The assessment of building sustainability in micro and small building firms – Case study on southern Brazil

Evaluación de la sustentabilidad de la construcción en micro empresas o empresas pequeñas de la construcción – Caso de estudio en el sur de Brasil

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Abstract

This paper describes a tool to assess building sustainability on micro and small building firms. In recent years occurred great transformations in design and management phases of buildings. Sustainability is very important because the environmental impact of building sector. The application of innovations generally occurs only in mid or large building companies, however the micro and small building companies represent the majority of the companies. We proposed a tool adjusted to smaller context. Using a sample of buildings, the tool demonstrated be adequate, because it is comprehensible and useful to users with different level of education and knowledge about sustainability.

Keywords: Civil construction, sustainable building, assessment, micro and small companies, Brazil

Resumen

Este artículo describe una herramienta para evaluar la sustentabilidad de la construcción en micro empresas o empresas pequeñas de la construcción. Durante los últimos años han ocurrido grandes transformaciones en micro empresas o pequeñas empresas de la construcción. La sustentabilidad es relevante, debido al impacto ambiental producido por el sector de la construcción. La introducción de medidas innovadoras, generalmente ocurre en empresas constructoras de mediano o gran tamaño, a pesar que la cantidad de micro empresas y pequeñas empresas representan el mayor número de esta actividad. Se propone una herramienta ajustable a un contexto menor. Al emplear una muestra de edificaciones, la herramienta demuestra ser adecuada, porque logra ser comprendida y ser útil para los usuarios, con diferente nivel de educación y conocimiento sobre sustentabilidad.

Palabras claves: Construcción civil, sustentabilidad en la construcción, evaluación, micro empresas y pequeñas empresas, Brasil

1. Introduction

Construction industry is a great customer of resources. The transformation of raw materials in buildings and the need to transport these materials over long distances requires an additional amount of resources, provoking significant environmental impacts. Resources for operation, maintenance, demobilization and demolition also are consumed throughout the life cycle of construction and, as a consequence of these characteristics, construction industry is also responsible for consume energy, water, and generate pollutants.

Looking for sustainable buildings involves a wide range of actions, among which we highlight the following: training builders and designers, improving the quality of materials, training of manpower, certification, recycling, improving the means of communication and information exchange, and search for innovative materials and technologies. These initiatives are expected to increase the competitiveness, improve the quality of products and services, reduce costs, optimize resource use, and especially reduce waste and environmental impact of construction.

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Some studies related to sustainable building are gaining importance, but the application of innovation often occurs only in mid and large companies, which work in larger cities. However, micro and small building companies are the majority on construction sector. Therefore are responsible for implementing large part of the buildings and also employment generation.

In view of this background, we developed a study to evaluate the application of concepts of sustainable construction, verifying the implementation of these concepts in micro and small businesses, especially in face of regional characteristics of the Caí River Valley, a region on southern Brazil. It was initially defined an evaluation method which was then applied to typical buildings in this region, with good results.

2. Indicators of building sustainability

The assessment of sustainability degree in construction sector is a complex issue. There are several approaches, although usually based on two lines: Life Cycle Assessment (LCA) or tools using a set of criteria and indicators. LCA is used to evaluate the environmental impact, through the quantification of materials and energy involved in a product. It is aligned to issues discussed at the Rio-92 and Rio+10, in terms of what actions should be planned for the development of policies for the production and consumption in order to improve products and services, reducing environmental impacts (UN, 1992, 2002). Methods and results of LCA used in developed countries may not be appropriate for Third World, and appropriate techniques must be developed in line with national conditions and peculiarities. In fact, the evaluation of the life cycle presents some practical difficulties such as lack of information from local manufacturers of materials and components, complexity of analysis and dependence on factors such as transport distances (Silva et al., 2002).

