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Building sustainability assessment methods

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Over last 15 years it has been increasingly important to understand the sustainability performance of buildings across a broad range of considerations. This has stimulated the development of a number of sustainability assessment tools intended to measure objectively a project's impact in sustainability terms and so encourage designers and planners to improve a building's performance. This paper examines the nature and contribution, as well as the limitations, of current sustainability rating assessment tools in evaluating building sustainability in different countries. Two yardsticks are used to review the current tools: first, how well they relate to the goal of sustainable development, and second, how adequately they adhere to the principles of objective assessment. Scope for further development of sustainability assessment tools is identified – in particular, the need for tools to assess more adequately how buildings provide well-being, and to expand how assessment systems capture qualitative information. The paper proposes that methodology and procedures of assessment methods should feature the broad participation of user groups drawn from the public.

1. Introduction

Sustainability assessment is a procedure used to evaluate whether environmental and societal changes arising from man's activities and use of resources are decreasing or increasing our ability to maintain long-run sustainability (Forbes, 2008, p. 28). It is used as a means to evaluate the impacts of policies, plans and projects in order to ascertain the extent to which they affect sustainable development (Pope *et al.*, 2004).

Whereas buildings and urban infrastructure contribute greatly to well-being, construction and the use of building are major factors in global and regional resource consumption. The design of built structures, their location within an urban system, their use of materials and energy resources in construction, operation and maintenance, and the waste and emissions arising, all have an impact on the sustainability of the environment. The well-being of future generations depends on managing the exploitation of the Earth's resources. The prudent use of resources in the development and maintenance of the built environment and methods of assessing the impact of buildings on the environment are required in order to promote economy through the processes of building and place design, construction and management of the use of buildings and their maintenance.

Developers, advised by local public authorities, increasingly undertake sustainability assessment before development and thereafter may make subsequent assessments to consider the design and management of each phase of a building's life cycle, including its demolition and disposal as waste. For such reasons the sustainability assessment tools used in building construction have received much attention. However, assessing the impact of buildings on sustainability is not straightforward. There are decisions to be made as to the scope of the assessment, the indicators used to measure impacts and the interpretation of results.

There has been a parallel development of several assessment tools and these have been taken up by the design, planning and construction professions. Local assessment systems have developed in different countries responding to perceptions of what is needed in their local conditions. These assessment systems share much in common but also evidence differences of scope, approach and reporting.

2. Aims of the paper

The research interest of this paper is to review how well current assessment systems appraise the sustainability of buildings. The research question to be addressed is how adequate are the assessment tools now in use? Assessment tools measure achievement against sustainable development targets, which are used to monitor progress and to promote preferred behaviour (Becker, 2004). Two aspects of research interest emerge from this statement: the first concerns what is measured by the choice of indicators or, in other words, attention is placed upon the scope of the assessment tool; the second interest is in examining the quality of the assessment tool from the perspective of its robustness as a process of appraisal: that is, how well the tool satisfies the principles of objective assessment.

3. Research method

Worldwide there are many building evaluation tools that focus on different areas of environmental performance and are designed for different types of projects. These tools include life cycle assessment and costing, energy systems design and performance evaluation, productivity analysis, indoor environmental quality assessment, operations and maintenance optimisation, whole building design and operations tools (Fowler and Rauch, 2006, p. 1).

For the purpose of this paper, the number of assessment tools included in this study was controlled. Interest was limited to 'sustainable building rating systems'. These are assessment tools that examine the performance or expected performance of a 'whole building' and translate that examination into an overall assessment that allows for comparison against other buildings (Fowler and Rauch, 2006, p. 1). The authors undertook a comparative analysis of sustainability building rating systems worldwide. The tools are designed for evaluating different types of buildings and they emphasise various phases of the building life cycle, relying on different databases, guidelines and questionnaires (Haapio and Viitaniemi, 2008, p. 12). Sustainable rating systems that are widely used were selected to be reviewed (see Table 1).

The authors reviewed written materials for each rating system that was publicly available and drew upon information using the internet, conference proceedings and journal articles. The

