Sustainable Construction: Value of Certification

[Amado, Miguel; Lucas, Vanessa, Ribeiro, Maria]

Abstract— ***The study and implementation of measures to promote sustainability for the future development of society development requires the definition of limits on the uncontrolled consumption of natural resources that are a result of human activities. The construction sector has an enormous effect on the environment due to its massive resource consumption; therefore the development of a process to increase sustainability in this sector is paramount. In this sense the systems that assess sustainable construction play a key role.***

The emergence of voluntary evaluation and certification systems of construction enables the assessment of sustainability of buildings – their construction and operation.

The evaluation and certification systems are in constant evolution, expanding their scope of application. Some countries are developing systems of sustainable construction evaluation adjusted to the local context.

Through the study of different systems of evaluation and certification and their contents it was possible to identify and select the key factors that support the development of a system that is geared towards application at the regional level thus accomplishing the value of certification systems of sustainable construction.

Keywords — Construction, Sustainability ,Evaluation, Certification

I. Introduction

The planet has been suffering profound changes in the last 50 years mainly in result of human activities. This situation is a result of the interaction of tree key factors: population growth; resource consumption; pollutant emissions (water, air and soil). Today, there are more than 7,000 million people on the planet and it is expected that this number will reach 9,150 million by 2050 [1].

This population growth will require more consumption of resources due to the need to build more homes. This will lead to negative consequences for the both the environment and to the development process of societies [2].

The concern with natural resources preservation and the way they are used in society, particularly in building sector, have been growing [3].

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These concerns have pressed society to reflect on the need to introduce sustainable concepts and apply them to the different sectors of society.

The construction sector is responsible for environmental problems in result of its excessive consumption of natural resources both in construction and building operation and it is also the largest generators of solid waste. This situation calls for both new materials and new construction techniques.

In order to inverse this trend of environmental disarticulation of increased natural resources depletion, emissions, deteriorating health and biodiversity, Charles Kibert proposed a concept adaptable to construction, named Sustainable Construction, in which the main theme is the "creation and responsible management of a healthy built environment, taking into account ecological principles in order to avoid environmental damage and an efficient use of resources" [4]. This new concept has the main preoccupation to help protect the environment and preserving natural resources while increasing the quality of human life.

Sustainable construction adopts in its model the principles of sustainable development in order to minimize the use of natural resources and develop methods that protect the environment and at the same time ensuring the protection and continued existence of ecosystems.

In the last decade sustainability assessment tools were created to enable the certification of a building's sustainability in the three dimensions of Sustainable Development - environment, social and economic.

The objective of this paper is to both overview and analyzes the current building assessment and certification systems used in different countries in terms of their structure and weight of each component to enable an in depth discussion and comparison between them.

The research methodology is developed taking into account the ability to integrate existing research to further develop the existing systems of certification of sustainable construction. This added knowledge will provide a clear identification of the determinant factors of sustainability in construction sector and relate them with both the national regulatory framework and the regional context. Through this step it is possible to promote a set of key parameters essential to an efficient system that haves the capacity to generate more value from the assessment systems and ensure the overall objectives of sustainable construction.

II. Sustainable Construction Evaluation

Environmental assessment initiatives applied to building sector began towards the end of the 80's. This kind of evaluation aimed to assess the negative and positive impacts that the activity of construction might have on the environment, developing further measures to minimize negative environmental impacts and promote the positive impacts [5].

The development of environmental impact assessment involves the creation of specific criteria in order to reduce and assess the environmental impact caused by the construction. However, it was observed that in many countries that have developed projects in order to minimize this impact the means used to verify if the buildings met the criteria were not sufficient [6]. As a result, many buildings that had the goal of preservation of the environment once the complete life cycle was assessed it had a higher energy consumption compared to the construction of the baseline solution [7].

Advances in environmental evaluation, in respect of building works began with the consensus among researchers and government institutions, which accepted certification systems as one of the most efficient methods for the improvement of buildings regarding its environmental performance. This step in the development of environmental evaluation was instrumental in the formulation of guidelines and methods for sustainable construction and its methods of evaluation and verification [8], leading to the fulfillment of various methods and systems for the evaluation of Sustainable Construction, that even today remain voluntary, but offer advantages in all areas that influence the buildings' construction.

