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"Comparative Analysis of Green Building Rating Systems in Developed and Developing Nations"

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Abstract:
The construction sector is one of the primary consumers of environmental resources and a significant contributor to pollution in both manmade and natural environments worldwide. In recent years, the concept of green buildings has gained substantial traction, leading to the establishment of various rating systems aimed at evaluating the sustainability of these structures. These rating systems serve to certify diverse aspects of sustainable development during the planning and construction phases, while also integrating best practices to achieve higher certification levels. This study is part of a larger research initiative with three main objectives: (1) to conduct a comparative analysis of different green building rating systems utilized in developed and developing nations, (2) to identify the roles and limitations of existing environmental building assessment methods in determining building sustainability in developing countries, and (3) to compute a sustainability and composite index using the Analytic Hierarchy Process (AHP), based on the framework proposed by Ding (2007). This paper specifically addresses the first objective, providing insights into the differences and similarities between rating systems across various regions. In the context of India, the research highlights that existing rating systems often overlook economic and climatic factors, which can impact their effectiveness. The findings of this study are intended to benefit all stakeholders engaged in the evaluation and promotion of green building practices.

Keywords: Green building, rating systems, sustainable development

1. INTRODUCTION

The construction industry is a major consumer of environmental resources and is responsible for a significant share of pollution in both manmade and natural ecosystems. In light of growing environmental concerns, the concept of green buildings has emerged as a pivotal solution to promote sustainable development and reduce ecological footprints. Green buildings are designed to be energy-efficient, resource-efficient, and environmentally friendly throughout their lifecycle, from planning and construction to operation and deconstruction. To effectively assess the sustainability of green buildings, various rating systems have been developed worldwide. These systems provide a framework for evaluating different sustainability metrics and certifying buildings that adhere to best practices in environmental design.

This paper aims to conduct a comparative analysis of green building rating systems used in both developed and developing nations, highlighting the strengths and weaknesses of each approach. It will also explore the roles and limitations of current environmental assessment methods, particularly in the context of developing countries where economic and climatic conditions may not be adequately addressed. The study utilizes the Analytic Hierarchy Process (AHP) to compute a sustainability and composite index, as proposed by Ding (2007), thereby providing a systematic evaluation of the effectiveness of various rating systems. The insights gained from this research are intended to inform stakeholders, including policymakers, architects, builders, and environmental advocates, in their efforts to promote green building practices that are both effective and inclusive.

India ranks as the seventh largest country globally, boasting a significant economy and a population exceeding one billion, all residing in diverse climatic zones. The construction sector plays a crucial role in the nation's economy, contributing 8.1 percent to the GDP. Within this sector, both commercial and residential markets consume substantial energy throughout the lifecycle of buildings, making them major contributors to greenhouse gas emissions. In response to the pressing need for sustainable development, the Government of India has mandated several corporate organizations and institutions to implement green practices in their new construction projects.

A green building is defined as one that demonstrates high efficiency in the use and consumption of natural resources, including water, energy, and materials, throughout its lifecycle—encompassing design, construction, operation, maintenance, renovation, and demolition. Implementing green building practices can significantly mitigate negative environmental impacts. These practices not only reduce operating costs but also enhance the marketability of buildings, improve worker productivity, and promote health benefits. Environmentally, green buildings contribute to the conservation of natural resources, waste reduction, improved air and water quality, and ecosystem protection.

Green building rating systems are established to evaluate and assess buildings from the stages of planning, design, construction, and operation. These rating system guidelines and standards can be divided into two main categories: those that focus on specific building components or areas and those that evaluate the building as a whole entity. Due to the