Sustainable building rating systems development basis	Country of origin	Continent
Breeam (Building Research Establishment's environmental assessment method)	UK	Europe
The German sustainable building certificate (DGNBSeal)	Germany	
The haute qualité environnementale (HQE)	France	
Innovation and transparency of the contracts – protocol (Itaca)	Italy	
Promise	Finland	
Verde (and Breeam derivative)	Spain	
Breeam Netherlands	Netherlands	
Green Globes^{TM} US	USA	America
Leed (leadership in environmental and energy design)	USA	
Sustainable building challenge (SBC – formerly known as the 'green building challenge' (GBC))	Canada	
Aqua/Leed Brazil (and Breeam derivative)	Brazil	
Consejo Mexicano de edificación sustentable	Mexico	
Building environmental assessment method (HK-Beam)	Hong Kong	Asia
Green building rating system	South Korea	
Green mark and construction quality assessment system (Conquas â)	Singapore	
Comprehensive assessment system for building environmental efficiency (Casbee)	Japan	
Estidama	United Arab Emirates	
GRIHA (green rating for integrated habitat assessment) and Leed India	India	
GB evaluation standard for green building	China	
Green Star SA	South Africa	Africa
The national Australian built environment rating system	Australia	Australia
Green Star	Australia	
Green Star ZN	New Zealand	

Table 1. Rating system source(s)

rating systems were categorised in accord with a frame of characteristics: describing the types of assessed buildings, the users of the tools, their systems structure, their flexibility, the phases of the life cycle and the form used to present the aggregated results. The categorisation and analysis of the rating systems drew on the published work of many researchers (Alwaer and Clements-Croome, 2010; Alwaer *et al.*, 2008a; Atkinson *et al.*, 2009; Brownhill and Rao, 2002; Chew and Das, 2008; Cole, 1997, 1998, 1999; Crawley and Aho, 1999; Fenner and Ryce, 2008; Fowler and Rauch, 2006; Haapio and Viitaniemi, 2008; King Sturge, 2009; Reed *et al.*, 2009; Seo *et al.*, 2006; Todd *et al.*, 2001).

On the conclusion of this process the data collection undertaken on applicable rating systems was seen as adequate to support a comparative review of the characteristics of the rating systems.

4. Promoting the goal of sustainable development

There is debate regarding the appropriate definition of sustainability as the concept is still evolving, often with competing and sometimes contradictory interpretations. Sustainability refers to that which 'continues' or 'endures' or is 'maintained'. Sustainability branches into three major dimensions, each linked to the other; these are 'the triple bottom line' – environment, economic and social sustainability (King Sturge, 2009, p. 4). The complexity and interdependencies of these elements is not yet well understood. Nevertheless it is recognised that policy and actions to safeguard sustainability require environmental, economic and social issues to be viewed in a holistic and integrated manner, taking into account their interdependencies and, as far as possible, allowing for uncertainties, while also considering the consequences of present actions for the future. There is also a growing appreciation of the consideration of values, particularly of the need for equity of access to resources affecting life chances, both intra-generational and inter-generational. Lastly, there is the matter of governance of managing for sustainability – in this respect, having regard for institutional systems that differ between countries, and through which sustainability goals are set and policy and regulation are framed and enforced.

Ultimately the purpose of sustainability assessment is to inform this complex process of societal governance. It is framed within the twin drivers of what society wants and accepts and what science and the accumulation of tested knowledge and understanding offer about how progress towards these ends might be made, monitored and objectively assessed, with rational management decisions being made. Assessments of sustainability can help to inform the societal discussion and influence the governance environment towards the goal of sustainability. The effectiveness of an assessment system in this regard requires that it matches up well against a number of requirements. The assessment system should be seen to be

- hopeful: assessing progress towards sustainable development guided by the goal to deliver well-being within the capacity of the biosphere to sustain it for future generations
- holistic: encompassing all key factors – economic, environmental, social and institutional – required to shape sustainable development, so enabling understanding of what is needed to plan comprehensively and sustainably, and yet recognise uncertainties
- protective: sustaining the capacity of the biosphere to support well-being by acting with a precautionary bias
- harmonious: balancing the criteria upon which sustainable development should be judged and considering the consequences of present actions into the future, including assessing equity considerations
- participatory: reflecting widely held aspirations and concerns and providing helpful information
- habit-forming: becoming a natural tool for all concerned and enabling better governance (adapted from Brandon and Lombardi, 2005, p. 122, 2011; Gasparatos *et al.*, 2008, p. 287; IISD, 2009; Zimmerman and Kibert, 2007, p. 684).

Assessment implies measuring how well or poorly something is performing against a declared range of indicators (Cole, 1998, p. 6). The building industry is confronted with an expanding set of regulatory practices and priorities which in the recent past have been largely generated by the push for sustainability in the face of climate change and carbon-based energy consumption. However, the concept of 'building performance' is more complex and in addition to environmental factors covers overlapping social and economic considerations. The challenge for sustainability appraisal is to promote the sharing of understanding across the broad dimensions of sustainability and thereby meet a wide range of requirements to include both regulatory imperatives and the aspirations of investors and users.

