Green Building Rating Systems: A Comparative Study of Global and Indian Standards

K. S. Anandh, M. G. Soundarya Priya, S. Senthamizh Sankar, and K. Prasanna

1 Introduction

The construction world is framed after decades of development, from basic brick walls to our advanced 3D printing. The construction industry is the leading industry in the world, giving new creations. Construction is the act of creating structures [1]. Also, the effects produced by this construction industry are good but still have an enormous impact on environmental degradation [2–6]. Here comes the aspect of pollution control caused by the construction industry. This leads to the responsibility of maintaining a deep-rooted balance of environmental, economic, and social health. It provides a set of rights for constructing environmentally friendly structures so that the adverse effects of buildings on the environment and occupants are mitigated. The vital aspect is adaptability to the upcoming advancements to establish required thermal, visual, and acoustic comfort with efficient energy usage. The act of living under a roof gave rise to the process of constructing structures. This leads to the well-known construction industry. Buildings have humongous and endlessly increasing effects on environmental issues about 0.4% of natural resources have been derived from industrial countries [1], utilizing about 0.7% of electric power and 0.12% of drinking water [7] and produce about 0.45–0.65% of the waste to

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landfills [6]. Further, they are reasonable for an enormous emission of harm. Considering about 0.3% of greenhouse gases are because of their operation, an additional 0.18% has been produced indirectly due to material waste and transportation [6–8]. Simultaneously, health problems are caused due to bad indoor environment quality, drastically reducing productivity [9]. GREEN BUILDING refers to both construction and operation of the building throughout its lifecycle, which positively impacts our climatic conditions and natural environment. GREEN BUILDING saves energy and resources and reduces toxic substances to provide occupants with a sustainable building and healthier space. The outlook of this paper is to expose a cluster of information available from technical manuals and official websites. This paper enriches the analysis of numerous building rating systems by collecting data from multiple sources, exposing the evolution of the considered rating systems over time, and providing a geographical representation of a global evaluation. In addition, the scoring credits for rating systems that are being analyzed are posted.

2 Methodology

The two most possible way for literature reviews is deductive and inductive paths [10]. The deductive path is employed here; whereas the literature identifies critical criteria, widely existing green building rating systems are used for analyzing those critical criteria. Here, a detailed review based on literature is accomplished to express the critical criteria. The resource data is obtained from the thesis, conference proceedings, journal papers, and manual books. After that, globally available rating systems were examined and denoted in further levels. The final phase of the paper involves a detailed discussion regarding the credit allocation of the considered rating systems. Globally significant GBRS (Green Building Rating System) to evaluate green buildings are recognized. Among those four rating systems are chosen, and a comparison is established. Existing comparison data are produced from various published papers, conference papers, and thesis. Compiling all these data, an overall comparison is shown. Chronological developments and their comparison to the convention are also obtained simultaneously. The research methodology of this paper is shown in Fig. 1. The major focus is given to Indian Green Building Council (IGBC), Building Research Establishment Environmental Assessment Method (BREEAM), Green Rating for Integrated Habitat Assessment (GRIHA), and Leadership in Energy and Environmental Design (LEED). Seven important themes are considered. Maximum and Mandatory Points of each theme have been calculated. Maximum Points of each theme have been analyzed and calculated as their Weightage in Percentage. Mandatory Points have also been calculated as per their Weightage in Percentage.

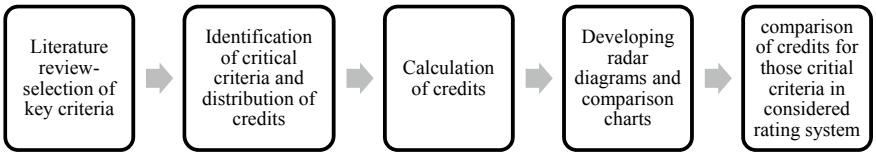

Fig. 1 Research methodology

3 Green Building

The Office of Federal Environmental Executive (OFEE) and the Environmental Protection Agency (EPA) defines GB as [11]—"the practise of increasing the efficiency with which buildings and their sites use energy, water, and materials and reducing building impacts on human health and the environment through better siting, design, construction, maintenance, and removal—the complete building life cycle" GB is a globally emergent new trend. The green building movement began when the built environment was transformed into one that is healthier, more sustainable, and more considerate of building occupants [12–14].

