Built Environment: The Sustainability of Heritage

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Abstract

Different sustainable evaluation tools can provide a way to certify the building`s performance during its life cycle: raw material depletion, production of materials and components, construction, use and demolition. In this process, several variables that analyze common components, such as the reduction of resources consume, the reuse and recycle potential, flexibility and adaptability, the pollution components generated during the process, are involved. Some examples of these tools are the systems like SBTool, BREEAM, BEE or LiderA that are used to evaluate a specific context according to specific conditions. Meanwhile, the existing evaluation systems are oriented to the building´s design phase or have under consideration patterns adapted to the 21st century reality. This work was developed due to the need to analyse and evaluate the built environment, specifically in what concerns the urban settlements in Portuguese cities, with more than three hundred years old, and that are not enclosed in the new construction's reality - both at materials and techniques levels. The knowledge gathered about the built environment allows the creation of a sustainable grid capable of guide-lining rehabilitation actions. The evaluation of these urban areas was carried out based on an exhaustive work of collecting the building's characteristics, in an area with around 770 buildings, allowing the creation of a built environment sustainability evaluation grid and adapted to socio, cultural, heritage, economic and environmental contexts. The grid mentioned before was designed after a set of parameters were analyzed, such as: i) the existent materials and the constructive solutions adopted; ii) the urban mesh and the meeting of the construction resources to the built environment; iii) the contemporaneous patterns and the possibilities of reusing; iv) the heritage and cultural values; v) the social and economic values. The evaluation grid presented in this work shows a set of different parameters, where the criteria that are related to the external environment are reassessed according to the existent urban possibilities and where the criteria related to internal environment are adapted to the existent spaces' possibilities.

Keywords: sustainable construction, evaluation systems, historical city centres, sustainable criteria

1. Introduction

1.1 Urban constraints

Urban growth consists in the main constraint of the issues related to sustainable development. The growth rhythm of several urban agglomerations, where a great and sudden increase of the inhabitant's number has occurred, without the proper improvement of the urban structures with capacity to support these changes, has led to the existence of ghettos located within the urban periphery. The impact of the sustainable development has been subject of several levels of intervention: global, regional and local ones, from the city to housing buildings. This intervention must be carefully planned, not only in terms of new buildings and urban space, but mainly to be renewed and invigorated in order to promote less use of resources and less production of waste.

The sustainable urban renewal consists in a way of recycling some city areas, sometimes with historical characteristics, disconnected in relation to existing social, economic and political needs. This renewal must always have in mind the features of the current built environment and the load that it represents in the environment, namely the issues associated with energetic waste (United Nations, 1992; Rogers and Gumuchdjian, 2001).

1.2 Urban rehabilitation

The urban rehabilitation is characterized of a complex intervention because it acts upon an existing structure with specific cultural and social characters that are usually consolidated. In historical zones these factors are amplified, for the resident population or for the cultural and architectural values of the sites. The city, attending to its urban image, tells its own history and these areas are its beginning (Wolf, 1974).

The intervention must be worked out based on the resident population and all the social impact that it will produce. This work is not based on sociological issues, but is unmistakable in its preponderant role as a factor of social integration and equality to access opportunities as it is praised in the United Nations Agenda 21 (1992), in its Rio Conference.

The main goal towards sustainability is the definition of strategies for buildings rehabilitation in consolidated historical zones, considering its impact in the environment and never as an isolated element. In these areas, the rehabilitation has become all the complex due: i) the characteristics of the structure and the impossibility of change, ii) the requirements of the building and its unsuitability to modern standards of habitability and comfort iii) the cultural importance of these areas that take a leading role the image and memory urban iv) the complex cultural and social. Faced with these constraints is important to rethink these areas in order to reintegrate them into the city, promoting their self-support through policies that boosting economic activity and renew social relations.