5. Meeting the principles of objective assessment

The rational method of goal-directed decision-making (Friend and Hickling, 2005) requires that choices of options are appraised to determine on a performance basis the preferred option, and that on a regular basis the effectiveness of the favoured option is evaluated. This strategic choice approach is informed by information gathering, knowledge-based analysis and comparison at every stage. The intent of the process is one of optimisation. Clarity is a requirement throughout the process so as to facilitate the means to audit and review the intelligence and the processes of generative thinking, comparative assessment and decision making with a view to system improvement. Assessment is an integral part of this rational approach. In particular, a key function of sustainability assessment should be to distinguish objectively between the performance of different courses of action (Forbes, 2008, p. 44; Walton *et al.*, 2005).

Objectivity requires that general principles of assessment underpin the design and operation of the assessment system. The general principles of assessment are essentially a specification of what makes for effective measurement and testability. The features can be summarised as follows (adapted from the BellagioStamp principles (IISD, 2009)).

- Scope: the assessment system has to frame an appropriate time horizon to capture both short- and long-term effects, and to have an appropriate spatial scope which may well range from local to global.
- A 'proven' conceptual framework: the conceptual framework has to be founded on appropriate and proven 'cause and effect' models which can be informed with reliable data and allow trends and projections or scenarios to be drawn.
- Reliable indicators: the use of standardised measurement methods permitting comparability and a robust selection of indicators with values and benchmarks, again providing for the basis for comparison.
- Transparency: there must be clarity about the assessment. Data sources and methods must be disclosed. The choices, assumptions and uncertainties must be explained. All conflicts of interest must be disclosed. The data, indicators and results must be accessible to the public and capable of audit and testing.
- Effective communication: assessments must be presented in a fair and objective way that enables interpretation and comment.
- Informative and hassle-free: communicating with and easy to use by a wide range of people.
- Capable of continuous enhancement: assessment practice must be responsive and the capacity to learn and adapt ingrained.

6. Categorising assessment systems by their characteristics

Serving goals and objective assessment are two sides of the same coin; that is, the measurement of performance is essential in order to know what progress is being made towards goals. However, goals are pervasive influences and may readily intrude upon the assessment process in subtle ways that could unbalance the objectivity of the assessment. To examine how well buildings sustainability rating systems measure up in terms of serving the goal of sustainable development and are compliant with the principles of objective assessment, the authors de-constructed the building assessment rating systems into a set of categories of key characteristics.

The characteristics defined are closely aligned with the general principles of assessment. Although primarily relevant to these principles, certain of the characteristics can also be seen to relate to influencing how decisions with regard to the goal of sustainability would be informed. These were the characteristics of assessed buildings and applicability, the benchmarking and calculations process, and the weighting systems and communicability. These characteristics enabled each assessment tool to be evaluated and allowed cross-comparison between the tools.

Table 2 identifies ten characteristics building on important areas to consider, as suggested by Haapio and Viitaniemi (2008), Saunders (2008) and Alwaer *et al.* (2008a).

6.1 Categorising characteristic: system maturity

This characteristic identifies when the tool was developed, first used, first available for public use, and when the most recent revision was completed. Also, it identifies the number of buildings assessed using the rating system. It is evident from Table 3 that established systems are regularly updated. This indicates that the rating systems are being progressively enhanced as new knowledge becomes available.

6.2 Categorising characteristic*:* assessed buildings and scope of assessment applicability

The tools included in this study mainly cover new buildings, existing buildings and buildings under refurbishment and including different buildings. However, is one building assessment tool able to assess various types of building equally well? Tools like Breeam and Leed have different versions for different building types (homes, multiple residents, schools, offices etc.). Different versions have been developed to better recognise the special requirements of the buildings (see Table 4).

The rating systems, to a greater or lesser extent, identify common criteria (see Table 5). Most often used criteria are those relating to impacts on the environment. However, the tools may have the same main criteria (e.g. energy) but use different sub-criteria and indicators to correspond with these criteria.

While there are no comprehensive assessment systems that are mandatory, Breeam and Leed are becoming a standard expectation by building regulators in the UK and the USA. Yet none of the existing tools comes close to being a 'sustainability' tool in terms of being capable of simultaneously addressing the social, environmental and economic core issues together with other factors such as cultural and technological constraints (Ding, 2008; Essa *et al.*, 2007). The recent additions