The necessity to implement mechanisms that ensure compliance of construction with regard to sustainable processes arises due to the fact that many countries had developed projects to minimize environmental impact but had no means to verify that the projects meet the objectives they were assigned [6]. As a result, there was the need to create for measures such as certification in order to assess and enforce procedures and systems related to the future sustainability of the construction sector.

Certification is a process performed by an external entity, independent, accredited or holder of the brand that can issue a document that verifies the conformity of a product, process or service, with the benchmark and standards, to the area in question.

The certification aims to recognize buildings that contribute to a sustainable future, through the construction of buildings taking into account economic, environmental and social aspects [8]. The level of performance requires both practices and processes of sustainable construction and the introduction of the principles of sustainability throughout the building life cycle [9], improving the quality in performance of buildings.

The process to assess and certify sustainable construction aims to stimulate, advise and encourage the market to develop and use practices that enhance environmental protection.

The evaluation and certification of sustainable construction promotes the minimization of the negative effects of the buildings in their areas, aims to encourage a healthy and comfortable indoor environment and contributes to minimizing the use of natural resources in order to contribute towards an effective sustainable development [10]. Some of the objectives certification of sustainable construction are: to differentiate the buildings with less environmental impact, encourage the use of best environmental practices in all phases of the lifecycle of the building [9], create parameters that are not imposed by legislation and highlight the importance and benefits of buildings with lower environmental impact to owners, users, designers and operators. So the evaluation and certification of sustainable construction wants to encourage the creation of an environmentally responsible attitude, the creation of profitable buildings, and healthy places to live and work.

A. *Contribution to sustainability*

The process of assessment and certification of sustainable construction aims to encourage good practices in the construction sector, in order to preserve the environment, enhance quality of life and the built environment [8].

It aims to help the development of projects and plans that enhance the level of sustainability of the project during their life cycle and management of works in various stages of construction and operation [11].

In order to contribute to sustainability in construction, some concepts considered as key: acoustic comfort, thermal comfort, air quality, are evaluated regarding the link with the social context of the building envelope and impact on the external environment, promoting the image of the building and its proper integration into the environment and the environmental management of the building process in all its phases and efficient use of resources.

B. *Contribution to the construction efficiency*

The evaluation and certification of sustainable construction has the goal of achieving efficiency in the construction process and guaranteeing a high level of efficiency and value of the construction solutions adopted [12].

It's intended that the construction be based on a sustainable process monitored at all stages of the life cycle of the building, to ensure that the principles of sustainability are always guaranteed. So, sustainability will be observed from the stage of project design, the efficiency of the method of construction, use and maintenance of buildings in a sustainable manner by those who inhabit and users them [13].

The system of assessment and certification allows the specification of areas of sustainability that require improvement, a situation that is monitored through the monitoring process and results that increase the value of buildings and go towards a more sustainable construction.

III. Assessment Systems

The assessment systems are designed to be easily incorporated by designers and the market in general, they have a simple structure, usually formatted as a checklist and linked to some kind of performance scoring.

These evaluation systems developed towards specific buildings reflect the significance of the certification of sustainability in construction. These systems are constantly evolving and expanding its scope because the interaction between buildings construction and the environment is still largely unknown. In part this reflects the limitation of the environmental building assessment systems in the context of performance of buildings. The major objective now is to "develop and implement an agreed method that serves as a support to the design of sustainable buildings that can be, simultaneously, transparent and flexible enough so that it can be easily adapted to different types of buildings and the constant evolution of technology that exists in the construction field " [14].

For a better understanding of evaluation systems, it's important to present most relevant systems implemented in several countries namely:

BREEAM (Building Research Establishment Environmental Assessment Method):

Developed in the United Kingdom in the 90's, developed as the primary method of evaluating the environmental performance of buildings [15].

This system provides not only guidelines to minimize the negative effects of buildings in their areas and aims to foster a healthy and comfortable indoor environment, addressing issues related to energy, environment, health, productivity, opportunities for improvement and financial benefits [16].

CASBEE (Comprehensive Assessment System for Building Environmental Efficiency):

This system was developed in Japan, based on two categories: one for new buildings and another for existing buildings.

