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CRITICAL ANALYSIS OF SUSTAINABILITY SCORING TOOLS FOR NEIGHBOURHOODS, BASED ON A LIFE CYCLE APPROACH

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Abstract

The neighbourhood scale has become an important focus in sustainable decision taking. To support designers and building stakeholders several Building Sustainability Assessment Methods (BSAM) have been developed. Among these methods, a distinction can be made between scoring tools and Life Cycle Assessment (LCA) tools. Scoring tools, such as BREEAM Communities and LEED Neighborhood, associate scores to a number of criteria (credits), covering a wide range of sustainability issues such as energy, materials, water, user transport and comfort. LCA tools, such as novaEQUER and GreenCalc+, are based on a systematic study of the environmental impact caused during the entire neighbourhood life span.

This paper analyses the effectiveness of scoring tools in assessing the sustainability of neighbourhoods, by comparing their methodology with an integrated life cycle approach, combining Life Cycle Assessment (LCA) and Life Cycle Costing (LCC). Based on a schematic neighbourhood model, the financial and environmental impact of a number of sustainability measures related to energy use, material use and user transport are evaluated. The results are compared with the credits awarded in BREEAM Communities, regarding those aspects. Based on this comparison, convergences and divergences are highlighted and recommendations for methodological improvements are formulated.

Keywords:

BREEAM Communities; Integrated life cycle approach, Life Cycle Assessment; Life Cycle Costing; Sustainability measures

1 INTRODUCTION

As buildings interact with their surroundings, the neighbourhood scale has become an important focus in sustainable decision taking. To support designers and building stakeholders, several Building Sustainability Assessment Methods (BSAM) have been developed. Among these methods, a distinction can be made between scoring tools and Life Cycle Assessment (LCA) tools [1]. Scoring tools, such as BREEAM Communities [2] and LEED Neighborhood [3], associate scores to a number of criteria (credits), covering a wide range of sustainability issues such as energy, materials, water, user transport and comfort. LCA tools, such as novaEQUER [4] and GreenCalc+ [5], evaluate the environmental impact generated during the entire neighbourhood life span. A comparative analysis of BSAM tools for neighbourhoods, based on a literature review can be found in [1]. In this study the strengths and weaknesses of the different tools are identified. Scoring tools are found to be more user-friendly compared to LCA tools, which deal with a huge quantity of data. Moreover scoring systems are more comprehensive as the focus of LCA tools is limited to the environmental dimension of sustainability, neglecting economic, social and quality aspects. However the robustness of scoring tools to support sustainable decision taking is questioned as these tools are not based on a systematic study of impacts.

The goal of this paper is to analyse the effectiveness of scoring tools in assessing the sustainability of neighbourhoods, by comparing their methodology with an integrated life cycle approach, combining Life Cycle Assessment (LCA) and Life Cycle Costing (LCC). In a previous research [6], LEED credits, applied to an office building case study, were analysed based on an LCA. The study revealed discrepancies between the rating levels and their actual environmental impact. In this paper, not only the environmental

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impact, but also the financial consequences of a number of sustainability measures related to the energy use, material use and user transport are evaluated, based on a schematic neighbourhood model. The results are then compared with the credits awarded in BREEAM Communities, regarding those aspects.

In the subsequent section, the methodology is presented, including a description of BREEAM Communities, the integrated life cycle approach and the analysed case study. Section 3 focuses on the LCA and LCC results and related BREEAM credits. In section 4, convergences and divergences between the life cycle approach and BREEAM are highlighted. Recommendations for methodological improvements and conclusions are formulated in the final section.

2 MATERIALS AND METHODS

2.1 BREEAM Communities

BREEAM Communities [2] is a sustainability assessment tool developed in the UK by the BRE Group. The tool focuses on the assessment of moderate to large scale developments. Assessment issues and the related indicators are subdivided in 6 thematic categories: Governance, Social and economic wellbeing, Resources and energy, Land use and ecology, Transport and movement and Innovation. Those issues cover the environmental, economic and social dimension of sustainability but also a number of qualities, such as functional, technical, site and process qualities [1]. The scores for the different indicators are weighted to an overall score by applying weighting factors, defined in consultation with a stakeholder and expert panel. Based on the overall score, a rating is attributed on a scale from Pass, Good, Very Good, Excellent to Outstanding.

2.2 Integrated life cycle approach

The integrated life cycle approach used in this paper is based on the sustainability evaluation method for buildings developed in the SuFiQuaD ("Sustainability, Financial and Quality Evaluation of Dwelling Types") research project [7][8]. This method assesses the environmental and financial impact over the entire building life cycle, by combining LCA and LCC calculations. In a recent research, the SuFiQuaD method was extended to the neighbourhood scale level, by evaluating building clusters, in combination with the required road infrastructure [9].