4 Rating Systems

A rating system provides a metric for designers, builders, and owners to evaluate their initiatives' relative environmental and sustainability performance. Focusing on a sustainability stage using an existing rating system can aid in ensuring that initial objectives are met through the completion of construction. The most excellent intentions may be jeopardized as a project's budget, schedule, and other pressures increase [13, 15]. Worldwide there are many GBRS (Green Building Rating Systems), such as:

BREEAM—Building Research Establishment Environmental Assessment Method, LBC—Living Building Challenge, BEAM PLUS—Building Environmental Assessment Method, HQE—High-Quality Environmental standard, TREE—Thailand Rating of Energy and Environmental Sustainability, GREENSHIP, IGBC—Indian Green Building Council, BCA—Building and Construction Authority, GRIHA—Green Rating for Integrated Habitat Assessment, BEE—Bureau of Energy Efficiency, LEED—Leadership in Energy and Environmental Design, GREEN MARK, CASBEE—Comprehensive Assessment System for Built Environment Efficiency, GPR—Green Point Rated, GS—Green Seal Standard, EDGE—Excellence in Design for Greater Efficiencies, LOTUS, DGNR—Deutsche Gesellschaft fur Nachhaltiges Bauen [16].

This paper uses four well-established GBRS (Green Building Rating Systems) from various countries. These rating systems were selected to compare globally used tools and those used in India. So, LEED, BREEAM, GRIHA, and IGBC are

Fig. 2 Globally existing GBRS [18]

chosen for this paper. Globally existing Green Building Rating Systems (GBRS) are shown in Fig. 2. The selected four rating systems are BREEAM (UK), LEED (USA), GRIHA, and IGBC (India). Many rating systems worldwide show the development of green buildings in sustaining the consumption of current energy for future use. This Rating System compiles thirty-four criteria classified into four sections. Some are as follows: Site selection, building planning and construction, building operation and maintenance, and innovation [17] (Fig. 3).

5 Main Features of the Above Rating System

The important features of the above-discussed four rating systems are listed in the following tabulation. The main features of the four rating systems, such as BREEAM, LEED, GRIHA, and IGBC, are listed in Table 1 [19]. The credit allocations of BREEAM, LEED, GRIHA, and IGBC with respect to categories are shown in Table 2.

6 Selection of Criteria

LEED, BREEAM, IGBC, and GRIHA are considered to compare. Comparison is made based on criteria, "attaining objectives by considering the analysis using the required parameters," as defined by Munier [19]. The basic conditions used to analyze each rating system are designated below [21, 24]—Site selection, Energy, Water,

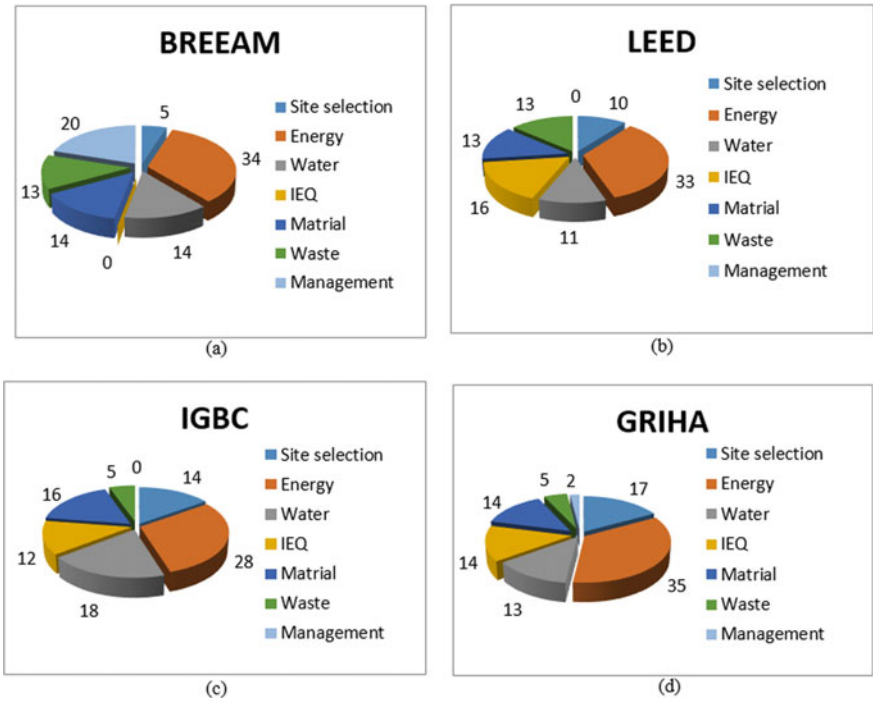

Fig. 3 **a–d** are the criteria allocated for BREEAM, LEED, IGBC, and GRIHA

Indoor Environment Quality (IEQ), Material, Waste and pollution, and Management. The assessment scope of rating systems with respect to criteria is shown in Table 2.

