes et al. 2008). This was done through a workshop and subsequent validation and supplementation via a questionnaire. These risks will be assessed in this research. Subjective probability and consequence is the
most commonly used method for risk assessment (Akintoye and MacLeod 1997). The approach is based on the assessment of the probability of the event occurring in conjunction with the consequences to the objective of the given event occurring.

**Setting the probability and consequence levels**

A five-point scale has been developed for the probability and consequences with risks in sustainability assessment. The probability scale, Table 1, ranges from ‘Almost Certain’ to ‘Rare’. The intermediate values can be applied as appropriate. There are indicative probabilities assigned to each level. The most likely (almost certain) considers probabilities in excess of 85% and the least likely (rare) less than 1%. The probabilities were adapted from the Risk Analysis and Management for Projects guide (ICE et al. 1998) which also included a sixth level of probability less than 0.01%. However, such a small probability in comparison to the next level of less than 1% was felt to be unnecessary for assessing the risks in sustainability assessment methods.

In a similar manner, the consequences are defined for the purposes of this research in a five-point scale as given in Table 2. These five points relate to the effect of the risk on the assessment outcome. A brief description of the effect on the assessment of sustainability is provided. For instance, the highest level is catastrophic, for example for an assessment that concludes a development is sustainable when in actual fact it is not.

*Table 1 Probability descriptors for probability and consequence approach*

<table>
<thead>
<tr>
<th>Description</th>
<th>Scenario/Details</th>
<th>Indicative Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almost Certain</td>
<td>Is present, or is most likely present in the assessment</td>
<td>85-100%</td>
</tr>
<tr>
<td>Likely</td>
<td>Is most likely/more than evens chance the risk is in the assessment</td>
<td>50-85%</td>
</tr>
<tr>
<td>Possible</td>
<td>Might be in the assessment</td>
<td>15-49%</td>
</tr>
<tr>
<td>Unlikely</td>
<td>Could potentially be in the assessment</td>
<td>1-15%</td>
</tr>
<tr>
<td>Rare</td>
<td>Risk will only be in the assessment in extreme circumstances</td>
<td>&lt;1%</td>
</tr>
</tbody>
</table>

*Table 2 Consequence descriptors for probability and consequence approach*

<table>
<thead>
<tr>
<th>Description</th>
<th>Scenario/Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catastrophic</td>
<td>Will lead to a fundamentally wrong assessment of sustainability</td>
</tr>
<tr>
<td>Major</td>
<td>Will lead to a wrong assessment output</td>
</tr>
<tr>
<td>Moderate</td>
<td>Will increase the complexity of the output/Moderate errors in the output</td>
</tr>
<tr>
<td>Minor</td>
<td>Will have a minor effect on the output of the assessment</td>
</tr>
<tr>
<td>Insignificant</td>
<td>Will not affect the output score significantly</td>
</tr>
</tbody>
</table>

**Setting the severity of the risk**

The probability and consequence are combined into levels indicating the severity of the risk. These severity levels define the actions which must be taken for each of the risks. Four levels have been developed. Each is assigned a required action as detailed in the table. The severity levels and responses are: Intolerable (Steps must be taken to reduce or eliminate this risk); Undesirable (Further investigation is required to investigate this risk and define further. If risk is to be retained, guidance is to be
provided to mitigate the effects or probability of this occurring.); Acceptable (Retain and acknowledge risk), Negligible (Can be ignored).

There is a range of approaches to assign probability and consequences to a problem and consider the appropriate severity (AS/NZS 2004; Godfrey 1996; ICE et al. 1998). The severity of a risk is defined by combining the probability and the consequence for each one. This can be done in two ways. Firstly, an absolute value (for instance numbers 1-5) is assigned to the probability and consequence. The risk severity is then determined by comparing the product of these two numbers to a pre-defined threshold. Secondly the matrix combining probability and consequence is defined by applying a reasoned approach to define the severity of each combination (Godfrey 1996). Where this second approach is suggested it is stated that the combined levels should be tailored to meet the individual problem (AS/NZS 2004).