2. Sustainable evaluation systems

2.1 Systems approach

In this work we have analyzed different systems of sustainability, including some implemented as formal tools that support designers and decision-makers in the management of the construction. These systems address the most important issues of sustainability in buildings, with different organizations, and are focused on four key issues (Graham, 2003):

- Resource management - consumption compatible with the natural replacement capacities by minimizing consumption, maximizing the use of renewable and recyclable resources and efficient use of resources (to do more with less);

- Create systems which maximize the consumption in terms of the energy / quality binomial - use of solar resources, efficient distribution of energy and minimization of waste;

- Production of materials which results in nutrients or raw materials for the production of resources - reduction / elimination of pollutants, use of biodegradable materials and reuse of components and systems of the construction;

- Improve the adaptability and functional and biological diversity - conscious analysis of the life cycle, allow access to easily recyclable materials without destruction of the materials difficult to recycle, protect and improve biodiversity.

According to Kibert (2003), the design process is very similar to the management of an adaptive ecosystem: they both need to learn from past experiences and anticipate the future, knowing that the world cannot be fully understood. In this sense, the implementation of sustainable solutions involves the perception of the life cycle of buildings and hence the various phases that the building must meet, each one with specific levels of requirements and targets. This complexity of factors, similar to an ecosystem, results from the interaction between the building and the environment.

Table 1, adapted from Graham (2003) and Newman & Jennings (2008), presents some overall strategies for sustainable communities and shows the extent of sustainability.

Starting from this overall assessment, is possible to understand the approaches outlined in the considered assessment systems, including the SBTool developed by the International Initiative for a Sustainable Environment (iiSBE), the system developed by the Building Research Establishment (BRE) entitled as BRE Environmental Assessment Method (BREEAM), the Leadership in Energy and Environmental Design (LEED), under the responsibility of the United States Green Building Council - USGBC (USGBC, 2008; Yudelson, 2008), and LiderA - Sustainability Assessment System, developed by professor Manuel Duarte Pinho (Instituto Superior Técnico, Lisbon Technical University). These systems have different approaches and different degrees of coverage: the SBTool is a system that seeks a global scope, participating in its development several teams from various

countries (Cole and Larsson, 2002); the BREEAM is a system developed for use in the United Kingdom with the possibility of application in other countries through the International version of BREEAM (BRE, 2006, BRE, 2006a); LEED is a system designed in the United States of America and has several variants which allow the assessment of different situations (USGBC, 2008a); the LíderA is a portuguese system that is being applied increasingly in the country.

Table 1: Strategies for sustainable communities

Feature	***Strategy***
Health	*Characteristics of atmospheric environment; renewable energy use; environmental monitoring; local needs; preservation of ecosystems; food production system with embedded strategies (sustainable ecosystems); low fuel consumption and waste production.*
Self-regulation	*Communities located in order to allow its self-regulation through a closed loop; population under local capacity.*
Permeability and renewal	*Adaptive learning; democratic structures; small communities with streamlined institutional structures; control of environmental impact.*
Flexibility	*Democratic; decentralized communities.*
Ethics	*Respect for land use and people, sustained by the emotional connection to the site through a continuous interdependence.*
Mobility	*Access, public transport, alternative transport.*
Psychology	*Historical and cultural value of the built environment; history, rituals and interaction with the place.*

The SBTool and LiderA systems present a comprehensive framework that allows its application to various types of buildings. The LEED system includes tools specifically adapted to buildings with different occupations and in accordance with the phase of its life cycle (design, construction, use). The BREEAM system presents a larger number of specific assessment tools covering buildings with different occupations and urban areas and provides analysis during various stages of their life cycle (design, construction, renovation / expansion).

2.2 Common approaches

Starting from the work developed in the previous paragraphs was possible to establish a common matrix to allow comparability between the various systems. This comparative analysis was possible by defining key areas of performance, defined from the existence of common criteria and / or assessment or analysis methodologies similar or equivalent. These key areas are based on the analysis of the Local Sustainability, Transportation, Resources Management – Water, Resources Management - Energy, Resources Management - Materials, Exterior Environment - Emissions, Interior Environment, and finally, the Use Sustainability - Control, Flexibility and Suitability.