The system has two aspects: the lifting / balancing between positive and negative impacts during the life cycle of building; and defining limits of the building analyzed. It also has the distinction of developing a concept referred to as closed ecosystems in order to determinate the environmental efficiency by relating the environment of the building in study with the external environment [17].

GBC (Green Building Challenge):

Was initially developed in Canada and later taken up by an international consortium and designated by GBTool. It aims for the development of an method to evaluate the environmental performance of buildings, taking into account to their suitability for different technologies, building traditions and cultural values of different regions of the same country or from different countries [18].

SBTool (Sustainable Building Tool):

Based on GBTool Method and developed by iiSBE (International Initiative for Sustainable Built Environment), through the participation of several countries. This methodology aimed at creating a system to evaluate performance of buildings at the international level, but making an adjustment to the country context where it's applied.

SBTool methodology has been used for development of several regional assessment tools like SBToolPT (Portugal), SBToolCZ (Czech Republic), Protocol ITACA (Italy) and GREEN (Spain) [19, 6].

HQE (Haute Qualité Environnementale des Bâtiments):

Evaluation system developed in France, with the following principles: reducing the impacts of buildings on the outside environment globally, regionally and locally and create an indoor comfortable for users.

The structure of this system is subdivided into management of enterprise and environmental quality, being composed by the following evaluation areas: eco-construction, management, comfort and health [20].

LEED (Leadership in Energy & Environmental Design):

Developed by United States Green Building Council (USGBC), in the United States of America, aiming the development and implementation of project practices and environmentally responsible construction sector that promotes the creation of environmentally efficient buildings and healthy places to live and work [21, 22]

This system is the most recognized worldwide and is present in 41 different countries, undergoing successive updates to its members.

LIDERA (System Volunteer for Evaluation of Sustainable Construction):

Is a voluntary evaluation and recognition system of sustainable construction and built environment, developed in Portugal and aims to support the development of plans and projects seeking sustainability by: evaluating the level of sustainability in various stages of the building, supporting management during the construction phase and operate and certificating through an independent evaluation [23].

NABERS (National Australian Buildings Environmental Rating System):

Born in Australia, with the peculiarity of having developed an online project that allows the possibility of self-evaluation in a global or by specific area. This self-evaluation is done through the questionnaire available on the website. This system addresses issues such as Energy, Land, Materials, Water, Internal Environment, Waste, Resources and Transportation [24].

A. *Structure of assessment systems: areas, parameters and weights*

The existing evaluation systems despite being built on a common basis differ from each other, this essentially determined by the following reasons: levels of concerns about the environmental aspects vary from one country to another, the design and construction practices are different, climatic conditions, latitude, social and economic aspects are different and the receptivity of markets to the introduction of methods and measures are different.

The search for sustainability in the field of assessment of buildings has been characterized by structural transformation and operational requirements of the assessment methods [18], since some of systems have their priority on the environmental assessment while others seek to evaluate the sustainability of buildings [11].

Table 1 summarizes the requirements that constitute the structure of each mentioned system presented, as well as their relevance areas, parameters and weightings.

