Comparison and evaluation of neighbourhood sustainability assessment systems

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ABSTRACT: The study concentrates on five internationally recognized assessment systems: CASBEE-UD, LEED-ND, the 2009 and 2012 versions of the BREEAM Communities and the DGNB-UD. These neighbourhood sustainability assessment tools have been compared and evaluated with quantitative and qualitative methods. The neighbourhood sustainability assessment tools can be compared based on the different levels of their structure. In the study the evaluation of the indicator assessment is presented. As a result of the detailed investigation of indicators the improvement from building evaluations, the sustainability coverage, and suggestions for the future improvement of the neighbourhood sustainability assessment tools are concluded.
Keywords: neighbourhood sustainability assessment; sustainability indicators

INTRODUCTION

Neighbourhoods are the building blocks of cities, which have their own architectural, cultural and economic system [1]. As a neighbourhood can work as a city on a smaller scale, a city is just as sustainable as its parts. So it is important to solve certain sustainability issues on a neighbourhood level. From the 1990s, building sustainability assessment systems have been used to integrate sustainability into the construction industry. The building sustainability certifications measure the internal and external characteristics and processes of buildings. However, in case of neighbourhood sustainability certifications, the main emphasis is on the working system between buildings, public and private spaces. While building assessment systems are used internationally, the neighbourhood assessment tools have just begun to spread [2].

Previous researches

The relatively new neighbourhood sustainability assessments have not received much attention yet, which is reflected in the limited number and depth of the existing studies. Recent studies compare neighbourhood sustainability assessment tools based on their structure, methodologies of their application, their performance on a case study [3], the components they assess [4], and their general characteristics [5]. These studies give a general description of the neighbourhood sustainability assessment tools, however, their scope does not fully cover the details of the assessment systems.

Content of the study

The study concentrates on five internationally recognized assessment systems. These neighbourhood sustainability assessment tools have been compared and evaluated with quantitative and qualitative methods. The comparison can be carried out on the level of general comparison to the detailed evaluation of the certification processes and their indicators. In the study, the evaluation of the indicator assessment is presented.

OVERVIEW OF THE NEIGHBORHOOD SUSTAINABILITY ASSESSMENT TOOLS

The importance of sustainability in the construction industry, especially in urban areas, has been recognized. Thus assessment systems were developed in several countries to measure the level of urban sustainability. There are 2 types of urban sustainability assessment systems: the decision making tools embedded into neighbourhood scale planning and the systems emerged from existing third-party building assessment systems [4]. In this study we evaluated the third party spin-off tools.

The sustainability assessment systems usually evaluate developments with a complex approach where besides the assessment of the buildings in the development, the built and natural environment are also considered. The common characteristics of the third-party sustainability assessment tools are:

- the use of a scoring system
- a multistage certification scheme
- defined criteria to satisfy their requirements
- the integration of the experiences of sustainable construction and the requirements of the local and international legislations and standards [6].

The sustainability assessment tools should be considered not just in the design phase but also in the construction and operation phase of a development. Within these systems the physical characteristics of the developments and their processes are evaluated.

In the scope of this study five assessment systems, the CASBEE-UD from Japan, the 2009 and 2012 versions of the BREEAM Communities from the UK, the LEED-ND, developed by USGBC and the DGNB-UD from Germany, were selected based on their accessibility of information, the representativeness of different parts of the world and their international recognition.

LEED Neighborhood Development

The LEED Neighborhood Development was first published by the USGBC in 2009. The LEED system was designed to fulfil the needs of the building industry of the USA, but it has no restrictions on international application. This neighbourhood assessment tool can evaluate a development in 3 stages: during the master planning phase, the construction phase or the complete development. The LEED-ND system integrates the principles of New urbanism, Smart growth and Green infrastructure and building design [7].

BREEAM Communities

The Building Research Establishment Ltd. (BRE) in the UK was the first organisation publishing a third party sustainability assessment tool. Since 2009, a neighbourhood sustainability assessment system is one of the schemes of BREEAM. The 2009 version of the neighbourhood assessment system was redeveloped and a newer version was published in 2012, with a modified approach [8, 9].