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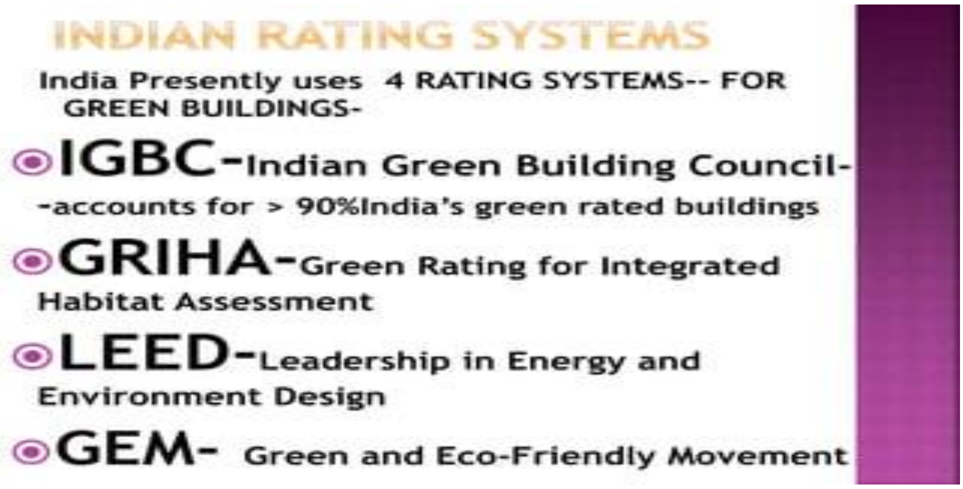
differing focuses of various rating systems, a single building may receive green certification from one system while failing to meet the criteria of another. Sathyanarayanan (2009) notes that there is minimal difference in health and safety for construction workers between green and non-green projects, suggesting that labeling such buildings as sustainable in terms of worker health and safety may not be accurate.

Given India's diverse geographic features and climatic conditions that vary significantly from north to south and east to west, it is essential to consider these factors within a green building rating system. This study compares different green building rating systems, categorizing them broadly into those from developed countries such as the USA and UK, and developing countries like India and China. The following section provides an overview of these rating systems, which are then compared based on key criteria, including life cycle assessment, renewable resources, forest certification, the use of locally sourced materials, construction worker health and safety, project management practices, and climatic considerations. The results of this comparison are then discussed, followed by conclusions.



2. AN OVERVIEW OF GREEN BUILDING RATING SYSTEMS

2.1 BREEAM - 2011 NC Rating System

The BREEAM (Building Research Establishment's Environmental Assessment Method) was introduced in 1990 and is recognized as the first method for assessing green building performance. Developed in the UK, the BREEAM-2011 NC evaluates building performance across various categories. These categories include management (12%), energy use (19%), health and well-being (15%), pollution (12%), transport (8%), land use and ecology (10%), materials (13%), waste (7.5%), water (6%), and innovation. The percentage values represent the weight assigned to each parameter within the rating system.

The BREEAM rating system is applicable to a diverse range of building types, including courts, eco homes, educational institutions, industrial facilities, healthcare buildings, multi-residential units, offices, and new constructions. The life cycle stages addressed by the BREEAM-2011 NC encompass both the design stage and the post-construction phase. Each building receives a certificate based on its assessment results, categorized into ratings of outstanding, excellent, very good, good, pass, or unclassified, corresponding to percentage scores of 85, 70, 55, 45, 30, and below 30, respectively.

BREEAM has significantly influenced green building practices worldwide, with countries such as Canada, Australia, Hong Kong, and the Netherlands adopting its methodology to develop their own environmental assessment methods. The assessment tools are designed to aid construction professionals in understanding and mitigating the environmental impacts of their designs. Since BREEAM primarily focuses on design-stage assessment, it is crucial for stakeholders to incorporate detailed sustainability measures early in the design process. This proactive approach not only facilitates the attainment of a higher rating but also promotes cost-effective solutions. Additionally, BREEAM's methodologies are beneficial during the master planning stage of large developments, such as new communities and settlements, ensuring that sustainability principles are integrated from the outset.

2.2 LEED-2011 for India NC Rating System

The LEED (Leadership in Energy and Environmental Design) rating system was established by the U.S. Green Building Council (USGBC) in 2000. The Indian adaptation of this system, known as LEED India, was developed by the Indian Green Building Council (IGBC) in October 2006. The LEED-2011 for India NC rating system consists of several categories, including sustainable sites (23.63%), water efficiency (9.1%), energy and atmosphere (31.82%), materials and resources (12.73%), indoor environmental quality (13.63%), innovation in design (5.45%), and regional priority (3.64%). This system is applicable to new constructions, existing buildings, commercial interiors, core and shell,