TABLE 1 - AREAS, PARAMETERS AND WEIGHTINGS OF SYSTEMS

Evaluation Systems	**Areas of Evaluation**	**Parameters of Evaluation**	**Weighting (%)**	**References**
BREEAM	Management	Aspects global of policy and environmental procedures	12	BREEAM, 2008
	Health and Wellbeing	Internal and external environment of the building	15	
	Energy	Operational energy and CO_2 emissions	19	
	Transport	Location of the building and CO_2 emissions related to transportation	8	
	Water	Consumption and leakage	6	
	Materials	Environmental implications of materials selection	12,5	
	Waste	Resource efficiency by effective management and proper construction waste	7,5	
	Land Use a. Ecology	Directing of urban growth; Ecological value of site	10	
	Pollution	Pollution of air and water, excluding CO_2	10	
	Innovation	Innovation in the field of sustainability	10	
CASBEE	Indoor Environment	Sound and Acoustics; Thermal Comfort; Lighting & Illumination; Air Quality	20	CASBEE, 2008
	Quality of Service	Service Ability; Durability & Reliability; Flexibility & Adaptability	15	
	Outdoor Environment on Site	Preservation & Creation of Biotope; Townscape & Landscape; Local Characteristics & Outdoor Amenity	15	
	Energy	Building Thermal Load; Natural Energy Utilization; Efficiency in Building Service System; Efficient Operation	20	
	Resources & Materials	Water Resources; Reducing Usage of Non-renewable Resources; Avoiding the Use of Materials with Pollutant Content	15	
	Off-site Environment	Consideration of Global Warming; Consideration of Local Environment; Consideration of Surrounding Environment	15	
SBTool	Energy and Resource Consumption	Water, Energy, Land and Materials	23	SBTool, 2007
	Environmental Loadings	Emissions, Effluents and Solid Waste	27	
	Indoor Environmental Quality	Air quality, Ventilation, Illumination and Comfort	18	
	Service Quality	Flexibility, Adaptability, User controllability, Outside spaces and Impacts on adjacent properties	16	
	Social and Economic aspects	Socio-Economic aspects	5	
	Site Selection, Project Planning and Development	Planning of the construction, Verification, Pre-delivery and Planning of the operation	8	
	Cultural and Perceptual Aspects	Culture and Patrimony	3	
HQE	Eco-construction	Relation of the building with its surroundings; Choose Integrated Product; Construction Systems and Processes; Construction with low environmental impact	-	Certivea, 2005
	Management	Energy Management, Water Management, Waste Management of use and operation of the building; Maintenance (remaining environmental performance)		
	Comfort	Hydrothermal, Acoustic, Visual, Olfactory		
	Health	Sanitary quality of the environment; Air Quality; Water Quality		
LEED	Sustainable Sites	Construction Activity Pollution Prevention; Site Selection; Development Density and Community Connectivity; Brownfield Redevelopment; Alternative Transportation-Public Transportation Access; Alternative Transportation-Bicycle Storage and Changing Rooms; Alternative Transportation-Low-Emitting and Fuel-Efficient Vehicles; Alternative Transportation-Parking Capacity; Site Development-Protect or Restore Habitat ; Site Development-Maximize Open Space; Storm water Design-Quantity Control; Heat Island Effect-Roof; Heat Island Effect-No roof; Light Pollution Reduction	23,6	LEED, V3, 2009
	Water Efficiency	Water Use Reduction; Water Efficient Landscaping; Innovative Wastewater Technologies; Water Use Reduction	9,1	

	Energy & Atmosphere	Fundamental Commissioning of Building Energy Systems; Minimum Energy Performance; Fundamental Refrigerant Management; Optimize Energy Performance; On-site Renewable Energy; Enhanced Commissioning; Enhanced Refrigerant Management; Measurement and Verification; Green Power	31,9	
	Materials & Resources	Storage and Collection of Recyclables; Building Reuse-Maintain Existing Walls, Floors and Roof; Building Reuse-Maintain Interior Non-structural Elements; Construction Waste Management; Materials Reuse; Recycled Content; Regional Materials; Rapidly Renewable Materials; Certified Wood	12,7	
	Indoor Environmental Quality	Minimum Indoor Air Quality Performance; Environmental Tobacco Smoke (ETS) Control; Outdoor Air Delivery Monitoring; Increased Ventilation; Construction Indoor Air Quality Management Plan-During Construction; Construction Indoor Air Quality Management Plan-Before Occupancy; Low-Emitting Materials-Adhesives and Sealants; Low-Emitting Materials-Paints and Coatings; Low-Emitting Materials-Flooring Systems; Low-Emitting Materials-Composite Wood and Agrifiber Products; Indoor Chemical and Pollutant Source Control; Controllability of Systems-Lighting; Controllability of Systems-Thermal Comfort; Thermal Comfort-Design Thermal Comfort-Verification; Daylight and Views-Daylight; Daylight and Views-Views	13,6	
	Innovation in Design	Innovation in Design; LEED Accredited Professional	5,5	
	Regional Priority	Regional Priority	3,6	
LIDERA	Land	Territorial Enhancement; Environmental Optimization of the Implantation	7	LIDERA, 2009
	Natural Ecosystems	Valorization ecological, Habitat Interconnection	5	
	Landscapes and Patrimony	Local Landscape Integration; Protection and Valorization of Patrimony	2	
	Energy	Energetic Certification, Passive Design, Carbon Intensity (and efficiency)	17	
	Water	Consumer of potable water, Management of local waters	8	
	Materials	Durability, Local materials, Low-impact materials	5	