There is no one formal classification, but environmental assessment schemes available can be clearly separated into two categories. On the one hand, there are systems designed to be easily absorbed by designers or receive and disseminate market recognition for efforts provided to improve the environmental quality of projects, implementation and operational management (such as BREEAM - Building Research Establishment Environmental Assessment Method, and LEED - Leadership in Energy and Environmental Design). On the other hand, there are some forms of evaluation-oriented tools, such as BEPAC (Building Environmental Performance Analysis Club) and its successor, the GBC (Green Building Council). In this case, the emphasis is to develop a comprehensive methodology and a scientific reasoning, which can guide the development of new systems (Silva et al., 2002).

Techniques based on criteria such as LEED and BREEAM are flexible and allow the use of qualitative assessments. Indicators of sustainability of the built environment describe the environmental, economic and social aspects. These indicators capture trends to inform decision makers, to guide the development and monitoring of policies and strategies, among other roles. They are useful for designers, owners, users, managers, policy makers and other public officials involved in the construction industry.

In order to meet the market requirements and follow the trend of sustainability, companies choose environmental certifications. However, an adjustment to current standards of environmental preservation require major investment for organizations, and represents a cost that usually presents no apparent profits on the short term, with the same profit can be quantified by certified firms, and then served as reference to the other. It's more difficult to smaller companies.

The best known and more used method in Brazil is LEED. This method of evaluation was created in the United States in 1999. It is currently the method with greatest potential for expansion, according to the massive investment being made for their dissemination and improvement. It was inspired by BREEAM and is a system based on criteria and indicators. The system is updated regularly (every 3 - 5 years) and versions for different types have been developed gradually (USGBC, 2005). The evaluation criteria are distributed according to the purpose of the property. The LEED criteria have to evaluate the following types of certification: new construction and major reforms, existing buildings (phases of operation and maintenance), interiors, core and "envelope", and schools in the pilot phase, neighborhoods, retail and residences. In LEED, the developments are assessed according to six dimensions or categories of requirements, and resulting in a total of 69 points (USGBC, 2001):

- Sustainable sites (01 prerequisite and 14 credits)*
- Water efficiency (05 credits)*
- Energy and atmosphere (03 prerequisites and 17 credits)*
- Materials and resources (01 prerequisite and 13 credits)*
- Indoor environmental quality (02 prerequisites and 15 credits)*
- Innovation and design process (05 credits)*

After Silva (2007), there are considerable efforts in Brazil to develop sustainability indicators at different scales of built environment, however, these indicators vary widely and are defined according to criteria and methodologies which are not replicable in some cases. In addition, there are some items that do not apply to national or regional phenomenon. Some studies have been developed for the generation of evaluation mechanisms in Brazil. For example, Kuhn (2006) and Sedrez (2004) proposed mechanisms for assess the sustainability of social housing projects, and Oliveira (2005) proposed a method of environmental assessment of roofing on social housing.

3. A method for sustainability assessment

A method for assessment of building sustainability need to take into account regional characteristics, characteristics of typical buildings (considering materials, manpower and techniques used), and size of the companies responsible for their implementation (in our case, micro and small companies), among other issues.

From the correlation of different systems to sustainability assessment, different visions and parameters proposed by some authors, we defined the dimensions of sustainability (themes) and indicators for assessing the sustainability of a building, whose matrix is presented in Table 1. The first 42 questions are considered directly by the evaluator, while the last 3 result of questioning people involved with the developments. All were assessed on a scale of 0 to 3 points.

Table 1. Proposed method for sustainability assessment: dimensions of sustainability and indicators
Tabla 1. Método propuesto para análisis de sustentabilidad: dimensiones de sustentabilidad e indicadores