Life Cycle Assessment (LCA)

The environmental impact assessment method in SuFiQuaD was recently updated within the MMG ("Environmental profile of building elements") research project [10]. In addition to individual impact indicators, the MMG method provides an aggregated single-score indicator, expressed in monetary value (EURO). This indicator represents the external environmental cost caused by environmental impacts. The environmental data, used in the analysis, are based on the Ecoinvent database version 2.2 [11]. However, in order to increase the representativeness for the Belgian context, Swiss data records were adapted by replacing the Swiss electricity mix and transport processes by European corresponding processes [10].

Life Cycle Costing (LCC)

The financial impact is calculated based on the LCC methodology. To assess the life cycle financial cost, discounting of future costs is applied, by calculating their present value. More detailed information on the assumptions and economic parameters can be found in [7][8]. The financial data are collected from different sources. Cost of building components are mainly based on the Belgian cost database ASPEN [12][13], combined with product specific data. For data related to road infrastructure and external works, the British Spon's Price Books are used [14][15]. Concerning the energy use, prices per energy source are based on Belgian statistical data [16]. For the financial cost of user transport, a study of Transport & Mobility Leuven is used, including the calculation of consumer prices for different transport modes [17].

2.3 Case study

Reference Case

As reference case, a schematic neighbourhood layout is defined, consisting of detached houses along a roadway with a footpath on both sides (*Fig. 1*). This neighbourhood layout can be seen as representative for the low density Belgian suburbs. Different assumptions are made. Firstly, simplified box buildings, consisting of 2 floors of each 60m², are used for the analysis. The glazing surface area is assumed to be equal to 15% of the total floor area of each housing unit, in order to achieve a good level of daylighting. Secondly, buildings are composed of standard building elements from the MMG database, which are in line with the low energy standards. Only the space delimiting elements (i.e. floors, walls, roofs, stairs, windows and doors) are considered in the analysis. The technical systems (e.g. heating, ventilation and water supply) are not included. For the road infrastructure, standard road and footpath sections with an asphalt pavement are selected.

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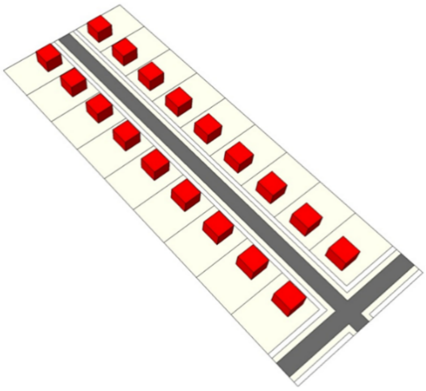

Fig. 1: Schematic neighbourhood layout.

Thirdly, the heating energy use in buildings is calculated based on the dynamic Equivalent Degree Day method, which is a simplified approach to estimate the heating demand in neighbourhoods [18][19]. Regarding user transport, it is assumed that the inhabitants have a transport profile similar to the Flemish average [20].

Sustainability measures

In this paper, four measures to improve the sustainability of the neighbourhood are analysed in detail (*Fig. 2*).

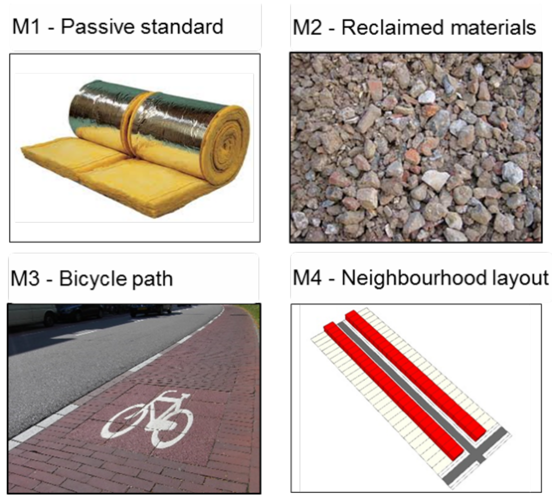

Fig. 2 : Analysed sustainability measures.

The first measure (M1) consists of improving the building insulation level to the passive house standards, by increasing the insulation thickness and replacing double pane glazing by triple pane glazing. Measure 2 (M2) focuses on the use of reclaimed materials for the road base and subbase by replacing crushed gravel by crushed rubble. In the third variant (M3), a bicycle path is integrated along both sides of the road in order to stimulate the use of the bicycle in the neighbourhood. In this scenario, it is assumed that the number of short distance trips by car, i.e. trips over a distance from 0 to 5 km, is reduced by 80%, in favour of the bike. The last measure (M4) focuses on the neighbourhood layout, by simulating a denser neighbourhood model, consisting of terraced houses.