Probability and consequence are combined to define the appropriate response. A tailored matrix for use in sustainability assessment is proposed in Figure 1. A product approach would tend to consider insignificant and almost certain risks at the same level as catastrophic and rare risks. For the purposes of sustainability assessment this was not considered appropriate, as an issue which would result in fundamentally wrong assessment of sustainability should at least be considered in more detail, regardless of how likely it is to occur. Therefore a subjective, reasoned, approach was used to assign the severity to the combined levels of probability and consequence. This assigned intolerable and undesirable categories to all catastrophic risks to ensure further investigation of these. Similarly major risks, which will lead to a wrong assessment, must all be investigated further except for those which only occur rarely. The moderate and minor risks have a spectrum of severities covering all four levels. Finally, risks of insignificant consequence do not need to be considered in any further detail, except for an acknowledgement of those that are likely or almost certain to occur as outlined in Figure 1. In effect, this process has placed a higher weighting on the consequence of the risks than on their probability.

*Figure 1 Outcome combinations for probability and consequence approach*

<table>
<thead>
<tr>
<th>Probability</th>
<th>Consequence</th>
<th>Catastrophic</th>
<th>Major</th>
<th>Moderate</th>
<th>Minor</th>
<th>Insignificant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almost Certain</td>
<td>Intolerable</td>
<td>Intolerable</td>
<td>Intolerable</td>
<td>Undesirable</td>
<td>Acceptable</td>
<td></td>
</tr>
<tr>
<td>Likely</td>
<td>Intolerable</td>
<td>Intolerable</td>
<td>Undesirable</td>
<td>Undesirable</td>
<td>Acceptable</td>
<td></td>
</tr>
<tr>
<td>Possible</td>
<td>Intolerable</td>
<td>Undesirable</td>
<td>Undesirable</td>
<td>Acceptable</td>
<td>Negligible</td>
<td></td>
</tr>
<tr>
<td>Unlikely</td>
<td>Undesirable</td>
<td>Undesirable</td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>Negligible</td>
<td></td>
</tr>
<tr>
<td>Rare</td>
<td>Undesirable</td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>Negligible</td>
<td>Negligible</td>
<td></td>
</tr>
</tbody>
</table>

**ASSESSING RISKS IN THE ECOHOMES ASSESSMENT**

A key part of the built environment is the housing sector. The potential for achieving a sustainable built environment through housing has been demonstrated by many authors (eg. Lovell, 2004); it has therefore become a focus for government targets on, primarily, reducing carbon emissions (Stevenson and Williams 2007). Therefore, the risks associated with the domestic BREEAM version, Ecohomes, will be investigated in this research.
How Ecohomes works

Ecohomes is the domestic version of the BREEAM family. It was developed in 2000 and has undergone revisions in 2003, 2005 and 2006 (BRE 2006). The most recent, 2006, version assesses environmental performance against eight headline categories. The categories are Energy, Transport, Pollution, Materials, Water, Land use and ecology, Health and wellbeing, Management. The scores for each category are combined into a total percentage score for the whole development. This score is then translated to a rating scale of ‘Pass’, ‘Good’, ‘Very Good’ and ‘Excellent’.

Assessing the risks in Ecohomes

The generic approach for assessing risks in sustainability assessment was used to determine the risks in the Ecohomes assessment method. This process used the full set of 48 risks which had been developed in previous research as being associated with sustainability assessment of housing (Forbes et al. 2008). This process allows a high level overview of the risks in sustainability assessment to be seen and for the characteristics of the assessment method which open it up to risks to be identified. The levels of probability and consequence were assigned to each of the 48 risks based on the definitions in the previous section. These were assigned by using an in-depth knowledge of the assessment methods based on the author’s personal experience as a qualified and registered Ecohomes assessor, and published literature and articles relating to the assessment method. Additional, further background understanding was obtained from the risk management workshop where the risks were initially identified.