URN	Category	Definition
1	Country of origin	Where the tool was originally developed
2	System maturity	How established the method of assessment is
3	Assessed buildings and scope applicability	The list of categories considered by the tool
4	Measurability and data	Criteria, whether both qualitative and quantitative criteria are considered
5	Benchmarking and the calculations process	The calculations process used to allocate different weights or scores to constituent parts of the tool
6	Uncertainties and errors	How reliable and accurate the calculations process method of assessment is
7	Building performance or building performance in use (life cycle assessments)	Whether the whole life cycle is considered in making the assessment
8	Sustainability scales *and* universal applicability and adaptability	The size of area with which the tool deals (e.g. single building, business park, town, region etc.), also, the degree to which the tool can deal with different areas (e.g. whether it applies just to the country from which it originates or further afield)
9	Weighting systems and communicability	What system is used to give the overall rating (e.g. 'very good', 'good' etc., or A, B, C , or +5, +3, +1 etc.) and the communicability process
10	Illustration	How the outcome of the tool is interpreted (e.g. if a diagram is used)

Table 2. Categorising characteristics

of social issues in tools like 'Breeam in use' may be considered as supplements to the environmental assessment rather than an effective means of measuring social sustainability of buildings (Forbes, 2008, p. 39).

6.3 Categorising characteristic: measurability and data

Assessment tools focus on explicit and measurable criteria. Explicit knowledge is codified, recorded and clearly articulated with standard methodologies for assessment and presentation. Quantitative criteria include measures of annual energy use, water consumption and greenhouse gas emissions (Clements-Croome, 2004; Ding, 2008, p. 7). Adopting proven measurement methods and widely accepted criteria can ensure that results are meaningful, that they can be repeated and that the information can be benchmarked within the framework of the individual assessment tool. However, the ability to check and validate the application of the assessment procedures and indeed to confirm the assumptions held is not always easy to achieve.

Quantitative measurements as compared to qualitative studies have the advantage of ease of representation, but on the other hand, the indicators that are presented for use in apparently objective terms can mask underlying cultural, epistemological,

	System age			Number of buildings		
System maturity	Initiated	Available for public	Recent revision	Completed and certified	Testing and development	System for revisions
Breeam	1990	1990	2008	7202[a] *	√	√
Casbee	2001	2002	2005	80[b] *	√	√/–
Green Star	2002	2003	2008	87[a] *	√	√
Leed	1998	1998	2009	2858[a] *	√	√
SBC	1996	1998	2007	--	√	√

[a]Certified buildings as of September 2008 (King Sturge, 2009).
[b]Certified buildings as of 14 August 2009 (Casbee).
Note on symbols used in Tables 2–5: √ meets criterion; O under development; √/– meets criterion with exception(s); — does not meet criterion; n/a not applicable; -- not available; blank indicates information unknown.

Table 3. Summary of the data gathered for the system maturity review criterion (adapted from Fowler and Rauch, 2006, p. 23)

	Type of projects			
Applicability	New construction	Major renovations	Tenant build-out	Operations and maintenance
Breeam	√	√	–	√
Casbee	√	√	–	√
Green Star	√	√	–	√
Leed	√	√	√	√
SBC	√	√	–	O

Table 4. Summary of data gathered for the applicability review criterion (adapted from Fowler and Rauch, 2006, p. 19)

economic and social influences (Alwaer *et al*., 2008b). Even after quantitative data collection, the scoring can be skewed by subjective judgement (Cole and Larsson, 1998).

6.4 Categorising characteristic: benchmarking and the calculation process

Each of the assessment tools in terms of the benchmarking, weightings and calculation systems is unique. This is not unexpected as the tools have been designed to cover different country contexts; they emphasise different phases of the life cycle with different benchmarking and priorities levels for the selected criteria, and they rely on different databases, guidelines and questionnaires.

> A benchmark is defined as a measurable variable used as a baseline or reference in evaluating the performance of an organisation (or environmental indicator). Benchmarks may be drawn from internal experience or that of other organisations, or formal legal requirements, and are often used to gauge changes in performance over time (Roaf, 2005, p. 99).

Benchmarking the baseline performance for assessment is difficult to establish (Ding, 2008). The real shortcoming is that there is insufficient consensus about the benchmarks against which to judge whether a particular building is successful in achieving a good sustainable building rating (Clements-Croome, 2004, p. 371).

In order to calculate a combined score from the diverse range of environmental criteria a weighting is required. The ways in which the assessment rating systems set these weightings differ. In some cases these are built into the value of each criterion, whereas for others they are built into the value of the environmental issue category (Saunders, 2008, p. 11). The weightings used are summarised in Table 6. Some assessment tools include the same categories (i.e. Breeam and Leed) but within each category (e.g. water category) there are different sets of indicators and priorities reflecting regional norms. The weightings applied and the benchmarks differ significantly from country to country.