Primary goals in site selection for green buildings include protecting sensitive sites, restoring and reusing previously developed sites, and minimizing transportation impacts on environmental and energy use. Reducing a building's energy demand by designing it from the outset to consume less energy and be more efficient through equipment selection and high-quality construction. The selection of materials for green structures appears laborious. Green building materials favor renewable over non-renewable resources and are environmentally responsible because their impacts are evaluated over the lifecycle of the product. In addition, green buildings are constructed with reusable, eco-friendly materials that do not compromise the building's durability or occupants' health [18]. Minimizing the potential for water consumption by reducing the quantity of water used in the home through enhanced efficiency. Buildings can be designed to include more water catchment systems, such as cisterns, containers, and swales. The collected water can be routed and utilized for a variety of purposes, including evaporation in toilets, refrigerators, etc. Improving residents' health by moderating the levels of indoor humidity, toxins, and pollutants. Greenhouse gases are not the only harmful pollutant that buildings emit. The levels of

Table 1 List of main features of four rating systems [18, 20, 21]

		BREEAM	LEED	GRIHA	IGBC
Full form		Building research establishment environment method	Leadership in energy and environment design	Green rating for integrated rating assessment	Indian green building council
Country		UK	USA	India	India
Organization		BRE	USGBC	TERI (The Energy and Research Institute)	CII (Confederation of Indian Industry)
Flexibility		77 countries	160 countries	India	India
First version		1990	1998	2000	2001
Last version		2016	2013	2015	2014
Rating criteria		Management Health and wellbeing Energy Transport Water Material Waste Land use and ecology Pollution Innovation	Integrative process Indoor Environment Quality Energy and Atmosphere Location and Transportation Water efficiency Material and Resources Sustainable Sites Regional Priority Innovation	Site parameters Maintenance and housekeeping Energy Water Human health and comfort Social aspects Innovation	Site selection and planning Water efficiency Energy efficiency Materials and resources Indoor environment quality Innovation in design
Rating level		Pass $\geq$ 30 Good $\geq$ 45 Very good $\geq$ 55 Excellent $\geq$ 70 Outstanding $\geq$ 85	Certified $\geq$ 40 Silver $\geq$ 50 Gold $\geq$ 60 Platinum $\geq$ 80	1star $\geq$ 25 2star > 40 3star > 55 4star > 70 5star > 85	Certified $\geq$ 50 Silver $\geq$ 60 Gold $\geq$ 70 Platinum $\geq$ 80 Super platinum $\geq$ 90
Rating scheme	Sections	10	8	7	7
	Criteria	57	57	36	42
	Total score	100	110	100	100

air pollution indoors are significantly higher than those outdoors. "Facilities management"—a discipline that plays a vital role in engineering, construction engineering, architectural, and management knowledge, particularly for maintaining or running commercial, institutional, and industrial buildings. The vital role of the facilities

Table 2 Assessment scope [22, 23]

Rating systems	Site	Water	Energy	IEQ	Materials	Waste	Management
LEED	✓	✓	✓	✓	✓	×	×
BREEAM	✓	✓	✓	×	✓	✓	✓
IGBC	✓	✓	✓	✓	✓	✓	×
GRIHA	✓	✓	✓	✓	✓	✓	✓

manager is to care existing building inventory as well as future planning and risk-based maintenance [23]. Growing waste generation and disposal rates will increase pressures on the environment. The main aim of sustainable waste management is to address long-term pressures through: recovery and recycling, resources reuse, waste streams to be reduced, and managing the resources in a sound environment and in an economically effective manner [23].