This common structure led to the need to reorder the criteria of each system within these areas, which were organized in different structures and in similar topics or classifiable those defined for the matrix. Table 2 presents the original structure of the systems.

Table 2: Comparative table between the systems

SBTool	*BREAM (Ecohomes)*	*BREEAM (Ecohomes XB)*	*LEED (New Buildings)*	*LEED (for existing buildings)*	*LiderA*
Location, design and development	*Energy*	*Energy*	*Local Sustainability*	*Local Sustainability*	*Local*
Location	*Transport*	*Transport*	*Construction activity and pollution*	*Efficient water mamagement*	*Land*
Design	*Pollution*	*Pollution*	*Efficient water mamagement*	*Energy and atmosphere*	*Ecology*
Urban planning	*Materials*	*Water*	*Energy and atmosphere*	*Management best practices for energy efficiency*	*Landscape*
Energy and resource consumption	*Water*	*Waste*	*Ensure that energy systems have the expected performance*	*Establish a minimum energy performance*	*Amenities*
Life cycle and non-renewable resources	*Land use and ecology*	*Health and welfare*	*Establish a minimum energy performance*	*Non use of equipments with CFCs*	*Mobility*
Máximo consumo eléctrico para utilização	*Health and welfare*	*Managemen t*	*Non use of equipments with CFCs*	*Materials and resources*	*Resources*
Energias renováveis	*Managemen t*		*Materials and resources*	*Policies for sustainability*	*Energy*
Materials			*Storage and collection of recyclable waste*	*Management of solid waste*	*Water*
Drinking water			*Indoor environment quality*	*Indoor environment quality*	*Materials*
Environmental loads			*Minimum performance of air quality*	*Inflation outside air and exhaust systems*	*Environmental loads*
Greenhouse gases emissions			*Control the environment – smoke*	*Control the environment – smoke*	*Effluent*
Other atmospheric			*Innovation and design process*	*Policies for green*	*Atmospheric emissions*

emissions				*environment*	
Solid waste			*Regional priority*	*Innovation and design process*	*Waste*
Rainwater and sewage					*Noise outside*
Impact of location					*Thermal pollution*
Others local and regional impacts					*Indoor environment*
Indoor environment quality					*Indoor air quality*
Indoor Air quality					*Lighting*
Ventilation					*Acoustic*
Air temperature and relative humidity					*Controlability*
Natural light and lighting					*Durability and accessibility*
Noise and acoustic					*Durability*
Service quality					*Accessibility*
Safety during operation					*Environmental management and innovation*
Functionality and efficiency					*Environmental management*
Controlabillity					*Innovation*
Flexibility and adaptability					
Cooperation of designers in the definition of systems with critical functions					
Maintenance of performance in use					
Social and economic					

aspects					
Social aspects					
Costs and economics					
Cultural aspects					
Culture and heritage					

Besides different systems, we have analyzed the variants for the assessment of new buildings and interventions in the built environment. These realities reflect two systems with different evaluation purposes, in the former case there is the possibility of evaluation at the project level which reflects a broad level of intervention, the second reflects the improvements made on existing systems and provides the optimization of resources and adaptation of solutions. This second reality limits the intervention and requires a meticulous knowledge of the characteristics of the built environment.

The reorganization of the criteria in the key areas set resulted in nine groups of parameters and in the recognition of parameters that are not common, including social, economic and cultural factors that are central themes of sustainable development. Table 3 shows an example of the groups formed, notably in the Resources Management - water.