The weighting issues remain a controversial aspect in terms of measuring sustainability and dealing with subjective outputs. There can be no definite rule to determine customised weighting (Chew and Das, 2008, p. 11). However, sustainability criteria

Scope and applications (assessment criteria)	Casbee 2004–2009 Japan	Green Star 2003–2009 Australia	Leed 1998–2009 USA	Breeam 1990–2009 UK	SBC 'formerly GBC' 1998–2009 Canada	IBI 2000–2009 Asia
Energy	√	√	√	√	√	√
Land use and site	–	√	√	√	√	–
Indoor environmental quality	√	√	√	√	√	√
Materials used and waste	√	√	√	√	√	–
Water	√	√	√	√	√	–
Management	√	√	–	√	√	–
Transport	–	–	√	√	√	–
Pollution	√	√	√	√	√	–
Economy	–	–	–	–	√/–	√/–
Innovation	–	√	√	√	–	–

Table 5. Criteria used in different assessment tools

	Breeam	Leed	Green star	Casbee
Management	15	8	10	It is not possible to calculate the value of each issue category for Casbee as the value is dependant on the final score
Energy	25	25	20	
Transport	25	25	10	
Health and wellbeing	15	13	10	
Water	5	5	12	
Materials	10	19	10	
Land use and ecology	15	5	8	
Pollution	15	11	5	
Sustainable sites	–	16	–	

Table 6. Summary table of issue value and weighting comparison (see http://www.breeam.org/ (Saunders, 2008: p.11))

must be organised in ways that facilitate meaningful dialogue and application. The structuring of criteria within the assessment system is critical to the output of the performance evaluation. Weighting remains a conceptually complex area to address within sustainability assessment systems, but when based on greater understanding of the various aspects of building then a better assessment of performance will be secured (Cole, 1997).

6.5 Categorising characteristic: uncertainties and errors

The rating tools may include errors in their definitions and calculation, which affect the aggregated outcomes and are very difficult to discover (Haapio and Viitaniemi, 2008, p. 10). The interpretation of the results can also lead to uncertainties and errors. These uncertainties exist in two key areas: first in the development of the methods and second in the application of the techniques. As a result, the calculation processes are not always adequate to provide a reliable assessment for the evaluator and decision makers (Chen, 2007, p. 33). Often there is a lack of clarity – the methods are 'black boxes' – they give answers, which produce a deterministic outcome, but the method of their calculation is not clear (Alwaer *et al.*, 2008a, p. 50; Forbes, 2008, p. 44). It can therefore be difficult to be certain regarding how risk-free a sustainability assessment method is.

Some reviewers have criticised the setting of these tools and the apparent arbitrariness of defining the value of credits available for each category (Forbes, 2008, p. 39; Lee *et al.*, 2002). The evaluator may choose a tool based on securing results which give a favourable answer. For example, if one tool gives better results for a certain type of building than the other methods, there is a risk that the evaluator's selection criteria are biased towards providing the desired results and hence the assessment's value is diminished (Haapio and Viitaniemi, 2008, p. 11). This applies especially if weightings are wrongly derived, and in the worst scenario, manipulated to improve the end score (Chew and Das, 2008, p. 11).

6.6 Categorising characteristic: building performance or building performance in use

Most rating systems look at the performance of a building *before* it is occupied – in fact, earlier assessment systems only rated design intent, without any post-construction evaluation. Today, most professionals still understand 'building performance' to mean the performance of an unoccupied building, thus rating the *potential* of a building, rather than its *actual* performance. Often, the credibility gaps between design expectations of energy efficiency and actual fuel consumption outcomes arise not so much because predictive techniques are wrong, but because the assumptions used are not well enough informed by what really happens in practice. Few people who design buildings go on to monitor their performance. While some differences are legitimate (e.g. the building is used more, or has more internal space filled), surveys nearly always reveal avoidable waste, which can arise from poor briefing, design, construction and commissioning, and not just bad training, bad maintenance and bad management (Bordass *et al.*, 2004, p. 1).

There are efforts to develop assessment methods to measure in-use performance (e.g. display energy certificates, Breeam maintenance and operations, Leed for existing buildings), but the ultimate goal – the mainstream acceptance of systems that measure and rate long-term actual building performance – is still set well in the future.

6.7 Categorising characteristic: sustainability scales – universal applicability and adaptability

No individual country, region, city or development project can achieve sustainability on its own if any greater system of which it is a part, or to which it is critically connected, is unsustainable (Rees, 2009, p. 306). Terms like 'sustainable city' or 'sustainable building' are meaningless taken out of context (Rees, 2009, p. 306). Regional scale along with the cultural variation can significantly influence the sustainability assessment. In some regions land is a scarce resource, while in other regions it is not, so the importance of these criteria/indicators will differ regionally (Alwaer *et al.*, 2008b; Alwaer and Clements-Croome, 2010; Todd and Geissler, 1999, p. 249). Also, taking the category of water as an example, in regions such as the UK water is not a scarce resource. This situation changes completely in the United Arab Emirates and Egypt, where water is a scarce resource (Todd and Geissler, 1999, p. 249).

