Selecting environmental assessment tool for buildings

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Introduction

Environmental assessment and rating of buildings have grown increasingly during the last years. For building owners or developers is it often possible to choose between a national rating or ratings which are internationally marketed, such as LEED (US), Breeam (UK) or Green Star (AUS). These methods have the advantage of being well known and to some extent facilitate international comparison. On the other hand, they may be poorly adapted to national climate, building techniques and building regulations in comparison with national tools.

In some respect all tools claim that they assess the sustainability of a building. But there is no international consensus about what that means. Apart from this difficulty tools have been developed in different environments, often have different focus und use different methodology for measuring and evaluating environmental issues. Since the rating scales generally have a few steps a certain building can have a similar rating from two systems although the basis for this is completely different. For a building owner it is likely that a good rating, apart from the market value, also represents high performance in terms of user qualities and low environmental impacts. Tools have increasingly tended to support not only environmentally benign solutions but also lot of related things like design procedures, innovations, proximity to service etc. Due to the extensive content of assessment methodologies it is very hard to grasp the differences in characteristics and meaning of a ratings.

Aim

The aim of this paper is to provide a framework for comparison of building environmental assessment tools as a basis for better understanding of their differences and selection of an appropriate tool for a certain building. The suggested framework also may serve as a ground for discussion of tool content and assessment methodology.

Framework for comparison

It is generally possible to organise the majority of the content of a building environmental tool under the following headings:

- Energy use and pollution
- Material and waste
- Indoor environment
- Water use (potable and rain)
- Site and ecology
- Environmental management

Environmental assessment mainly deals with prevention of negative environmental impacts caused by buildings, i.e. avoiding environmental problems. From this perspective the above shown headings are not well suited for comparisons since they only tell what is assessed but not which impacts are addressed, how prevention is rewarded, how rating is carried out, etc

A systematic comparison of assessment tools needs a framework that addresses the main characteristics that may differ between tools. The following three fundamental questions about an environmental assessment tool are used as a starting point for tool comparison:

1. What is assessed?
2. How is the assessment made?
3. What is the price of an assessment

These questions have been further broken down into comparison aspects in the table below:

Question		**Comparison aspects**	**Examples**
What is assessed?	CONTENT	Which physical elements are included ?	Building materials, technical systems, building, site, district
		Which environmental impacts are evaluated?	Indoor impacts, local impacts, global impacts
		Which life cycle stages are assessed?	Extraction, manufacturing, transports, use, end of life.
How is the assessment made?	METHOD	Which type of indicators are used?	Performance, procedures, features, other
		How significant are the measurements?	Validity, accuracy, repeatability
		How have rating criteria and scales been set?	Levels, degree of challenge, references,…
		How is aggregation of single assessments to a final rating performed?	Points, weights, priorities, normalizations,..
What is the price for an assessment?	COST	What expert involvement and time for assessment is needed?	Certified consultants, assessment procedures, advanced calculations,..
		What are the certification fees?	Initial, extra, consultation, final
		Are there attendant costs?	Computer programs, manuals,.

In the paper the comparison aspects are discussed one by one and summarized in important checkpoints for comparison.

Conclusion

Although assessment tools may look similar at first glance, tools are generally very different. This is because there are so many options for a tool designer to choose between what should be assessed, how to assess it and how to measure and aggregate results.

There are also good reasons for tools being different. They may be directed towards different target groups and to some extent they have to adapt to local conditions in different countries, such as climate, building codes, building traditions, building techniques, environmental priorities, etc.

The examination of comparison aspects shows that there are many issues to consider at tool comparison but that the systematic approach can clarify significant tool differences. The suggested framework may be used for screening purposes at tool selection or deeper analysis for other purposes.

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Summary
Evironmental rating of buildings have been increasingly popular during recent years. Often building owners or developers can choose to make an assessment according to a national assessment stystem or an international often more recognized system. But since building assessement tools differ a lot regarding content and assessment methodolgy it is difficult grasp characteristic differences between them. In the end also the cost of a rating is an important factor. This paper present a framework for tool comparison useful for screening at tool selection or a deeper analysis by experts.

Keywords:
building, assessment tool, methodology, choice, comparison, content, performance, procedures, features,

1. Introduction

Building assessment tools often claim that they measure sustainability. This concept is normally described as being based on three pillars; environmental, social and economic sustainability which interacts (Figure 1a). For a single building the social and economic meaning of sustainability is somewhat diffuse.The relation between buildings and the environmental sustainability is clearer since buildings consume physical resources, creates emissions directly or indirectly and have an impact on biodiversity locally but to some extent also on a larger scale via resource extraction and emissions.