Table 3: Sustainability in the Resources Management - water

Sustainability in the management of resources - water (supply and drainage)					
SBTool07	LEED - New Buildings	LEED - Existing Buildings	BREEAM - Ecohomes	BREEAM EcoHomes XB Existing housing	LiderA
Location, design and development / Energy consumption and resource / Environmental loads	Sustainability of the place / Efficient water management	Sustainability of the place / Efficient water management	Pollution / Water	Water	Resources / Environmental loads
Design	Construction activity and prevention of pollution	Rainwater Management - capture and reuse / evapotranspiration	Curtailment of surface runoff - covered surfaces and roofs	Internal use of potable water - water consumption in the various activities	Water
Use of renewable resources	Rainwater Management - monitoring the quantity	Efficient water management	Internal use of drinking water	External use of potable water - the collection of rainwater for outdoor use	Consumption of drinking water (indoors)
Existence of a management system of surface water	Efficient water management	Reduction of losses in water facilities of buildings supply	External use of potable water - the collection of rainwater for outdoor use		Consumption of water in outdoor spaces
Availability of system water treatment	50% reduction in the consumption of drinking water for irrigation	Verification of water consumption and system performance			Control of consumption and losses
Availability of water supply systems separate for drinking water / gray	Only use non-potable water for irrigation or without irrigation	Increasing the efficiency of the building water supply			Use of rainwater
Drinking water	Waste water treatment on site and its reuse into the building	Reduce the consumption of drinking water / groundwater			Management of local waters resources
Use of drinking water for irrigation	Reduction of water consumption of the building - 20% reduction	Reduce the use of water in cooling towers			Wastewater
Use of water for the needs of occupation	Reduction of water consumption of the building - 30% reduction				Flow of wastewater
Rain water and sewage					Type of wastewater treatment
Liquid waste discharge					Flow of wastewater reuse
Collection of rainwater for reuse					
Rain water not collected					

The systems approach is similar, although with significant differences in the organization of its structure analysis. Aspects related to construction and the life cycle of buildings appears in all systems. Those who evaluate the built environment variables are not related to land use. The economic, social and cultural issues are sparse and are named only in the SBTool. The importance of the quality of life inside the house is relevant and it's, in fact, taken into account, whether in the health and well-being concern or the indoor environment quality.

In terms of results, these systems are based on establishing an overall grade for the building, in some cases to assign weights to the different areas and criteria in order to take into consideration problematic issues regarding specific places or regions.

3. Evaluation of the built environment

3.1 Building the model

After defining the main areas involved in the assessment of sustainability, discussed earlier, it were defined the analysis' parameters for each one of them, based on the characteristics of the historical areas of portuguese cities, the sustainability principles and the strategies outlined by the Urban Rehabilitation Corporations that exist, such as in Lisbon, Porto and Coimbra. The particularity of these urban areas requires detailed knowledge of its evolution, the constraints and potential impacts of their specificities. While the physical conditions of buildings, the age of residents, the conditions of infrastructure and urban space constraints are important, the historical and cultural value, the urban memory urban, the economic activities and the built environment are key factors that characterize the enormous potential of these areas. Figure 1 shows some images of the historic area of Coimbra's downtown.

Figure 1: Historical Coimbra city centre images

The images show the advanced degree of degradation of some buildings in Coimbra's downtown. This area is in the outskirts of the city of Coimbra, built from the X Century and it was occupied by the full population of the less wealthy and with a strong commercial element. Nowadays, it is an important commercial hub of the city, with a diversified economic activity, and especially, an area of great historical value and heritage. It is currently the target of interest through the initiatives of urban regeneration driven by policy initiatives, such as the creation of Rehabilitation Corporations consisting of support structures to the owners for the preparation and implementation of rehabilitation.

Given these factors, it is necessary to conduct the processes of intervention in encouraging activities that promote local sustainability, through initiatives that promote social relations, environmental quality, economic activity, self-support, recovery and optimization of the built environment, cultural heritage and history as part of urban memory.

3.2 Evaluation model of sustainable rehabilitation

The evaluation model of sustainable rehabilitation is designed to lead the process of intervention as a tool to support decision. This model addresses various parameters of analysis and evaluation grouped into nine areas defined above.

Through the analysis performed was possible to define an evaluation system with the following objective:

- To direct the activities of intervention in historic areas;
- Safeguard the cultural and historical interest of the area and its memory;
- Promote the generation of jobs and activities that develop the area and respects its neighbours;
- To create conditions to return a part of the urban fabric that values the city existence;
- Promote social spaces and rest areas, open spaces and its relationship with the interior;
- Apply the principles of sustainability, which have been properly identified in Table 1;
- Return to the dialogue between the habitat and the environment that has existed since the dawn of human existence, as a way to reduce its impact.