Dimensions/ Dimensiones	Indicators/Indicadores
(A) Sustainable sites (A) Sitios sustentables	1 Urban integration/ Integración urbana
	2 General location and solar orientation/ Ubicación general y orientación solar
	3 Assess ways/ Vías de acceso
	4 Parking space/ Estacionamiento
	5 Alternative transportation/ Transporte alternativo
	6 Storm water management/ Administración de agua de lluvia
(B) Water efficiency (B) Eficiencia del agua	7 Reduce water use/ Reducción del uso de agua
	8 Reduce sewage and gray water/ Reducción de aguas grises y residuales
	9 New technologies for reduce water use/ Nuevas tecnologías para reducir el uso de agua
	10 Storm water reuse/ Reutilización de agua de lluvias
	11 Wastewater reuse/ Reutilización de agua de desechos
(C) Energy and atmosphere (C) Energía y atmósfera	12 Energy efficiency/ Eficiencia Energética
	13 Renewable energy and green energy use/ Uso de energía renovable y energía limpia
	14 Thermal insulation/ Aislación térmica
	15 Building reuse (retrofit or other strategies)/ Reutilización de edificaciones (readaptación u otras estrategias)
(D) Materials and resources (D) Materiales y recursos	16 Reuse or recycling materials and components/ Reutilización o reciclaje de materiales y componentes
	17 Construction waste management/ Administración de desechos de la construcción
	18 Local or regional materials/ Materiales de origen local o regional
	19 Renewable materials/ Materiales renovables
	20 Certified wood/ Madera certificada
	21 Easy maintenance/ Mantención simple
	22 Environmental quality of materials/ Calidad medioambiental de los materiales
	23 Life cycle assessment/ Análisis del ciclo de vida
	24 Layout and use flexibility/ Distribución y uso flexible
	25 Natural ventilation/ Ventilación natural
(E) Indoor environmental quality (E) Calidad ambiental de interiores	26 Thermal comfort/ Comodidades térmicas
	27 Daylight and views/ Luz de día y paisajes
	28 Noise control/ Control de ruido
	29 Finishing and furnishing adequate to users/ Terminaciones y mobiliario adecuado para los usuarios
	30 Waste management/ Administración de desechos
(F) Environmental loads (F) Cargas medioambientales	31 Environmental responsible management/ Administración ambiental responsable
	32 Water infiltration into the soil/ Filtración de agua hacia el terreno
(G) Design and building (G) Diseño y construcción	33 Design innovation/ Diseño innovador
	34 Structure type/ Tipo de estructura
	35 Soil pavement type/ Tipo de pavimentación del terreno
	36 Neighbor integration/ Integración vecinal
	37 Surroundings and building vegetation/ Vegetación en alrededores y de la edificación
	38 Building adaptation to elderly and disabled/ Adaptaciones de la edificación para adultos mayores y discapacitados
	39 Local workers degree/ Nivel de los trabajadores locales
	40 Employment formality/ Formalidad contractual
	41 Food supply to workers/ Suministro de alimentación para trabajadores
	42 Security on work/ Seguridad laboral
	43 Discrimination absence/ Discriminación por ausencias
	44 Perception of importance of sustainability/ Percepción de la importancia de la sustentabilidad
	45 Transport way used by workers/ Medio de transporte empleado por los trabajadores

The assessment considers the adequacy of the parameter for each case, following criteria presented in Table 2. There are a small difference only on the last question, which took into account the energy consumption for transport to the job site, taking 3 points for access by foot or bike, 2 using public transport, 1 when people use car, and 0 when people goes to site on truck.

All indicators have the same weight, so the maximum score is 135 points. Because there are different amounts of indicators in each dimension, the results were converted into percentages, so that all dimensions have equal weight in the final index and aiming at the transformation to a more easily understood.

Table 2. Levels of assessment of the indicators

Tabla 2. Niveles de análisis de los indicadores

Condition/ Condición	Assessment/ Análisis
No: the indicator examined is not seen in the context of the building No: El indicador examinado no es detectado en el contexto de la edificación	0
In part: the indicator is applied in a small part of the building – around 33% Parcialmente: El indicador aplica en una parte reducida de la edificación – cerca del 33%	1
Most part: the indicator is applied in a great part of the building – around 66% Mayoritariamente: El indicador aplica en gran parte de la edificación – cerca del 66%	2
Full: the indicator is completely attained Totalmente: El indicador se encuentra completamente logrado	3

4. Application of the proposed methodology

The assessment of sustainability in some buildings on the Caí River Valley was performed by analysis on three residential projects (two single-family homes and a multifamily residential building), monitoring of construction sites and contact with several agents, including architects, civil engineers, builders, workers, realtors, municipal officials, suppliers, and other people involved with these projects. We take in account all persons involved directly in building site and around to 50% of people working outside (realtors, suppliers, and others).