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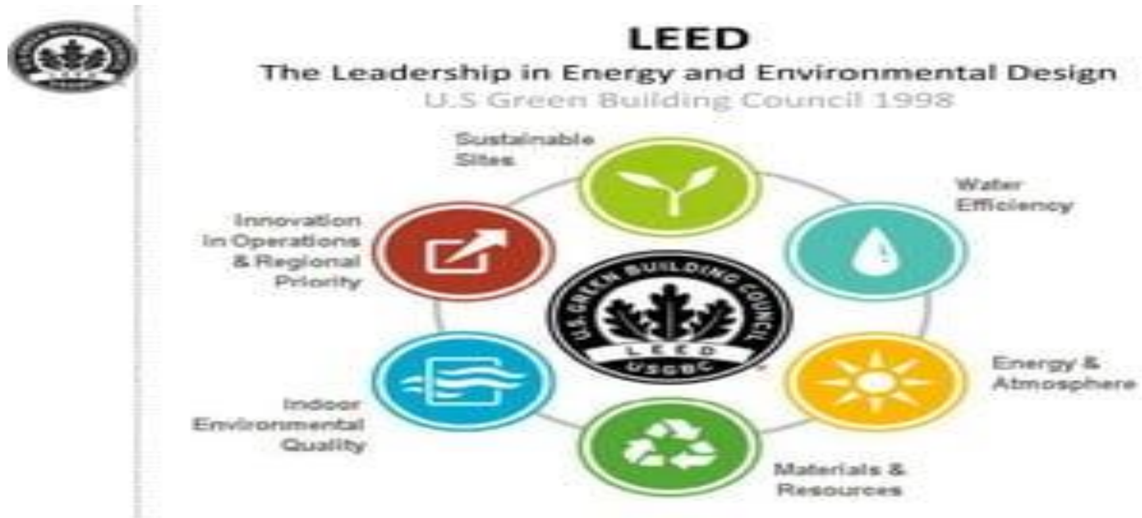
residential projects, neighborhood developments, schools, and retail spaces. Building performance is assessed using a straightforward checklist format, and projects can achieve ratings of certified, silver, gold, or platinum.
One significant component of the LEED rating system is the indoor air quality (IAQ) management during construction, which explicitly addresses the health and safety of construction workers. This aspect aims to protect workers and occupants from potential air quality issues during the construction or renovation phases. Successful implementation of an IAQ management plan earns the project one LEED-NC credit, though this credit is minimal, indicating a limited emphasis on construction worker safety within the rating system. However, other components aimed at enhancing the safety and health of end-users, such as the use of low-emitting materials, may indirectly benefit construction workers as well.
Despite the positive intentions behind the LEED rating system, some critics argue that the system could do more to prioritize the well-being of construction workers. The focus tends to be primarily on the health and comfort of building occupants rather than the workforce that constructs these structures. Enhancing the emphasis on construction worker safety and health could strengthen the system's overall sustainability claims and ensure a more holistic approach to green building practices.



2.3 DGNB Rating System
The DGNB (German Sustainable Building Certificate) rating system was established in June 2007 by the German Federal Ministry of Transport, Construction, and Urban Development, with certification introduced to the real estate market in January 2009. The DGNB rating system evaluates buildings based on several key factors, including process quality (22.5%), technical quality (22.5%), ecological quality (22.5%), economic quality (22.5%), and social quality (10%). This rating system is designed for a wide variety of building types, including offices, high-rise buildings, detached residential homes, and infrastructure projects.
The DGNB certification process aims to foster the creation of living environments that are environmentally compatible, resource-efficient, and economically viable, while also safeguarding the health, comfort, and performance of building users. The emphasis on a holistic approach ensures that various quality aspects are integrated into the building design and construction processes. Certification levels within the DGNB framework are classified as bronze, silver, and gold, allowing for a nuanced evaluation of sustainability achievements. By promoting an integrated approach to sustainable building practices, the DGNB system contributes to a broader understanding of what constitutes a truly sustainable built environment.
Moreover, the DGNB system encourages innovation by recognizing and rewarding projects that go beyond conventional practices. By integrating social quality into its criteria, the DGNB acknowledges the importance of user experience and well-being, which can enhance the long-term value and functionality of buildings. This comprehensive evaluation framework positions the DGNB as a leader in sustainable building certification, influencing both local and international practices.