	Food Products	Local food production	2	
	Effluent	Treatment of residual waters; Reuse flow of waste water	3	
	Air Emissions	Flow of Air Emissions - Particles and / or substances with acidifying potential (Emission of other pollutants: SO2 and NOx)	2	
	Waste	Production of waste; Management of hazardous waste; Recycling of waste	3	
	Outside Sound	Fonts sound to the outside	3	
	Illumine-Thermal Pollution	Thermal effects (heat island) and luminous	1	
	Air Quality	Levels of Air Quality	5	
	Thermal Comfort	Thermal comfort	5	
	Illumination and Acoustic	Illumination levels, sound insulation / sound levels	5	
	Access for All	Access to public transport, Low impact mobility, Inclusive solutions	5	
	Lifecycle Costs	Low life cycle costs	2	
	Local Economic Diversity	Flexibility - Adaptability to the uses; Economic Dynamics; Local Labor	4	
	Amenities and Social Interaction	Local amenities; Interaction with the community	4	
	Participation and Control	Capacity Control; Governance and Participation; Control of natural risks - Safety; Control of human threats - Security	4	
	Environmental Management	Conditions of use the environment; Environmental Management Systems	6	
	Innovation	Innovations	2	
NABERS	Land	Biodiversity	16	Nabers for Home, 2010
	Materials	Environmental impact of materials u	7	
	Energy	Energy consumption during constru	17	
	Water	Consumption and pollution of water	7	
	Indoor En	Indoor air quality	13	
	Resource	Efficiency of resources	10	
	Transport	Access to public transport in order t	17	
	Wastes	Emissions to the environment	13	

B. *Dimensional evaluation approach*

Although there are differences between the systems, they adopted different performance levels in part because these assessments are not originally designed to serve as design guidelines [8] and each one reflects regional context and its normative requirements. Therefore, there ares adjustments required, such as provision for higher or lower requirements with regard to water, reduce or increase the importance given to wood; set the conditions for acoustic and thermal isolation and lighting for the reality of each country; adjust the ways of calculating the energy balance; specifications regarding the determination of CO_2 emissions and energy recovery.

However, these adjustments aren't made only between the various systems in different countries. An evaluation criterion was developed which focuses on the importance for regional evaluation of buildings, this means that, in the same country, different regions have different realities, in terms of social and cultural aspects, land occupation, climate or even on the level of construction practices. This fact confirms the creation of different evaluation parameters and performances to their specific needs [14, 25].

The Internal environment, Environmental Loading and External Environmental Impact as well as resources, have the highest number of parameters. It is concluded that the environmental component is more important when compared with the planning, social and political components [6].

For the internal environment, the various systems provide special attention to this area because they are focused on thermal comfort, acoustics, lighting, hydrothermal, olfactory and visual quality of the building, as well as aspects related to air quality, internal ventilation and health, which are essential to quality of life of the user inside the building [27, 28].

Regarding the areas related to the socio-economic and political dimensions, innovation, environmental management and planning aspects, not all systems provide parameters in these areas. On the other hand, there are systems that attach particular importance to these areas, such as the LIDERA in the socio-economic and political area, and the case of LEED, the environmental management area.

Planning is one of the areas that presented a lower number of parameters and should be developed by the various systems. Planning is essential to contribute to a organized and studied future, with products and technologies adapted to sustainable construction.

The area of innovation is also poorly developed and very few systems analyze it and only the BREEAM, LEED and LIDERA systems have some parameters in the evaluation area.

The conclusion is that it is possible that the areas that bring together a larger number of parameters analyzed by certification systems are the area of the internal environment, then the areas of resources, environmental loading and external environmental impact, environment integration, environmental management, planning, socio-economic and political and, finally, innovation.

IV. Evaluation Parameters

All previously analyzed systems share the same aim: stimulate market demand for sustainable buildings with better performance and value. The developed analysis allowed the determination of the most important parameters for each regional context. Has already been mentioned the different systems developed for a local use and to most of the regions do not have capacity to allow is spread of application. This fact is linked with the variations of climatic conditions, materials and cultural and economic valuations [2, 18].