CASBEE for Urban Development

The CASBEE assessment system, developed with the participation of the Japanese Government, has become mandatory in some regions of the country in 2011 to support the promotion of sustainability. In addition to their sustainability assessment systems for buildings, since 2006, it is possible to assess neighbourhoods with the CASBEE system. The speciality of the CASBEE tools is the possibility to assess developments not only with the full version, but with a brief version too. [10]. The Japanese sustainability assessment tool also differs from the others in its scoring system and the lack of international applicability [11].

DGNB Urban Districts (DGNB-UD)

The DGNB Urban Districts sustainability assessment system was published in 2012. The DGNB gives special attention to its international application, especially in the European Union, as the system integrates European standards and objectives. The DGNB limits the scope of the assessable projects (area, function, number of buildings) more strictly than the systems mentioned above. The phases of DGNB-UD system evaluate a development in the master planning phase, in the infrastructure construction phase and finally in the construction phase [12].

Structure of the neighbourhood sustainability assessment tools

The examined neighbourhood sustainability assessment systems show similarities to each other in their main structure. The content of the systems can be categorised into 3 levels: Topics, Indexes, and Indicators. The neighbourhood sustainability assessment tools organise their requirements of scoring into general topics, for guidance in the diverse areas they address. All topics include indexes that deal with certain sustainability issues. The fulfilment of the index requirements gains points in the certification process. To assess whether the index requirements have been fulfilled, some tools for quantification had to be introduced. These tools are the indicators that are "statistical measures that give an indication on the sustainability of social, environmental and economic development" [13]. The common characteristics of indicators are their analytical soundness, time-boundness, measurability, resource demand and relevance [14]. Indicators used for sustainability assessment should be integrating, forward looking, distributional and developed in cooperation with multiple stakeholders [4].

METHODOLOGY OF INDICATOR-BASED COMPARISON

In our research, we compared the neighbourhood sustainability assessment tools based on the different levels of their structure. Firstly during a general comparison, the systems can be evaluated from different points of view to determine their operating characteristics, general content, market impact and adaptability. Secondly during an index based comparison, the relation of the systems to the different aspects of sustainability can be discovered. Finally the most detailed method of comparison is the indicator-based evaluation, where the core components of the sustainability assessment tools are collected and evaluated. The latter is presented in this paper.

The aim of the indicator based comparison was to discover the measured object and the purpose of an indicator. We defined a methodology to compare the indicators of the neighbourhood sustainability systems, where these steps were conducted:

1, We defined the indicators in the indexes: Indicators were originally listed in the BREEAM 2012, the CASBEE-UD and the DGNB certifications, but in the LEED-ND and BREEAM 2009 systems they had to be determined based on their common characteristics.

2, We defined the mandatory indexes and indicators: The LEED-ND and BREEAM systems use mandatory indexes, unlike the DGNB-UD and CASBEE-UD systems. The value of these indexes is zero in the

BREEAM 2012 and the LEED-ND systems so their indicators could not be weighted. Accordingly the mandatory indicators have been evaluated separately from the optional indicators.

3, We determined the importance of indicators within the whole system: the fulfilment of the minimum required value of an indicator does not have the same importance in different sustainability assessment systems, which is reflected in the different scoring methodologies. In order to compare the importance of different indicators, a common evaluation system is necessary. The scoring systems of the LEED, BREEAM and DGNB are straightforward, in their case the calculation of indicator importance is simple (Fig. 1). In case of CASBEE-UD, which does not use a scoring system, a different approach had to be applied. This system summarises the collected points in the two topics (Environmental quality, Environmental load reduction), then creates the final score from the proportion of the environmental quality and environmental load (which is the reciprocal of environmental load reduction). To make CASBEE comparable to the others, this approach had to be converted to a traditional scoring system. The following calculation method was used: we calculated the score of the two topics, then instead of dividing the environmental quality with environmental load, the points of the two topics were added.

$$ind.\,\% = \frac{index * proportion\ of\ ind. * weighting}{total\ score} * 100$$

index: the score of an index (is determined in each system)
proportion of ind.: the unit of an index is distributed between its indicators, according to their role in the fulfilment of the index
weighting: calculated if an index is weighted (based on its regional value, value of importance etc.)