2.4 Green Star Rating System
The Green Star rating system has been developed based on existing frameworks and tools from international markets, notably the British BREEAM (Building Research Establishment Environmental Assessment Method) and the North American LEED (Leadership in Energy and Environmental Design) systems. It establishes specific environmental measurement criteria tailored to the Australian context, facilitating the evaluation of sustainable building practices in Australia.

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Green Star certification signifies a project's commitment to sustainability by adhering to established standards in design, construction, or ownership. The rating standard is organized into categories such as management, indoor environmental quality, energy, transport, water, materials, land consumption and use, emissions, and innovation. The certification levels range from 0 to 6 stars, reflecting varying degrees of sustainability achievement.

A review of the Green Star system, along with other major sustainable rating systems, reveals a notable gap in the consideration of construction worker safety and health. This gap highlights the prevailing perspective within the building industry, which often prioritizes resource efficiency and occupant health over the well-being of workers involved in the construction process. Addressing this imbalance in future iterations of the rating systems could lead to a more comprehensive understanding of sustainability that includes the welfare of all stakeholders involved.

2.5 GRIHA Rating System

GRIHA (Green Rating for Integrated Habitat Assessment) represents India's national green building rating system, developed by TERI (The Energy and Resources Institute) in 2007. The GRIHA rating system encompasses several categories, including sustainable site planning (21.2%), health and well-being (9.6%), building planning and construction (7.7%), energy end use (36.5%), renewable energy (7.7%), water recycling, recharge and reuse (6.7%), waste management (4.8%), building operation and maintenance (1.9%), and innovation points (3.9%). GRIHA rates buildings on a scale from one star (50-60 points) to five stars (above 90 points), assessing predicted performance throughout the entire lifecycle of the building—from inception to operation.

The evaluation process includes three key life cycle stages: pre-construction, building design and construction, and building operation and maintenance. Each stage addresses critical issues such as intra- and inter-site concerns, resource conservation, demand reduction, resource utilization efficiency, and occupant health and well-being. The primary resources considered in this assessment include land, water, energy, air quality, and green cover.

The GRIHA rating system emphasizes a comprehensive approach to sustainability by considering the entire lifecycle of a building. This holistic perspective encourages stakeholders to focus on the long-term impacts of their decisions and promotes practices that support environmental, social, and economic sustainability. Furthermore, GRIHA serves as a valuable tool for policymakers and practitioners seeking to advance green building practices in India and address the challenges of sustainable urban development.

2.6 GBAS - China

China's green building assessment method, introduced in 2006, operates as a credit-based system applicable to existing residential buildings and various public building types, including offices, shopping malls, and hotels. This evaluation framework comprises six key indicators: land-saving and outdoor environment (8 items), energy-saving and energy utilization (6 items), water-saving and water resource utilization (6 items), materials-saving and materials resource utilization (7 items), indoor environment quality (6 items), and operation management (7 items). The system certifies buildings with ratings ranging from 1 to 3 stars, providing a structured approach to assessing sustainability in the Chinese context.

The GBAS system emphasizes the importance of energy efficiency, resource conservation, and improved indoor environmental quality in promoting sustainable building practices. By establishing a clear set of criteria, GBAS encourages project developers and builders to prioritize environmental considerations in their designs and operations. This alignment with sustainability goals not only contributes to ecological preservation but also enhances the quality of life for building occupants.

As the Chinese green building market continues to evolve, the GBAS system plays a crucial role in shaping construction practices and fostering a culture of sustainability. By incorporating localized environmental challenges and promoting resource-efficient designs, the GBAS framework sets a precedent for future developments in green building assessment methods across China and beyond.

3. COMPARISON OF DIFFERENT GREEN BUILDING RATING SYSTEMS

Table 1 presents a comparative analysis of various green building rating systems. The symbol "✓" indicates the inclusion or consideration of the specified issue within each rating system, while "X" denotes its absence. For instance, life cycle assessment (LCA) is recognized in BREEAM, LEED, DGNB, and GRIHA, whereas Green Star and GBAS do not include this aspect. The results of this comparative analysis will be discussed in detail in the following section.