6.8 Categorising characteristic: communicability

The main challenges in making assessments are: which criteria are the most important; which indicators correspond to these criteria best; and which alternative gives the user of the tool most significant information (Haapio and Viitaniemi, 2008). To add to this list, the extra challenge of how information and results are presented is no less important. A key component of effective evaluation is how information is presented. This depends on the purpose of the evaluation and the target audiences. For example, building owners and facilities managers may look for different sets of information (Becker, 2004, p. 210). However, 'the presentation of the results is particularly important in making evaluations operational, with clarity often compromised for technical detail and simplicity by the abundance of indicators' (Becker, 2004, p. 201). It is essential not only to collect a wide range of performance criteria scores but also to combine these into a manageable number of measures in order to make measurement flexible and easy to understand (Cole, 1998).

Two formats have been used to express the results of sustainability assessment. First, 'sustainability labelling' is often used, typically to classify the performance into descriptive categories such as 'fair', 'good', 'very good' or 'excellent'. In the Breeam system there is a dependency on the difference in the number of credits possible for the particular building being assessed. Similarly the Leed assessment is judged as meeting a 'bronze', 'silver', 'gold', or the best, 'platinum' performance benchmarks (Cole, 1999). In the Green Star programme of the Green Building Council of Australia, a building is judged as meeting one to six stars, with four to six stars obtaining official certification. This nomenclature is somewhat confusing since the term 'certification', which includes all buildings in the four grades in the case of Breeam and Leed, for example, is also the title of the lowest grade 'certified' or 'fair'. Thus 'certified' is used in two ways, this is ambiguous; for example, the Leed building was certified gold or the Leed building was given as 'certified' (Murphy, 2009, p. 3).

Awarding of points is related to the way that the points are distributed over the declared range. Most programmes use a simple linear points allocation. In Breeam, eight credit points are given for carbon dioxide emissions between 160 and 140 kg/m^2 per year and more points are awarded if carbon dioxide emissions are further reduced (Breeam, 2009). This recognises the fact that effort required typically increases as industry norms are exceeded. The advantage of such systems is simplicity, but the disadvantage is that the weightings of relative importance tend to be developed for one location, but then used in many others. Similarly, benchmarks of what is considered good performance also tend to have limited regional application. In some tools where labelling constitutes the system of assessment there is a fairly obvious limitation: it is not sufficient to express performance level as 'good' or 'very good' because there is no obvious or logical agreement on what it means to build or create a green building or even how to define 'green' building.

Weighting system and communicability	Results representation	Weighting system used	Result product
Breeam	Pass, good, very good, excellent, outstanding	Labelling	Certificate
Casbee	'Spider web' diagram, histograms and BEE graph	Rating	Certificate and website published results
Green Star	Two Star: 20–29 points, average practice; Three Star: 30–44 points, good practice; Four Star: 45–59 points, best practice; Five Star: 60–74 points, Australian excellence; Six Star: 75+ points, world leadership	Labelling	Certificate
Leed	Certified (26–32), silver (33–38), gold (39–51), platinum (52–69)	Labelling	Award letter, certificate and plaque
SBC	Range of detailed and broad histograms	Rating	n/a

Table 7. Summary of data gathered for the applicability review criterion (adapted from Fowler and Rauch, 2006, p. 19)

The second presentation format used is 'sustainability rating'. This approach provides the parameters and a basis for scoring and weighting them in the assessment. In this system, negative implications, which can be considered as unsustainable performance, have been considered, thus helping researchers, designers and planners to bridge the gap between sustainable and unsustainable criteria. The benefits from the applications of this system can be noted with reference to the provision of a complete, coherent profile of the building that helps the reader to understand the conversion of reference data into numerical aspects and the avoidance of a subjective interpretation. For example, Green Building Challenge (and its associated application SBTool 2007 (Larsson, 2007)), is a method developed by international teams from 14 countries. The mechanism used in this system allows for the relative importance of performance issues in a particular region, and makes it possible to include regional benchmarks. Regional authorities can ensure that the system will be relevant to their unique local conditions.

7. Discussion and conclusions

The authors of this paper have sought to examine the adequacy of the assessment tools now in use by the design, building control and construction professions as the means by which to judge the performance of buildings in meeting the needs of sustainability. This primary question required that the authors should review the scope of the assessment tools most widely applied throughout the world to rate the sustainability of buildings, and assess the objectivity evident in the framing and use of these tools.