Figure 1: Base calculation of the importance of indicators

4, We categorized the indicators: Each neighbourhood sustainability assessment system groups their indicators and indexes into topics based on the principles they follow. To make the huge amount of indicators comparable, a common categorisation system is required. For this purpose, we collected 25 different classifications from sustainability assessments, sustainable city indexes etc. [7, 8, 9, 11, 12, 15]. We developed a final category (Table 1) and subcategory list by means of highlighting, organising and eliminating of the categories in the original classifications. This category list classifies indicators based on what part of the development they measure.

Categories		
Buildings	Community	Ecology
Economy	Energy	Infrastructure
Location	Resources	Transportation

Table 1: The categories of indicators

5. We determined the number of indicators in each category and subcategory: First, we summed the numbers of indicators without their weighting in each category and compared their proportion to the total number of indicators. This proportion does not show the real value of the indicator groups in the system, because they are weighted during the certification process. Therefore we determined these proportions with weighted indicators as well.

RESULTS OF INDICATOR ANALYSIS

After we determined the methodology of the indicator comparison, we applied it on the 5 neighbourhood sustainability assessment systems. During the analysis of mandatory indicators we categorized them without weighting as not all systems assign weightings to these indicators. For the analysis of the optional indicators, the weighted proportions were also determined.

Mandatory indicators

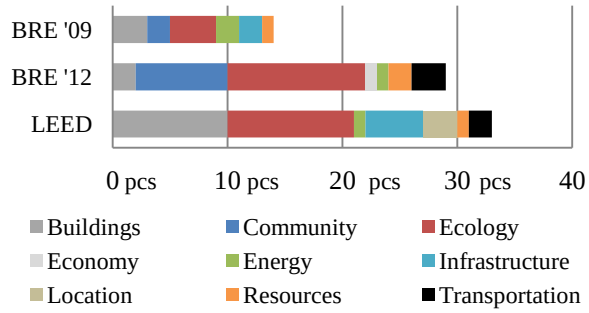

Figure 2: Number of mandatory indicators

Mandatory indicators represent on one hand a constraint to the design of the development. On the other hand, a minimum sustainability level can be reached with the obligatory fulfilment of the indicators, which can ensure a diverse application of sustainable solutions. The priorities of the neighbourhood sustainability systems can be discovered by means of an investigation on these indicators. In the BREEAM 2009, BREEAM 2012 and LEED systems, the mandatory indexes form an important part of the systems: approximately 15-20% of all indicators of these systems are mandatory. In the LEED system, there is more than one path to fulfil a mandatory index, this is the reason why LEED has the most indicators in this evaluation. From their categorization, it is revealed that the mandatory indicators cover in the case of LEED-ND and BREEAM

2012 7 categories, in the BREEAM 2009 6 categories. With the coverage of most of the categories (Figure 3) they ensure the application of a wide range of sustainable solutions. In the LEED-ND the Ecology and the Buildings, in the BREEAM 2012 the Ecology and the Community categories have the largest amount of indicators. (Fig. 2)

Optional indicators

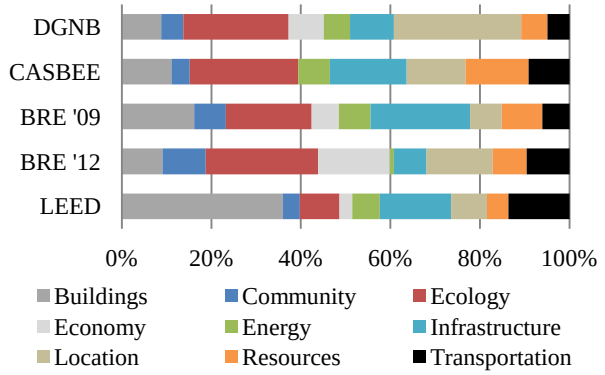

Figure 3: Distribution of weighted indicators in the systems

For analysis of the results we used the weighted evaluation. The evaluation of the indicators shows that every category is represented in each system. However, the indicator proportion of the Energy category in the BREEAM 2012 system and the Ecology category in the CASBEE system is under 1%. The categories with highest proportions were the ones which measure the group of Buildings, the Ecology and the Location of a development (Fig. 3). It is also worthy to compare the performance of the different neighbourhood sustainability systems in the 9 categories:

Buildings

	LEED	CAS-BEE	BRE. 2009	BRE. 2012	DGNB
Accessibility	-	-	--	1	-
Certificated	10	-	6	3	1
Existing developments	2	1	2	3	1
Facade	8	3	2	-	-
Interior	3	-	-	1	-
Main features	14	-	1	-	5
Placement?	2	5	4	-	-
Roof	-	1	-	-	-
Building types	9	1	-	2	2
	35,99	11,06	14,16	9,2	8,91

Table 2: Indicators of the Buildings category

In the LEED-ND, more than 1/3 of the optional indicators measure the sustainable performance of buildings in the neighbourhood. Every system rewards the refurbishment of an already existing building on site. The interiors are not important, instead the building types (mixed function, residential, commercial units, and their main features (square footage, number of residential units etc.) are emphasized. (Table 2)

Community

	LEED	CAS BEE	BRE. 2009	BRE. 2012	DGNB
Community management	1,99	1,25	1,61	1,5	0,33
Community usage	-	1,23	-	0,35	-
Involvement	3	1,65	4,838	7,45	4,08
Population	-	-	-	0,9	0,33
Society/government	-	-	-	-	0,82
	4,99	4,13	6,45	10,2	5,57

Table 3: Indicators of the Community category

In the Community category the indicators measure the activity and well being of the local community. The indicators addressing people, rarely measure the individual needs and conditions, but they evaluate individuals as a group. The most represented subcategory is the involvement of the community in the decision making processes. The involvement of the community operates on more levels. Besides the organisation of community meetings with the designers, the implementation of the community opinion into the development can be more valuable. (Table 3)

Ecology

	LEED	CAS-BEE	BRE. 2009	BRE. 2012	DGNB
Air management	-	2,36	0,53	-	3,82
Climate	4	1,25	0,53	4,55	1,73
Conservation	-	3,68	-	3,9	2,2
Disasters	-	-	-	0,4	0,66
Ecological values	2	1,13	1,61	2,3	-
Habitats	1	2,01	3,22	-	1,77
Pollution	-	-	-	5,38	5,55
Soil conservation	1	4,16	1,61	1,4	2,7
Vegetation	3,6	3,11	3,45	1,69	1,57
Water conservation	-	5,5	5,35	5,66	3,89
Wildlife	-	-	-	1,1	-
	11,6	23,28	16,32	26,39	24,0

Table 4: Indicators of the Ecology category

The Ecology category has the largest proportion in average compared to the other categories. Environmental sustainability is measured with a broad spectrum, the climatic, water, soil conditions and the vegetation of the developments are all considered. (Table 4)

Economy

	LEED	CAS-BEE	BRE. 2009	BRE. 2012	DGNB
Business	0,75	-	3,35	1,25	-
Development cost	-	-	0,5	-	5,33
Development income	-	-	-	1,25	0,66
Housing costs	-	-	-	-	0,22
Jobs	3	0,4	1,612	13,02	0,088
Management	-	-	-	1,25	-
Marketing	-	-	-	-	1,64
	3,75	0,4	5,5	16,8	7,95

Table 5: Indicators of the Economy category

This category is one of the 2 least represented in the systems. It appears the most time in the BREEAM 2012 certification. The DGNB system is the only one which measures both the costs and incomes of a development. The systems only encourage the creation of local job opportunities and businesses. (Table 5)

Energy

	LE-ED	CAS-BEE	BRE. 2009	BRE. 2012	DGNB
Energy consumption	5	0,7	-	-	1,56
Energy management	3	5	3,22	0,363	4,11
Energy resources	-	1,25	3,225	-	0,33
	8	6,95	6,43	0,36	6

Table 6: Indicators of the Energy category

The Energy category is the other least represented category in the neighbourhood assessment systems. As the neighbourhood assessments systems do not evaluate the operational characteristics of the buildings in the area, the measurement of the energy consumption and efficiency is based on the integrated, shared energy systems. (Table 6)

Resources

	LEED	CAS-BEE	BRE. 2009	BRE. 2012	DGNB
Materials	-	4,69	5,06	3,00	1,11
Recycling	2,25	1,66	1,06	0,20	1,11
Resource management	-	-	0,53	0,20	-
Waste management		1,66	0,00	2,40	2,00
Water management	4,00	6,25	1,61	2,16	2,22
	6,25	14,26	8,27	7,96	6,44