Figure 2a-c contains a full set of the risks and the corresponding probability and consequence of each in the Ecohomes assessment method. Additional background notes supporting the defined levels are included along with the overall severity of the risks.

What are the risks in Ecohomes?

The risk analysis undertaken demonstrates the severity of the risks associated with the Ecohomes assessment method. It allows a high level assessment to be made of the risks in sustainability assessment and in particular the Ecohomes assessment method. The risks which emerged from the analysis of Ecohomes are discussed below.

Low Level Risks

An analysis of the overall level of risk in Ecohomes showed that there were two risks which were negligible. There were 19 at an acceptable level, and 15 and 12 at undesirable and intolerable levels respectively. The negligible risks are important because it is these areas which demonstrate where Ecohomes is extremely robust. Two strengths of Ecohomes result in these outcomes. Firstly, the context of an Ecohomes assessment is clearly defined within the boundaries of housing. This is facilitated further by the remainder of the BREEAM family which is designed to take account of other types of building.

The second aspect of Ecohomes which inherently minimises some the risk is the prescriptive nature of the assessment. This allows all assessments to be carried out using a common reference point and protects against subjectivity by the assessor.

In addition to the negligible risks Ecohomes had 18 risks which were acceptable. These risks are considered to be of a sufficiently low combination of probability or consequence that they can be retained. This is the largest group of risks within Ecohomes, and again demonstrates that there are effective built-in mechanisms to
keep the severity of the risks low. The characteristics which keep it low are the established nature of Ecohomes in UK as an assessment method, and its context within the BREEAM family. Similarly, the expertise and experience within BRE in developing the suite of tools and the consultation undertaken to develop them contributes to keeping the severity of these risks acceptable. The process of Ecohomes is rigid in collecting evidence, awarding credits and quality assurance checks. There is very little scope to allow deviation from a prescribed path. This is of benefit to risks in measuring, accuracy, complexity and conceptual issues.

**High level risks**

Despite the ability of Ecohomes to maintain the severity of the risks at an acceptable level or less for 20 out of 48 risks, there remain 28 risks which are undesirable or intolerable. These risks require immediate attention or further investigation. Firstly, Ecohomes was originally an environmental assessment method; an increasing number of social issues have been incorporated in recent revisions. A pure environmental assessment may be appropriate for some applications. However, the extent of its coverage in three dimensions should be established. The risk assessment has critically highlighted the lack of the economic dimension in the assessment. There are also weightings are applied to each of the eight categories. The effect and consequences of these should be investigated. This is coupled with trade-offs in the assessment making Ecohomes a weak sustainability measure.

Additionally, Ecohomes is a design-stage assessment and there is no check on the post-construction outcome of the dwellings. There is little account is taken of differences between rural and urban settings and new-build against existing stock. The assessment methodology is restricted solely to housing. Alternative tools should be used if a wider assessment context is required. These are partly controlled by rigid guidelines set by BRE to maintain rigour in the process (eg. licensed assessors, quality assurance, updates). However, these must be observed to ensure the risks are minimised.

There is a heavy data requirement to carry out an assessment. The full extent of the data requirements should be investigated. This heavy data requirement impacts on the verbose nature of the report. Despite this heavy data requirement the output is a fixed percentage value. The appropriateness of such a point value should be investigated. Included in calculating this fixed value are a range of fixed parameters and thresholds pre-defined by BRE. The effect of these fixed parameters and thresholds should be considered in more detail. Ecohomes also relies on other tools to define the output (eg. SAP2005, Considerate Constructors Scheme). These are all widely acknowledged industry tools, however their appropriateness should be considered by the assessor organisation prior to use. These risks have been shown, in a subjective approach to be of an unacceptably high level. Therefore they need further investigation, or have control measures put in place to reduce the risks to an acceptable level.