As the study was restricted to a 'high-level' review of the characteristics of scope and the adequacy of the building performance rating systems against the various 'tests of objectivity', the comparison made between the rating systems was of a 'broad-brush' nature. Using this perspective, additional to the scope of the framework, the fundamental requirements of 'good practice' were defined as requiring the proven relevance and the reliability of the data; comparability over time and place of adopted indicators and benchmarks; transparency of the measuring and weighting processes; and ultimately the fairness and quality of reporting performance.

In general, the adequacy of the systems with respect to aiming for objectivity in their analytical and evaluation processes can be regarded as satisfactory. All the rating systems compared have been up-dated in recent years to expand the scope of their interest, both regarding the building life cycle and the understanding of the dynamics of environmental change. Their systems are sufficiently transparent to make it possible to identify the methods of calculation, the setting of targets and benchmarks, and the assumptions taken to support weighting of indicators.

Differences were indicated between the rating systems in their treatment of weighting of factors. Leed placed a low rating on water and on land-use and ecology, but gave a high rating to materials, energy and transport, and to sustainable sites; whereas Breeam, although also rating low for water and rating high for energy and transport, gave less weight to materials. These differences invite further examination to understand better how these aspects are defined and what value drivers are being applied.

Differences were also evident regarding the communicability of the results of the building assessments. Comparability between the rating systems is frustrated by their use of different reporting practices. The labelling approaches in use by Breeam, Leed and Green Star have the merit of simplicity, but a greater communication, and arguably more instructive presentation, of results is achieved by Casbee's use of 'spider web' diagrams, histograms and built environment efficiency (BEE) graph.

In general terms, what perhaps is most significant is the broad similarity of the rating systems in terms of their procedures and coverage. Of greater interest, however, is what these systems fail to cover adequately with regard to their scope. All sustainability assessment tools have a framework of elements which defines what is viewed as relevant for measurement. This framework, which represents the scope of the building assessment tool, has two components: the first is what life cycle stages of the building are examined and the second is what range of performance impacts or effects is considered. Conceptually, a comprehensive framework will take account of all phases of the building's life cycle, from its initial site location through to its ultimate disposal. Sustainability is affected by impacts and effects associated with the building's performance over the building's life cycle.

Regarding the scope of the currently developed building sustainability assessment systems, the rating tools in use today have their origins in a concern with the impact of building on the 'green' environment. They emerged at a time when public and political interest was no longer limited to historical and current environmental impacts, and increasing concern was being given to future implications of climate change. The systems were designed and named to identify their relevance as tools for measuring environmental impacts. However, the discourse about the concept of sustainable development has developed over the last two decades. The goals of sustainable development now include social, environmental and economic considerations.

Sustainability indicators arise from values ('we measure what we care about'), and they create values ('we care about what we measure') (Meadows, cited in Singh *et al*., 2009, p. 191). The benefit of indicators is their ability to summarise, focus and condense the enormous complexity of the dynamic environment to a manageable amount of meaningful information (Godfrey and Todd (2001), as cited in Singh *et al.*, 2009, p. 191). The current building sustainability rating systems have emerged in response to environmental concerns. The issues covered by current sustainability assessment tools remain mainly related to the use of fossil fuels, materials and land along with the pollution impact of buildings. The progress made over past decades has been to pay greater attention to the cumulative impacts that buildings have at local and regional scales and to address global environmental issues (Fenner and Ryce, 2008, p. 62).

However, societal concern about the social and economic costs of stressed urban communities reflects a growing awareness of the importance of including the goal of ensuring human well-being within the definition of sustainable development. This implies that the sustainability assessment of a building must have regard to the sustainability of its functionality, and critically should record the experience and the satisfaction (its value-in-use) derived by users. To date, the assessment systems address social aspects indirectly, usually by referencing to other standards that have social equity components built into them (Zimmerman and Kibert, 2007, p. 683). Aspects of health, comfort, safety, well-being and user satisfaction are assigned to the social dimension of sustainable development for single buildings (Lützkendorf and Lorenz, 2006). Indoor environmental quality covers health-related issues, and aspects such as accessibility and building-related illnesses have come to be included.

More problematic is the neglect with respect to assessing the relative value that users place on buildings. There are cultural and social variations between social groups, localities and regions regarding how buildings are experienced and the affectivity felt towards building features, spatial configuration, the propensity for social engagement and the perceived security of the locality of buildings. Yet, mindful of the economic and psychological costs caused by failed neighbourhoods, these considerations should be a critical concern. Thus, the design of a sustainability assessment system has to consider both quantitative and qualitative data.

Sustainability rating systems have concentrated on quantitative measurement. They neglect qualitative techniques which can be the means for recording socio-psychological perceptions of value. Qualitative knowledge reflects an individual's perceptions, it reports opinions and estimates, which reflect values often tacitly held by the individual (Himanen, 2004, p. 30). However, the capture and interpretation of 'soft' data is difficult to make 'objective'.