3 RESULTS

3.1 Life Cycle Assessment

The results of the LCA, expressed in euro per inhabitant, are shown in *Fig. 3*, with a distinction between the impact resulting from the building materials, energy use and user transport. For the reference case user transport and building materials contribute most to the life cycle environmental cost, with respectively 71 and 20% of the total impact. The contribution of heating energy use is much lower (9% of the total impact) because the reference case is in line with the low energy standards.

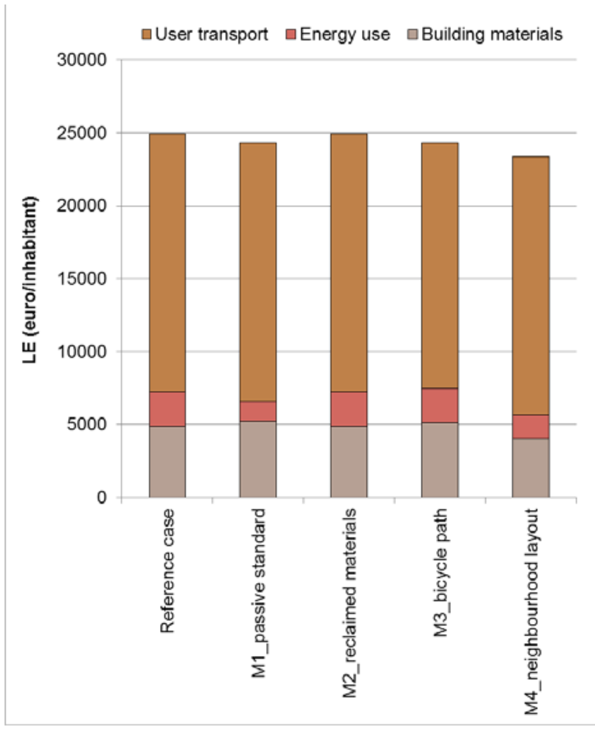

Fig. 3: Life cycle environmental cost (LE) of the reference case and the four sustainability measures.

Considering the different sustainability measures separately, the highest reduction in life cycle environmental cost is obtained for measure M4, followed by M3, M1 and M2, with reductions of respectively 6%, 2%, 2% and 0.02%. Firstly, measure M1 has only a limited influence as the reduction of the environmental cost of energy use is partially compensated by an increase in the cost for building materials. Secondly, the use of reclaimed materials for road construction leads to a negligible reduction in impact because the environmental impact of gravel mainly results from the crushing process, which is also required in the production of rubble. Thirdly, measure M3 results in a small reduction of the environmental cost due to the additional impact of the construction and maintenance of the bicycle path and the limited

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reduction of the environmental load based on increased bicycle use. Even if for 80% of the short distance trips bicycles are used, the effect upon the total impact of user transport is limited as short distances represent only a limited fraction of the transport movements. Finally, the highest impact reduction is obtained for measure M4 as compact terraced buildings have a lower material and energy use per inhabitant.

3.2 Life Cycle Costing

Similar trends can be seen from the financial results (*Fig. 4*). User transport and building materials are the biggest contributors, with respectively 50% and 45% of the life cycle cost of the reference case. The contribution of heating energy use is much lower, i.e. limited to 5% of the life cycle cost.

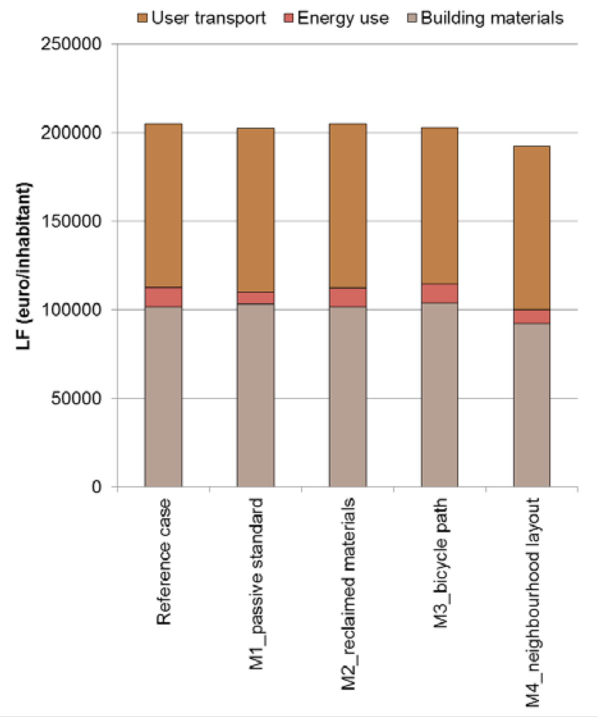

Fig. 4: Life cycle financial cost (LF) of the reference case and the four sustainability measures.