Table 7: Indicators of the Resources category

The indicators of the Resources category measure the cycle of resource use from the incorporated materials until their end use. The waste, the communal water management, the built in materials and their possibilities of reuse are the topics of the indicators. (Table 7)

Location

	LEED	CAS-BEE	BRE. 2009	BRE. 2012	DGNB
Accessibility	-	-	-	2,35	0,22
Connection with surroundings	4,85	2,70	-	0,91	2,92
Construction	-	-	-	0,45	0,44
Controlling	-	1,25	-	0,32	3,56
Design	-	-	-	6,74	10,72
Land use	5,56	8,23	4,84	1,34	8,33
Security	-	-	1,61	1,58	1,56
	10,40	12,17	6,45	13,67	27,75

Table 8: Indicators of the Location category

The Location category includes two aspects of the development: the indicators related to the existing characteristics of the location, and the land use of the development. Besides the evaluation of the used area, the neighbourhood sustainability assessments lay a great emphasis on the connections to the surroundings of the developments (connections with previously developed areas, with the existing road network etc.). (Table 8)

Infrastructure

	LEED	CAS-BEE	BRE. 2009	BRE. 2012	DGNB
Coverage	1,00	-	0,45	0,54	1,22
Facilities	7,66	5,26	3,76	3,60	1,53
Ornaments	-	-	0,23	-	0,67
Transport facilities	10,95	0,99	12,80	3,77	5,50
Utilities	0,80	10,66	1,61	2,40	2,54
	20,41	16,91	18,85	10,31	11,46

Table 9: Indicators of the Infrastructure category

The background processes of a neighbourhood are evaluated by the indicators in the infrastructure category. The utilities, roads, service buildings are all evaluated in the systems. (Table 9)

Transportation

	LEED	CAS-BEE	BRE. 2009	BRE. 2012	DGNB
Accessibility	2,34	-	2,41	-	2,11
Quality of transportation	7,50	3,02	0,80	6,84	2,22
Traffic	8,50	6,40	1,61	0,60	0,94
	18,34	9,42	4,83	7,44	5,27

Table 10: Indicators of the Transportation category

The category of Transportation mainly measures the possible uses of alternative transportation, the improvement of the transportation with cars and the accessibility of different transport options. (Table 10)

CONCLUSION

This paper presents the methodology and results of a comparative investigation of 5 neighbourhood sustainability assessment systems. These systems categorise and rate the indicators differently. Therefore, it was an important step to integrate their processes which makes them comparable by means of a common unit of measurement for analysis on the indicator level. From the evaluation, the following conclusions can be drawn:

The neighbourhood sustainability assessment systems were formed from building assessment systems. On the neighbourhood level, the Community category focuses on a new aspect of the sustainability performance measurement. This result supports the fact that neighbourhoods play an essential role in forming community and social networks.

The mandatory indicators, in the 3 system where they appear, are hard to compare because the 3 systems treat them differently (in scoring method, use of option paths etc.). Based on their comparison, it can be stated that they does not use mandatory indicators from all categories. From the evaluation of the optional indicators, the proportional difference of the categories in the systems can be concluded. The DGNB and the BREEAM 2009 presents the indicators the most equally distributed between categories. The analysis showed that the categories with highest weight in the certification were the ones which measure the group of buildings, the location of developments, and the ecology. Therefore, a lot of points can be gained at the beginning of a project with the choice of location with good connections to the surroundings, construction method which disturbs the environment minimally and suitable building uses. The Economy and Energy dimension, in itself, is the least represented, especially in the CASBEE systems.

OUTLOOK

This study of the neighbourhood sustainability assessment systems shows that the sustainability of neighbourhoods can be obtained with a complex method. As the requirements towards neighbourhoods changes with different times, places, and cultures, the neighbourhood assessment systems have to constantly improve, and adapt to the current state of the environment. This means that there is a need for their further analysis, and they still have room for future progress. Research should be conducted to investigate the possible methods of their improvement (e.g. through the coverage improvement of the 3 pillars of sustainability, their improvement through making their requirements more stringent, widening the scale of evaluated sustainability problems etc.).

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