**CONCLUSIONS**

There are risks in sustainability assessment methods for the built environment which are not properly investigated. The research presented in this paper has investigated the process of managing risk in sustainably assessment and proposed a generic means of their analysis. The probability and consequence approach presented in through this research is an initial step in the risk management process to manage these risks which
### Figure 2a Risks assessed in Ecohomes

<table>
<thead>
<tr>
<th>Risks Assessed in Ecohomes</th>
<th>Acceptable</th>
<th>Undeniable</th>
<th>Unlikely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risks related to the environmental impact of materials and processes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risks related to water and energy consumption</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risks related to indoor air quality and health</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risks related to the durability and maintenance of the building</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risks related to the financial viability of the project</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risks related to the social and economic benefits of the project</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Risks</th>
<th>Acceptable</th>
<th>Undeniable</th>
<th>Unlikely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risks related to the environmental impact of materials and processes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risks related to water and energy consumption</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risks related to indoor air quality and health</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risks related to the durability and maintenance of the building</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risks related to the financial viability of the project</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risks related to the social and economic benefits of the project</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

*Note: The table above outlines the risks assessed in Ecohomes and their categorization into acceptable, undeniable, and unlikely.*
Figure 2b Risks assessed in Ecohomes

<table>
<thead>
<tr>
<th>Risks Assessed in Ecohomes</th>
<th>Likelihood</th>
<th>Probability</th>
<th>Impact</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Impact</td>
<td>Greater</td>
<td>Higher</td>
<td>Higher</td>
<td>Greater</td>
</tr>
<tr>
<td>Economic Impact</td>
<td>Greater</td>
<td>Higher</td>
<td>Higher</td>
<td>Greater</td>
</tr>
<tr>
<td>Social Impact</td>
<td>Greater</td>
<td>Higher</td>
<td>Higher</td>
<td>Greater</td>
</tr>
<tr>
<td>Technical Impact</td>
<td>Greater</td>
<td>Higher</td>
<td>Higher</td>
<td>Greater</td>
</tr>
</tbody>
</table>

Legend:
- Likelihood: Greater, Higher, Moderate, Lower, Negligible
- Probability: Unlikely, Unlikely/Moderate, Moderate, Likely
- Impact: Low, Medium, High, Critical