The criteria defined analyze issues related to the land use and the impact on the surrounding environment, the consumption of resources at all stages of the life cycle of the building, in this case in comparison with the current situation and the improvements incorporated through the intervention operations. They also evaluate the support for the mobility of users, both in relation to the provision of services such as the existence of alternative traffic routes and conditions for use of automobile

alternative means of transportation. Also appreciates the quality of indoor and outdoor environment, showing the natural relationship between these spaces. The improvement of living conditions are also analyzed to improve existing conditions and to make urban space more attractive to newcomers.

The flexibility of the building is valued according to its adaptability, a key factor that allows a versatility that follows the changing social and area needs. Finally, is taken under consideration the architectural, social and cultural value of the building as a way to maintain the existing characteristics and adapting the use.

Table 4 presents the general structure of the evaluation model.

Table 4: Evaluation Model of sustainable rehabilitation

Sustainable place	
SL1	*Density*
SL2	*Exterior spaces*
SL3	*Type of occupation*
SL4	*Exterior ventilation*
SL5	*Exterior thermal conditions*
SL6	*Impact on surrounding environment*
Sustainable Transport	
ST1	*Availability of public transport*
ST2	*Conditions for use of alternative transport*
ST3	*Need to travel to access services*
Sustainability in the Management of Resources - Water	
Supply	
SA1	*Consume of Drinking water*
SA2	*Efficiency of the building water supply*
SA3	*Different interior supply water systems*
SA4	*Use of rainwater for irrigation and non-potable uses*
Drainage	
SA5	*Waste water treatment for reuse*
Sustainability in the Management of Resources - Energy	
Efficiency	
SE1	*Definition of minimum performance levels*
SE2	*Types of equipment used*
SE3	*Types of lighting inside and outside the building*

SE4	*Monitoring of energy consumption*
	Renewable Resources
SE5	*Use of renewable resources*
SE6	*Strategies for maximizing the potential passive solar*
	Sustainability in the Management of Resources - Materials
	Consumption
SM1	*Reuse of the main existing structure*
SM2	*Use of local materials*
SM3	*Use of materials with recycling potential in rehabilitation operations and maintenance*
	Production and Collection
SM4	*Availability of devices to collect waste*
SM5	*Reduction of waste resulting from operations of rehabilitation and maintenance*
	Recycling
SM6	*Recycling of household waste*
SM7	*Recycling of waste from the operations of rehabilitation and maintenance*
SM8	*Management of non-recyclable waste*
	Sustainability in the Exterior Environment - Emissions
SAE1	*Control of annual CO2 emissions*
SAE2	*Emission control greenhouse gases, acid or photo-oxidants*
SAE3	*Monitoring of outdoor air quality*
	Sustainability in the Interior Environment
SAI1	*Control of indoor air quality*
SAI2	*Use of indoor coating materials with low emission*
SAI3	*Air renovation*
SAI4	*Temperature and relative humidity*
SAI5	*Levels and quality of lighting*
SAI6	*Privacy and outside views*
SAI7	*Acoustic comfort*
SAI8	*Articulation and minimum areas of the interior spaces*
	Sustainability in the use
	Controllability
SU1	*Controllability in the building's systems*
SU2	*Document the principles and practice of building*

Flexibility	
SU3	*Usability for new features*
Adaptability	
SU4	*Adapting to new energy sources*
SU5	*Interior adaptability*
SU6	*Technical systems adaptability*
Sustainability Cultural, Economic and Social	
CES 1	*Patrimonial valorization of the building*
CES 2	*Architectonic valorization of the building*
CES 3	*Social valorization of the building*
CES 4	*Stimulation of local economy*

The model also evaluates the intervention according to a hierarchical structure as follows (Figure 2):