Long-term environmental sustainability can be looked at as a precondition for the wider sustainability of a society (Figure 1b). For this reason focus here is on the environmental dimension.

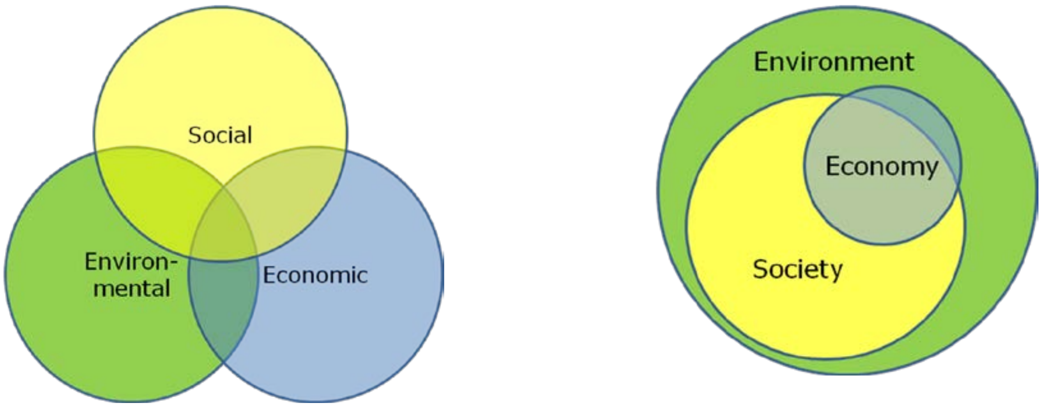

Figure 1. a) A common way to show the interrelationships between environmental, social and economic sustainability. b) It is also possible to regard environmental sustainability as a precondition for the other sustainabilities.

2. Aim

The aim of this paper is to provide a framework for comparison of building environmental assessment tools as a basis for selecting tool and understanding their different characteristics.

3. Types of tools

When comparing assessment tools for buildings, it can be fruitful to distinguish between tools for environmental analysis and tools for environmental rating. An analysis tool may be more elaborated and suitable for professionals and educational purposes, while a rating tool preferably should be easy to understand and suitable for market communication. An analysis tool must be strong in the area of calculating environmental impact, while the rating tool needs to focus more on the assessment processes and relate to current building manners.

4. Tool comparison

There are a number of building environmental/sustainability tools available throughout the world. However, even those which claim to assess the same thing are normally very different. Since there is no standard or agreement about tool structure and content, there are endless possibilities for designing an assessment tool.

It is often possible to use a national tool or tools which are internationally marketed, such as

LEED (US), Breeam (UK) or Green Star (AUS). These methods have the advantage of being well known and to some extent facilitate international comparison. On the other hand, they may be poorly adapted to national climate, building techniques and building regulations in comparison with national tools.
There are many aspects to consider when comparing and selecting a tool. These include:

- Marketing value
- Suitability for different types of buildings
- Ability to compare environmental performance
- Environmental relevance
- Suitability for environmental management at design and operation phases
- Issues assessed
- Cost of an environmental rating

It is very difficult to compare tools, since they generally are so different. Many attempts to compare tools have been made over the past decade, for instance by [1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11]. Such comparisons have either primarily focused on general aspects or have made a closer analysis of one tool at a time. Another reason for the difficulty to compare tools might be that building environmental assessment methods have generally been developed 'in a way that is different from the normal scientific approach' [12].

5. A framework for comparison

It is generally possible to organise the majority of the content of a building environmental tool under the following headings:

- Energy use and pollution
- Material and waste
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Environmental assessment mainly deals with prevention of negative environmental impacts caused by buildings, i.e. avoiding environmental problems. From this perspective the above mentioned headings are not well suited as a basis for comparison since they only tell what is assessed but not which impacts are addressed, how prevention is rewarded, how rating is carried out, etc.

A systematic comparison of assessment tools needs a framework that addresses the main characteristics that may differ between tools. One such possibility is outlined in Table 1.

Table 1. Different aspects that are possible to use for comparison of environmental assessment tools. Focus is on environmental sustainability as a basis for human wellbeing and persistence.