7 Discussion: Comparison of Criteria and Scoring

The comparison of criteria and scoring of BREEAM, LEED, IGBC, and GRIHA is shown in Fig. 4. Considering the comparison among rating system from the first priority. Table, it shows energy condition is having. Rating systems IGBC, GRIHA, LEED, and BREEAM have given importance for energy condition above 30% than other conditions. But LEED has highest priority to energy of about 39.75 of the total percent. The important point for causing enormous of the GB rating systems is because the future is going to suffer a greater energy demand crisis [25]. After comparison among LEED, BREEAM, GRIHA, and IGBC, among these, LEED is having a rigorous and comparatively lesser flexible than remaining GB rating tools. Based on the observation, it is known that "energy" criteria are approximately equivalent in considered rating tools.

The next most pressing matter here is "Water" condition. Among all, IGBC acquires about 20.22% of final score for water criteria. Water criteria are least in GRIHA showing 13% of total score. Main aspect in this criterion is to maintain a controlled usage of water which is attained by focusing on the implementation of water saving indicators and also innovative water technology; these can be viewed in LEED [25]. Here comes the next concern toward "IEQ" condition and in LEED, this condition is well maintained by securing of about 19.77% of ultimate score. Further [26], eliminates the relation of the LEED rating attained between the comfortable performance state attained in occupant state with the construction state. Consequently, this emerges as the cause to know more about conditions following IEQ criteria. Major Green rating systems consider "energy" and "IEQ." Identically a comparative study was established among rating tools for refurbishment projects where a conclusion was attained stating that most strongly considered regions are "energy" and "IEQ" [27]. Materials are the basis for construction for anything in

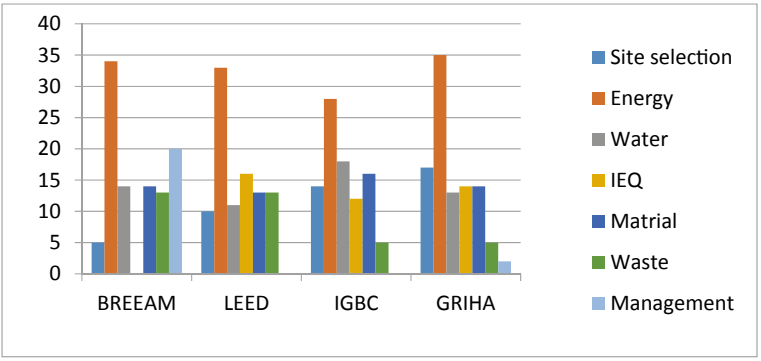

Fig. 4 Comparison of criteria

general. So efficient utilization of materials and also after its usage life, reuse of destroyed materials is the main aspect focused in green buildings concept. Regarding materials, transferring them from the market to site is the bigger deal. All these aspects are pointed for credit allocation in "Material" condition for IGBC [25]. Likewise, remaining rating tools also focus on materials used. "Site selection" condition is considered in all rating system but comparatively it's been seeking greater significance of 17.97% of net score than the rest of rating tools. The product after its utility period is considered as waste. This leads to the condition of "waste." BREEAM and LEED gives a higher importance for waste management among the four rating system compared. Where GRIHA and IGBC give the least importance for waste. "Maintenance and management" is the least considered component in the above compared rating system criteria. Only BREEAM and GRIHA have considered maintenance in the criteria of rating system. LEED and IGBC have not even considered maintenance as criteria. In BREEAM, maintenance is considered as the second most important component, but as in other rating systems it's considered the least and mostly not taken under consideration.

8 Conclusion

Origin of green buildings concept leads to requirement of evaluation tool. Here comes the GBRS, according to various aspects, many GBRS are available. From that, a small scaled comparison is been established. Based on topography, globally LEED and BREAM are chosen and locally available IGBC and GRIHA are considered. Overall their evaluation is being studied based on the available manuals and journals, from which a solid criterion is fixed and comparison is produced. This shows energy is the aspect considered in all evaluation to a greater extent. Criteria which must be improved are waste management in local GBRS and in global scenario, site selection requires some importance. Overview of evaluation process in various rating system

is being evaluated. Theoretical comparison is done for considered green building rating system. Considered theoretical comparison is done based on the process and criteria for evaluation. This theoretical study is for better understanding and evaluation process. This evaluation consists of collecting data from various sources, establishing criteria and distribution of score for criteria using which comparison is being established. Based on this comparison, overall working process is explained. This shows the importance of evaluation sequence and required developments can be recommended.

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