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Table 1: Comparison of Green Building Rating Systems

Issue	**BREEAM**	**Weight**	**LEED**	**Weight**	**DGNB**	**Weight**	**Green Star**	**Weight**	**GRIHA**	**Weight**	**GBAS**	**Weight**
Life Cycle Assessment (LCA)	✓		✓		✓		X		✓		X	
Life Cycle Cost	✓	7%	X		✓	11%	X		✓	1%	X	
Renewability	✓	4%	✓	8%	✓	8%	✓	1%	✓	14%	✓	10%
Certification of Materials Used	✓	0.5%	✓	1%	✓	0.5%	✓	6%	X		X	
Locally Produced Materials	✓	3%	✓	2%	✓	2%	X		✓	1%	✓	5%
Health and Safety of Construction Workers	X		X		X		X		✓	2%	X	
Project Management	✓	12%	✓	2%	✓	4%	✓	18%	✓	4%	✓	17.5%

Notes: 6. Project management is vital for achieving economic efficiency and minimizing construction waste on-site. 7. In LEED, the regional priority category allocates 1 to 4 points for credits addressing specific environmental priorities unique to different regions.

4. DISCUSSION

BREEAM evaluates various life cycle stages, including the design stage (DS), which leads to an interim BREEAM certified rating, and the post-construction stage (PCS), resulting in a final certification. The BREEAM system employs two assessment approaches at the post-construction stage: one involves a review of the interim design-stage assessment, while the other focuses on a comprehensive assessment post-construction.

All rating systems consider renewability, which is essential for sustainability. In the LEED-NC framework, points are awarded when 5% of the total value of building materials originates from rapidly renewable sources, defined as having a rotation period of 10 years or less. BREEAM allocates four credits for effective construction waste management and one credit for the use of recycled aggregates. Similarly, Green Star awards points for initiatives involving recycling and waste management, while GRIHA emphasizes renewable energy utilization, with points allocated for hot water systems and water recycling initiatives.

In terms of material sourcing, BREEAM mandates the endorsement of forest certification at Tier level 3. LEED offers one point for projects utilizing 50% or more FSC-certified wood-based materials. However, Green Star assigns two points for using FSC-certified timber, while GRIHA incentivizes the use of fly ash, recognizing its value in construction.

Health and safety considerations for construction workers are crucial; however, BREEAM, LEED, and Green Star currently neglect this aspect. GRIHA addresses this gap by allocating points for minimum sanitation and safety facilities for construction workers, highlighting the necessity of prioritizing worker safety alongside occupant health.

Project management is another significant factor in achieving economic efficiency and reducing waste during construction. BREEAM allocates 12% weight to project management, whereas Green Star emphasizes this aspect even more, assigning 18 points. GRIHA also recognizes project management's importance, assigning it a weight of 6%.

5. CONCLUSION

Green building transcends mere integration of environmentally friendly design, materials, and techniques; it embodies a comprehensive approach to achieving sustainable development throughout the project life cycle, encompassing planning, design, construction, operation, and eventual demolition. This paper has compared various green building rating systems utilized in both developing nations, such as India and China, and developed nations, like the USA, UK, and Germany. Notably, while BREEAM emphasizes life cycle assessment and allocates significant points for it, the Green Star and GBAS systems do not incorporate this critical aspect. For developing countries, where economic considerations are paramount, it is vital to account for the life cycle costs associated with green buildings, a factor often overlooked in GRIHA, GBAS, and LEED frameworks.

While all rating systems recognize the importance of renewability, there is a notable absence of provisions regarding sustainable sourcing of timber, a key material in construction. It is essential to grant credits for wood that is sourced sustainably and certified through credible programs, a consideration that is currently lacking in GRIHA and GBAS. The authors advocate for the inclusion of construction worker safety and health as a parallel priority to occupant health in green building initiatives. Moreover, project management practices must be further enhanced across all rating systems to optimize resource efficiency and minimize waste during construction. Lastly, considering India's diverse topography and climate variations, it is imperative that green building rating systems adapt to these factors to ensure their effectiveness and applicability.

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