Note: The table above outlines the Risks assessed in Ecohomes, with likelihood, probability, and impact ratings provided for each. The summary column provides a brief overview of the risks assessed, highlighting the greater, higher, moderate, or lower likelihood, probability, and impact of each risk category.
<table>
<thead>
<tr>
<th>Page</th>
<th>Section</th>
<th>Description</th>
<th>Likelihood</th>
<th>Impact</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>33</td>
<td>Life Cycle</td>
<td>Does the assessment process fail to take account of the full life-cycle of the project?</td>
<td>Possible</td>
<td>Major</td>
<td>Undesirable</td>
</tr>
<tr>
<td>34</td>
<td>Measurement</td>
<td>Are there indications omitted/unnecessary included in the assessment which could affect the measure of sustainability?</td>
<td>Almost Certain</td>
<td>Major</td>
<td>Intolerable</td>
</tr>
<tr>
<td>35</td>
<td>Stakeholder Views</td>
<td>Are there views of specific stakeholders omitted from the assessment?</td>
<td>Unlikely</td>
<td>Moderate</td>
<td>Acceptable</td>
</tr>
<tr>
<td>36</td>
<td>Tacit Knowledge</td>
<td>Is knowledge of the assessment held within individual parties involved in the assessment and thus adversely affecting the output of the assessment?</td>
<td>Rare</td>
<td>Moderate</td>
<td>Acceptable</td>
</tr>
<tr>
<td>37</td>
<td>Unknowns</td>
<td>Is there the possibility of omissions which could adversely affect the output of the assessment?</td>
<td>Likely</td>
<td>Major</td>
<td>Intolerable</td>
</tr>
<tr>
<td>38</td>
<td>Calculation</td>
<td>Are the calculations required for the project over-complicated?</td>
<td>Possible</td>
<td>Moderate</td>
<td>Undesirable</td>
</tr>
<tr>
<td>39</td>
<td>Data is complex</td>
<td>Is the data required for the assessment so complex that it might affect the output?</td>
<td>Possible</td>
<td>Minor</td>
<td>Acceptable</td>
</tr>
<tr>
<td>40</td>
<td>Over-Simplified</td>
<td>Is the data required for the assessment so over-simplified that it might affect the output?</td>
<td>Rare</td>
<td>Moderate</td>
<td>Acceptable</td>
</tr>
<tr>
<td>41</td>
<td>Timing</td>
<td>Does the timing of the project increase the complexity which could affect the output of the assessment?</td>
<td>Possible</td>
<td>Catastrophic</td>
<td>Intolerable</td>
</tr>
<tr>
<td>42</td>
<td>Too Difficult to Understand</td>
<td>Are the assessment and/or its inputs/outputs too difficult to understand?</td>
<td>Possible</td>
<td>Minor</td>
<td>Acceptable</td>
</tr>
<tr>
<td>43</td>
<td>Too Expensive</td>
<td>Is it too expensive to carry out an assessment?</td>
<td>Likely</td>
<td>Moderate</td>
<td>Undesirable</td>
</tr>
<tr>
<td>44</td>
<td>Too Many</td>
<td>Are there too many inputs to measure to carry out an assessment?</td>
<td>Likely</td>
<td>Major</td>
<td>Undesirable</td>
</tr>
<tr>
<td>45</td>
<td>Too Subjective</td>
<td>Is the assessment too subjective and open to mis-application?</td>
<td>Rare</td>
<td>Minor</td>
<td>Negligible</td>
</tr>
<tr>
<td>46</td>
<td>Cost &amp; Boundaries</td>
<td>Is the cost of the assessment ill-defined, and not connected to the boundaries which are defined for the assessment?</td>
<td>Possible</td>
<td>Minor</td>
<td>Acceptable</td>
</tr>
<tr>
<td>47</td>
<td>Cost-benefit</td>
<td>Is there no cost benefit for those involved in the assessment for actually carrying out the assessment?</td>
<td>Possible</td>
<td>Minor</td>
<td>Acceptable</td>
</tr>
<tr>
<td>48</td>
<td>Life Cycle Costs</td>
<td>Is there no value for money obtained over a life cycle in the use of the assessment?</td>
<td>Likely</td>
<td>Moderate</td>
<td>Undesirable</td>
</tr>
</tbody>
</table>
has not been applied before. This approach is generic and could be applied to a set of identified risks in any sustainability assessment method. There are, however, limitations associated with applying probability and consequence to the problem, not least the subjective nature of the approach. Its application to the Ecocohomes assessment methods has been successfully demonstrated in this research. Further research should apply the approach to other assessment methods (eg. CEEQUAL, Code for Sustainable Homes) to determine its effectiveness and generic capabilities.

Beyond showing the applicability of the probability and consequence approach the particular risks associated with Ecocohomes have been assessed. This has shown that there are several built-in strengths which make it robust. These are controlled by rigorous updates, quality assurance, evidence collection and assessor training. However, there are a number of risks which require further investigation to ensure appropriate controls can be put in place. There are four ways of dealing with these: firstly the risks which are inherent which should be considered on a case-by-case basis, secondly the risks which require existing safe-guards to be put in place before they are controlled (eg. the standard reporting format), thirdly those risks which are affected by the Ecocohomes process and finally those risks which require further investigation. These four groups should be considered in more detail to gain a greater understanding of the risks in Ecocohomes.

ACKNOWLEDGEMENTS

The support of the Engineering and Physical Sciences Research Council (EPSRC) in funding this work is gratefully acknowledged.

REFERENCES