Question		Comparison aspects	Examples
What is assessed?	CONTENT	The physical object	Building materials, building, site, district
		The environmental impacts	Indoor, local, global
		The life cycle stages	Extraction, manufacturing, transports, use, end of life.
How is the assessment made?	METHOD	The type of indicators	Performance, procedures, features
		Measurements	Validity, accuracy, repeatability
		Criteria	Levels, challenge, references,…
		Aggregation	Points, weights, priorities,normalisation,..
What is the price for an assessment?	COST	Consultant costs	Certification, assessment procedure,..
		Fees	Initial, extra, final
		Attendant costs	Computer programs, manuals,.

These comparison aspects reflect the possible variation of tools. Full analysis of a tool to determine all its characteristics based on these aspects might be quite a task. However, a simple overview with reference to the aspects listed might provide valuable insights when selecting tools. Therefore the possible evaluation aspects are discussed one by one below.

6. Content

6.1 The object

This aspect deals with the spatial borders chosen for the assessed object. It ranges from building materials, building elements, installations and buildings to site and neighbourhood. Some tools only assess the building, but most also include some parts of the surrounding area. It is also important to note whether an aggregated rating can be obtained on different levels.
If the main purpose of the assessment is to select structure and building materials, there is no need to use tools that emphasize location. Even for a developer the site is often given.

In general, the more issues assessed, the more difficult it is to understand the meaning of a label and the more time consuming is it to get a label.

When comparing tools, check:

- whether the objects assessed coincide with your requirements
- the number of issues assessed that are relevant for you

6.2 Environmental impacts

Environmental impacts refer to the impacts on man, nature and depletion of natural resources. Impacts from human activities can occur on three different levels: indoor, local and global. These impacts can be further subdivided as shown in Table 2.

Table 2. Examples of commonly used impact categories

Global	Local	Indoor
Climate change	Land use	Thermal comfort
Ozone depletion	Biodiversity	Indoor air quality
Acidification	Local climate	Noise
Eutrophication	Pollution (dust, NOx,..)	Daylight
Photochemical oxidants	Noise	Allergy, SBS (emissions)
Toxicity	Tap water use	Electric environment
Ionising radiation	Rain water use	Hazardous substances
Natural resource depletion - energy	Material recycling	
Natural resource depletion - other	Nutrient recycling	
	Light pollution	

In addition to basic impacts, tools often cover aspects linked to environmental impact but not directly measuring the it, for example management issues, cost, etc.

When comparing methods check:

- the extent to which different impacts are addressed directly or indirectly
- whether the impacts coincide with what is perceived as most important
- the amount of indirect indicators

6.3 Building life cycle

This aspect deals with the temporal steps involved, from natural resource extraction, via materials manufacturing and building operation, to demolition and handling of waste. The physical life cycle of a building is illustrated in Figure 2.

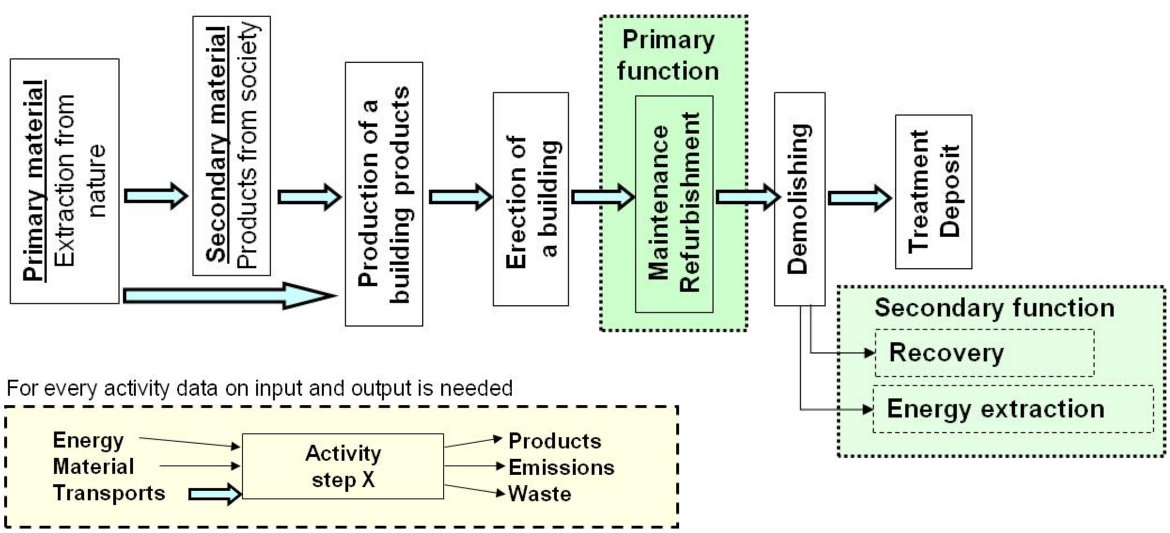

Figure 2. The physical life cycle stages of a building product where the primary function is the use stage.