Taking into account the Portuguese context, design procedures, bioclimatic architecture, materials and techniques, building stocks and importance of water and energy resources, it's possible to identify and selected what are the most important evaluation parameters (Table 2).

The parameters are defined according to: the state of development of the country, socio-economic aspects, social and cultural climate, environmental concerns, construction practices, project type and state of the housing stock as previous mentioned. To increase the efficiency of the decision process the certification also involves knowledge of the financial and politic opportunities to develop urban areas.

Parameters are structured according five factors: Comfort; Local Environment; Management; Project and Planning Design; Natural Resources.

TABLE 2 - EVALUATION PARAMETERS TO PORTUGUESE CONTEXT

Factor	Areas of Evaluation	Parameters of Evaluation	Weighting (%)
COMFORT	Internal Environment	Acoustic Comfort	15
		Hydrothermal and Thermal Comfort	
		Lighting Comfort	
		Visual Comfort	
		Indoor Air Quality	
		Internal Ventilation	
		Healthy Environment	
LOCAL ENVIRONMENT	Socio-Economic and Political Model	Amenities and Social Interaction	7
		Access for All	
		Lifecycle Costs	
		Local Economic Diversity	
		Participation and Control	
	Environmental Loading and External Environmental Impact	Effluent	5
		Atmospheric Emissions	
		Impact on the Surroundings and External Spaces	
		Impact on Local Ecology	
		Illumine-Thermal Pollution	
	Environment Integration	External Environment	3
		Land Use	
		Public Transport and Smooth Mobility	
MANAGEMENT	Environmental Management	Recycled Content	18
		Waste Control of Use of Building	
		Control of Construction Waste	
		Climate Control Systems	
		Reuse of Materials	
PROJECT AND PLANNING	Innovation	Innovation and Design Process	3
	Planning	Adaptability, Durability and Flexibility	7

		Planning the Operation of the Building and Construction	
RESOURCES	Water	Water Conservation and Efficiency	18
		Water Recycling	
		Efficiency of Building Systems	
	Energy	Energy Conservation	14
		Renewable Energy	
	Materials	Materials – Durability e Reuse	10
		Materials of Low Impact	
		Priority for Local Delivery	

The weights of the different parameters reflect the assessment of the sustainability of the building, because the balance between each parameter and its relation with all the others is related to the amount of concerns with the various principles of sustainability [26]. The table above shows the weightings assigned to each area of sustainability. This selection can support the develop of a system with value, given the adaptability to the Portuguese context and the type of concerns that the construction sector considers as most important [29].
The decision to assign more weight (18%) to water is a result of the importance that this element has in terms of sustainability in the overall context of population growth and the consequent need for new buildings. In the same way, the environmental management is weighted equally due to need to efficiently handle the resources in the construction sector.

V. CONCLUSIONS

Sustainable construction can improved the performance of building sector especially in the use of environmental resources. The impact of construction sector in the environment is one of the largest if we consider all the effects it has during the complete life cycle of buildings. On the other hand Sustainable Development requires major action in the preservation of natural resources and protection of future generations. In this sense there is no doubt that it is necessary to make changes in the design process and construction of buildings and take into account the goal of stakeholders that desire generating economic value from their investments. The certification systems of sustainable construction can be seen as a method applicable to different contexts and regions and to assure investment in ecological procedures.
Systems evaluation and certification of sustainable construction intend to assess the conformity of the techniques and processes of construction.
Regarding evaluation and certification systems for sustainable construction, many countries have developed their own certification systems applied to their local context. The study of each system shows the parameters, weights and enables useful comparisons of the different knowledge processes and techniques used in the certification of buildings. This in turn enables the identification of the strategies and most determinant factors of each system. In general the analyzed systems shows more importance to the environmental factor when compared with planning, social, economic and political components. These tend to focus on aspects related with the comfort and welfare of users, with protection of the environment, the impacts of construction on its surroundings and with the natural resources.
The study of different systems of evaluation and certification enables the identification of the most relevant group of parameters to the Portuguese reality and their weights in order to promote the use of technology and methods of construction with lower environmental impact, thus ensuring the sustainability of the whole process.
The future development of a system addresses the reality of the Portuguese region and can help towards the creation of better decision-making processes in the building sector.

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