The projects are located in the region of the Caí River Valley and they are administered and enforced by micro and small building companies. The region has around 160,000 inhabitants (on 2007), it has 20 cities covering 1,854 km², and it has a GDP of US\$ 6,500 (on 2006).

The projects identified for the case studies are typical in the region, and they were selected as base on their characteristics, availability of information from building companies, easy access to project information and construction sites. The basic features of each of the projects are as follows:

- 1) Vertical, multi-family residential development – analyzed in the design phase, it has a built area of 3,200 m², composed of twenty-four apartments, and thirty-six parking spaces;

- 2) *Single-family residential development – analyzed during the implementation phase, with built area of 117.95 m²;*
- 3) *Single-family residential development – analyzed during implementation phase, with built area of 204.53 m².*

Access to construction sites and the information concerning new developments and business was secured during the entire investigation. Analyzing comparatively the enterprises studied, we note the similarities and differences in their main features.

After detailed contact with the developments, we evaluated the score for each indicator. For the last three questions, we interviewed 25 people involved with the developments. We observed that these agents had no difficulty understanding the indicators, and no matter their education levels. The results are presented in Table 3.

Table 3. Evaluation of the projects analyzed
Tabla 3. Evaluación de los proyectos analizados

Dimension/ Dimensión	Building/ Edificación			Average/ promedio
	1	2	3	
(A) Sustainable sites/(A) Sitios sustentables	83%	89%	67%	80%
(B) Water efficiency/ (B) Eficiencia del agua	60%	40%	53%	51%
(C) Energy and atmosphere resources/(C) Recursos energéticos y atmosféricos	78%	56%	56%	63%
(D) Material and resources/(D) Materiales y recursos	57%	43%	43%	48%
(E) Indoor environmental quality/(E) Calidad ambiental de interiores	93%	87%	87%	89%
(F) Environmental loads/ (F) Cargas medioambientales	44%	56%	44%	48%
(G) Design and building/ (G) Diseño y construcción	74%	77%	72%	74%
Average/ Promedio	70%	64%	60%	65%

The highest level was reached in dimension (E) and the smaller are on dimensions (B), (D) and (F). We may conclude that the quality of the internal environment is good, while the efficiency on materials and resources (D), water efficiency (B) and environmental loads (F) do not reached a similar level. These dimensions generate construction waste. These issues represent opportunities to improve buildings, helping the decision-making of designers. In the overall evaluation, these buildings have reached an average level (about 2/3 of the maximum of the proposed method), with a balance between them.

The chart below (Figure 1) helps to examine the results qualitatively. It appears that the buildings studied are similar, although involving different professionals, clients and projects, for example. We can see major differences in the dimensions (A) and (C) and balance among (E) and (G), among the 3 projects. In Figure 1 we can see the potential for progress, represented by the blank area on the chart. It's easy to understand this figure, which is useful to professional and non-professional.

Figure 1. Evaluation according to dimensions of sustainability and buildings
Figura 1. Evaluación de acuerdo a las dimensiones de sustentabilidad y a las edificaciones

5. Comments

We proposed a method for assessing the sustainability conditions for micro and small building companies working in smaller cities. Some indicators were organized according a thematic structure. The proposed method was suitable to the context, and is also flexible, allowing for easy inclusion, exclusion, union or subdivision of indicators.

The next steps on the research are dissemination to people involved, and proposing a mechanism for use in project licensing on small cities of the region, initially as a guide. In the future it may work as part of a property tax law perhaps indicating incentives in the form of discounts on taxes in proportion to the level of sustainability achieved by the project.

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