A building has a number of life cycle stages and the building process has several life cycle phases, including project development, design and construction. The assessment tools primarily deal with procedures regarding the preliminary design, detailed design, construction and property management phases.

The impacts from material production are usually distributed over the whole lifetime of the building. Therefore the life expectancy of the materials and the building itself becomes important. The relative significance of the operational stage declines with decreased life span of the building.

When comparing tools check:
- the life cycle stages included
- whether any service lifetimes are considered.

7. Method

7.1 Type of indicators

Tools can support actions, items or performance. Most tools include a mixture, which creates problems in understanding the meaning of an aggregated result. For this reason it might be better to aggregate the different type of indicators separately. Another possibility is to make certain actions or features mandatory for obtaining a label.

Procedure indicators support actions intended to improve environmental performance, such as environmental management (ISO 14001), commissioning of ventilation systems or use of an accredited assessor. Procedures in general may be denoted as preventive indicators [13].

The results of precautionary procedures carried out at the design stage have to be validated when the building is erected.

Feature indicators reward specific technical solutions or equipment, e.g. labelled white goods, a heat exchanger or solar panels, but normally without evaluating the improvement in performance. Features are easy to assess and sometimes preferred for that reason.

Performance indicators directly measure a property of the assessed object, e.g. energy demand or CO_2 emissions from operation. The evaluation generally includes calculations or measurements, which may be less transparent for clients than procedures and features, especially when computer calculations are involved.

Most tools have their main focus on performance. Supporting features and sometimes also procedures may hamper development and innovation, since certain solutions are already rewarded. In this respect functional performance indicators are superior. Feature issues are often less environmentally relevant since they do not recognise the size of the benefit. For a building owner or a tenant performance is of superior interest.

When comparing tools check:
- the distribution of performance, procedure and feature indicators
- whether the indicator types coincide with your purpose – comparing performance, management, etc.

7.2 Measurement

Environmental problems can seldom be easily measured, so a tool designer has to look for simplifications as indirect measurements. Choosing robust and reliable indicator measurement is a compromise between theoretical and practical demands for a tool designer (Table 3).

Table 3. Aspects to consider when choosing indicators for environmental assessment of buildings(after [14])

Theoretical	Validity	To what extent is the aim/impact measured?
	Accuracy	How accurately is the aim/impact measured?
	Repeatability	Does a new measurement give the same result?
Practical	Influence	To what extent can the building proprietor influence the result?
	Intelligibility	How easy is it to communicate the indicator?
	Simplicity	How easy is it to collect data and calculate the indicator?

To understand the significance of an indicator, its aim has to be clarified. To what extent does it reward a reduction of any basic environmental problem? Take for instance rewarding labelled white-wares. The aim is obviously to reward reduced electricity use, but does the indicator measure the extent to which the actual choice reduces the use of electricity and determine the problem with using electricity? The latter depends on how electricity is produced. If fossil fuels are involved, electricity generation contributes to climate change, while if nuclear power is involved there is an additional risk associated with production and ionising waste generation. The electricity used for white goods also needs to represent a substantial proportion of the total contribution to climate change from the building in order to be a significant indicator.

Direct measurements are preferable. Procedures are always indirect measurements, since the outcome is not evaluated in terms of performance. Features are also indirect measurements when the size of improvement is not rewarded. The distribution of direct and indirect measurements tells something about the robustness and credibility of a tool.

When comparing tools:

- make a screening (poor, fair, good) of the indicators of a tool with reference to the aspects in Table 3
- reflect about measurement qualities with reference to the screening.

7.3 Criteria

For each indicator there are criteria for each rating level. Sometimes the increments in the criteria scale vary. It can often be relatively more difficult to make improvements to an already good building than to a relatively poor building. This is a reason for some tools to have smaller increments for achieving higher rating at the top of the scale.

It should be challenging to achieve a good rating. If it is too easy, it means that a very good building can receive the same label as a comparatively poorer building and therefore the owner of the good building is not rewarded for its superior quality. On the other hand, if it is very difficult to achieve a good rating, it might be too costly to reach a desired target level.