When looking at the sustainability measures, measures M1, M2 and M3 have a negligible impact on the life cycle cost, with reductions of respectively 1%, 0.1% and 1% compared to the reference case. Similar to the environmental cost, the highest reduction (6%) in life cycle cost is obtained for the denser neighbourhood layout.

3.3 BREEAM credits

In BREEAM Communities different assessment issues in the categories "Resources and energy" (RE) and "Transport and movement" (TM), are linked to the impact of building materials, energy use and user transport. An overview of those assessment issues and the related weighting factors is given in *Fig. 5*. Most credits are awarded for issues related to user transport (16.5%), followed by the building materials (8.1%) and energy use (4.1%).

For each sustainability measure, we estimated the number of credits awarded in BREEAM. Firstly, measure M1 results in a reduction of 13% in CO2 emissions compared to the Target CO2 Emission Rate, defined in the English building regulations [21]. For this measure, a weighted score of 0.4% is attributed to the assessment issue "RE 01 – Energy strategy". Secondly, a weighted score of 1.3% is awarded to "RE 05 – Low Impact materials" for the use of reclaimed road construction materials. Thirdly, the integration of a bicycle path results in a weighted score of 2.1% for the assessment issue "TM 03 – Cycling network". Finally, no specific credit is awarded for measure M4 as the neighbourhood layout is not evaluated in any assessment issue.

ASSESSMENT ISSUES	WEIGHTING (%)
Building materials	**8.1**
RE 02 – Existing buildings and infrastructure	2.7
RE 05 – Low impact materials	2.7
RE 06 – Resource efficiency	2.7
Energy use	**4.1**
RE 01 – Energy strategy	4.1
User transport	**16.5**
TM 01 – Transport assessment	3.2
TM 02 – Safe and appealing streets	3.2
TM 03 – Cycling network	2.1
TM 05 – Cycling facilities	1.1
TM 04 – Access to public transport	2.1
TM 06 – Public transport facilities	2.1
RE 07 – Transport carbon emissions	2.7

Fig. 5: BREEAM Communities assessment issues related to building materials, energy use and user transport.

4 DISCUSSION

Based on the comparison of the LCA/LCC results with the BREEAM credits, convergences and divergences can be identified. Concerning the convergences, BREEAM allocates a high number of credits to assessment issues related to user transport, which is also one of the main contributors to the neighbourhood life cycle environmental and financial cost. Furthermore, a limited number of credits are attributed to issues linked to energy use, which contributes to a small part of the impact in low energy neighbourhoods.

However discrepancies are found between the BREEAM credits and the LCA/LCC results (*Fig. 6*). Firstly, a weighted score of 1.3% is awarded to measure M2, while the use of reclaimed road construction materials has a negligible influence on the financial and environmental impact. Secondly, the neighbourhood layout seems to be a key parameter to reduce the financial and environmental impact of neighbourhoods but no credit is attributed to this aspect in BREEAM. Finally, the consequences of burden shifting between sustainability aspects are not taken into

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account in the BREEAM methodology. For example, credits are awarded for improvements in energy efficiency, without considering the potential impact increase related to the building materials.

	M1	M2	M3	M4
LCA (impact reduction)	2%	0.02%	2%	6%
LCC (impact reduction)	1%	0.1%	1%	6%
BREEAM (credits)	0.4%	1.3%	2%	0%

Fig. 6 : Comparison between the LCA/LCC results and the BREEAM credits for the four sustainability measures.

5 CONCLUSIONS

In this paper, the scoring tool BREEAM Communities is compared with an integrated life cycle approach, combining LCA and LCC. The analysis of a number of sustainability measures shows discrepancies between the LCA/LCC results and the credits awarded in BREEAM. Measures leading to higher reductions in financial and environmental impact are not always stimulated, confirming the assumption that scoring tools are not adapted to support sustainable decision taking [1].

Therefore two recommendations are formulated. Firstly, the weighting factors in scoring tools should be adjusted based on a detailed life cycle study of the assessment issues. Moreover, assessment criteria which result in a low reduction of the financial and environmental impact should be removed. Secondly, a more in depth adaptation would be to integrate life cycle evaluation criteria in scoring tools in order to increase their robustness. For example, second generation scoring tools, such as DGNB New Urban Districts [22], already include a number of criteria based on LCA and LCC for the evaluation of the economic and environmental dimension of sustainability.

In this research, only the preliminary results of a more extended research on sustainability scoring tools were presented. Further research should focus on the analysis of additional sustainability measures and the application to other case studies in order to confirm the above mentioned conclusions.

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