The integration of social and economic factors into the assessment process has received less attention for reasons of past dominant perspectives, as well as the issues of methodology and measurement complexity. Therefore, existing tools cannot be regarded as delivering integrated sustainability assessment. The shift from 'green building' to 'sustainable building' presents a major challenge for enhancing environmental assessment tools (Fenner and Ryce, 2008, p. 62; Forbes, 2008, p. 46; Haapio and Viitaniemi, 2008). The processes of 'operationalising' sustainability assessment may well need to be revised. Weaver and Rotmans (2006) suggest sustainability assessment should be understood as a 'cyclical, participatory process of scoping' through which a 'shared interpretation of sustainability ... is developed'. This highlights the importance of stakeholder involvement in the creation of sustainability assessments (Weaver and Rotmans, 2006, p. 12). The aim should be to establish a broad participative process that can be adapted from broad-brush assessments to detailed ones as required in any future assessment tool framework (Fenner and Ryce, 2008, p. 62).

Further complicating the application of sustainability assessment tools is the reality that the characteristics of regions and of countries differ. The sustainability issues of localities with a dispersed population are very different from those of a high-density urban environment. Most existing assessment methods were not explicitly designed to handle regional specific issues (Birtles, 1997; Cole, 1998; Todd and Geissler, 1999). The assessment tools were developed with a particular country in mind and reflect dominant perceptions regarding the environment and sustainability, as held within that country at the time of framing the assessment system. They are not readily universally applicable, as countries will find some categories more important than others. After comparing building rating methods Breeam, Green Star and Leed, Saunders (2008, p. 41) concludes,

> It is reasonable to assume … that none of the schemes travel well if used in countries other than those which the system was initially designed to work in. It therefore suggests that, where used outside the native country, any of the systems should be tailored to take account of the local context.

Striving to form a more holistic vision of sustainable development and progressively improving the objectivity of the procedures and techniques used in the assessment process in accord with principles of objective assessment does not imply that the rating systems will all coalesce. The drivers and needs vary considerably between the regions and countries. There are differences between climates, physical and urban geographies, governance systems, and social, cultural and economic emphases. What may be needed is a standard which can adapt to take account of 'home territory regulatory effects'. For example, the SBTool (formerly GBC) system is a rating framework, designed to allow countries to tailor their own locally relevant rating systems. SBTool is designed to include consideration of regional conditions and values, in local languages, but the calibration to local conditions does not destroy the value of a common structure and terminology (Larsson, 2007). The newly developed 'Breeam International' from which all-regional derivatives, starting with Breeam Emirates, will be generated and independently calibrated has a similar intent (Saunders, 2008, p. 44). There is no scope for a 'one size fits all' approach (Atkinson *et al.*, 2009, p. 25), but there is considerable benefit to be gained from comparing and learning from 'best practice' in assessment systems and adapting systems tailored to local conditions.

Significant advances in sustainability assessment methods have been seen over the last 15 years. They have been intended to foster sustainable building design, construction and operation by promoting and facilitating better integration of environmental solutions with cost and other traditional design criteria (Fenner and Ryce, 2008, p. 55). However, the success that building assessment systems have experienced to date with certifying 'green' buildings is at risk. The purpose of sustainability assessment is to inform the progress of the governance environment towards the goals of sustainability – social, environmental and economic. There is increasing appreciation of a more inclusive discourse with respect to the understanding of sustainability issues, such as differences emerging between assessing environmental impacts of building designs with more complex sustainability issues (Zimmerman and Kibert, 2007, p. 689). In short, there is an ongoing need to enhance the assessment systems approach.

The conceptual under-pinning of the scope of sustainability is enlarging. The concept is recognised as multi-dimensional. Moreover, there is increasing appreciation that, although measurement by quantification provides efficiencies of standardisation and objectivity, the reality is that assessors, design professionals and building users will all hold somewhat differing relative values with regard to what matters in relation to sustainability issues. The selection may be made on technical grounds, for example, having regard to differing regional climatic conditions, but cultural and governance forces operating in different countries also shape the application of assessment tools and the interpretation of their results. In addition, increasingly in a globalised world there is the advocacy of 'human rights' values. These assert rights to expect and to protect well-being and to participate in the debate and determination of societal goals and actions. These primary values acknowledge the importance of comparability and hold the hope that resulting learning about effective practices will feed back to improve local sustainability action. The authors expect the scope of sustainability tools to become increasingly inclusive of the expanding understanding of sustainability, notwithstanding local variation in the detail and deployment of such tools, and also that the development of such systems will continue to be informed by pursuing the principles of objectivity.

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