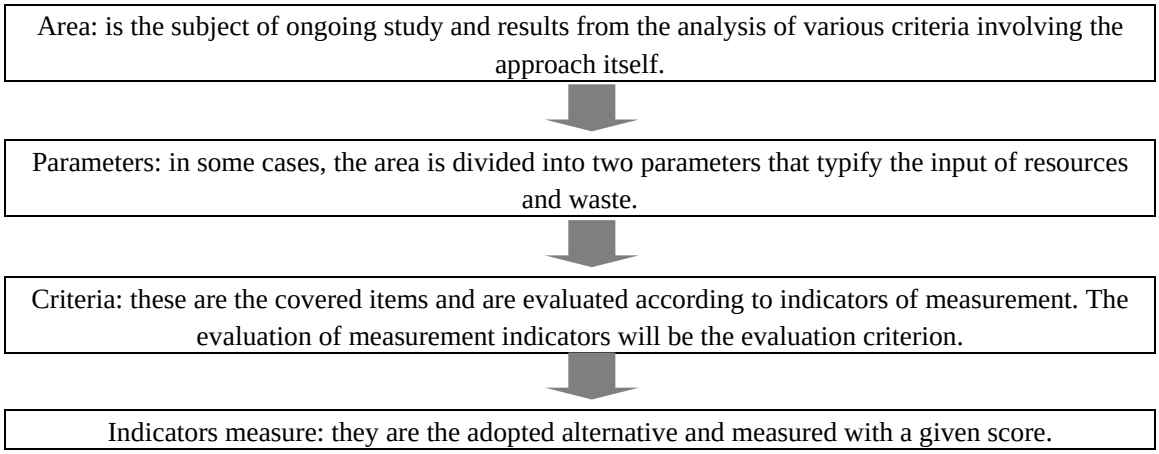

Figure 2: Structure of the evaluation model

The results of applying the model are presented in graphical and report form, as the marks awarded shall be duly justified. The performance seen in the chart will make it possible to visualize the effectiveness in each area evaluated, which identifies the improvements to be introduced, at the building itself level or at the urban management model used level.

4. Conclusions

The fundamentals issues for the creation of an array of assessment of existing buildings, in this case with specific characteristics and a net asset value and cultural value, consist of:

- The fact that these areas constitute part of the urban fabric with little flexibility or low changeability, defined by a consolidated urban mesh;
- The existence of a network of mobility defined and shaped by a constrained urban environment, usually with distinct patterns of occupation;
- The high value patrimonial and cultural heritage;
- The representation of the heritage of a people with values and customs that make up its story;
- The tourism potential of these areas and the possibility of forming an economic powerhouse, with a significant representation in the productive fabric;
- The feasibility of becoming a nerve center for employment and business opportunities.

In this sense, the system draws a set of lines that clarify the actors involved in the various stages of the life cycle of the building. The model has been designed considering, as starting point, the existence of a building, in this sense there is an initial performance and the model assesses the improvements implemented to address this performance. The assessment is always carried out in relative terms, working on a percentage basis compared to the existing.

There has been a great effort to implement sustainable systems and methodologies; however, there is a need to change the current context of construction, to guide decision-makers and active agents in the process of design and construction. This model includes this component and helps to clarify the best strategies.

The score of the criteria allows the setting of a final rating that promotes comparability between some rehabilitation activities, reflecting the improvement implemented. Some of the criteria are presented as urban management; they must be analyzed attending to local policies and highlights the need for joint efforts to achieve the desired outcomes.

There are several initiatives aimed at building sustainable level of new buildings, or even intervention in the built environment, where the historical areas consist of critical areas. These areas have been marginalized, even in regulatory terms, and due to lack of existing conditions and difficulties of intervention, have been exonerated of responsibilities about their performance. This part of the built heritage should take their part in environmental responsibility and alternatives must be found to regulate their effectiveness and measure their impact. The complexity of the intervention should not cause an "urban autism" and these areas must communicate and relate to the town, as well as must respond adequately to the environment.

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