When comparing tools check:

- the criteria scale on individual indicators and for the whole system. Look for already labelled buildings as references
- that efforts required to reach the different criteria levels are reasonable

7.4 Aggregation

To produce conclusive results and an environmental label, aggregation of individual scores is necessary. The way this aggregation is performed has a crucial impact on the rating and the possibility to compare different labelled buildings.

A way to compensate for varying significance between assessed issues is to vary the number of scores that can be obtained for an indicator. This indirectly means a weighting. A good result for an issue where four points are available will contribute twice as much to the final result as an issue where only two points are available. Another way to compensate for variations in significance is to assign different weights to issues and/or categories.

Aggregation of scores by addition, multiplication or both is simple. Tradable scores represent an obvious risk that a highly rated building can have serious drawbacks which have been compensated for by high scores in other areas. To some extent this can be prevented by mandatory criteria. The possibility of achieving additional scores for innovative design or other issues plays the same role, i.e. it reduces the need for good scores on the basic set of indicators. Having extra scores available also distorts the meaning of a label and thus comparability.

Weights for issues or categories can be based for instance on opinions, cost or damage. Opinions can be obtained from environmental experts, professionals or laymen, and the weighting figures can be derived from many answers, for instance as mean values or consensus values reached through a discussion process. Weights can be avoided, for example by priority principles, e.g. the final rating is set relative to the number of poor or good scores. Various multicriteria decision-making tools are used in life cycle assessment [15].

Different indicators are originally measured in different units, which prevents aggregation. If assessment results are turned into points, this simplifies aggregation since all results have the same units. One drawback is that tuning of indicators is not possible, because the step between one and two points is large. An alternative to using points is to normalise, i.e. divide by a reference value with the same unit, which makes results dimensionless. Comparisons are meaningless if the basis for normalisation differs.

When comparing tools check:

- Number of weighting levels – the fewer there are, the more understandable the results
- Weights and the basis used for them – damage-based weights are less subjective than opinion-based
- The aggregation system – preference systems are superior to weighting
- The basis for allocation of points to different indicators – science-based are preferable
- If additional points are available – comparison is distorted
- If points are tradable – comparison is distorted
- If normalisation is used, what are the reference values – they should be appropriate for the case

8. Cost

8.1 Consultancy costs

Some rating systems demand that certified assessors shall be involved in the assessment and application processes. In such cases, contact a certified assessor and ask for an approximate cost for some objects of different sizes. Extra points are sometimes awarded if a certified assessor participates in the design team. If so, investigate the cost of such participation.

8.2 Fees

Certification is associated with a fee that usually is related to the size of the building. It may for instance be split into an application fee and a certification fee. These fees normally include a certain time for questions, clarifications, etc. Outside this time, a consultation cost is charged. Check if additional costs are frequent.

8.3 Additional requirements

In some cases an assessment in reality demands that certain books, manuals or computer tools have to be bought. Check the cost of required additional facilities and possible related consultant cost.

When comparing methods:

- Check the approximate total cost for assessment with alternative tools
- Investigate the total assessment cost for similar projects
- Assess what is gained relative to the total cost for different tools

9. Conclusions

Tools for environmental assessment of buildings have expanded greatly during recent years, both in number and complexity. Within a country, national and international tools are often available, sometimes claiming that they measure the same thing, i.e. the sustainability of a building.

Although they may look similar at first glance, tools are generally very different. This is because there are so many options for a tool designer to choose between regarding what should be assessed, how to assess it and how to measure and aggregate results. Standardisation efforts are underway through SB-Alliance and the CEN/TC 350 and ISO TC 59 SC 17 groups, [16], [17]. However, in view of the great differences between the existing tools that are in use today, greater harmonisation seems quite far away.

There are also good reasons for tools being different. They may be directed towards different target groups and to some extent they have to adapt to local conditions in different countries, such as climate, building codes, building traditions, building techniques, environmental priorities, etc.

Because of all these differences, it is very difficult to compare tools and really understand their individual characteristics, qualities and shortcomings. The meaning of different labels in terms of environmental impact is difficult to grasp. A systematic approach with predesigned comparison aspects will improve the knowledge of differences and their consequences.

A framework of aspects that are relevant to consider when comparing or selecting tools is provided in this paper. It can be used for screening purposes or deeper analysis. The required information regarding an evaluation aspect is sometimes difficult to locate in available manuals and on websites which must be regarded as a drawback for that tool.

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