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A Review of Green Building Certification Systems through the Lens of Sustainable Architecture

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Abstract: Today, the building sector, with its investments, consumes 30–40% of the world's primary resources and is continuing to grow. Energy saving through energy efficiency in buildings has become essential globally. The construction industry has thus become a crucial element not only economically but also in terms of its significant environmental impacts. Therefore, recognizing various aspects of sustainability in green buildings is worth considering. The present study has been conducted using a descriptive and analytical method, relying on quantitative data and library research. First, the principles of sustainable buildings were thoroughly examined, followed by a review of various rating systems such as BREEAM, CASBEE, GBTool, U.S. Green Globes™, and LEED®.

It was found that the LEED rating system, compared to other systems, enjoys broader global acceptance. However, the research shows that each rating system reflects the policies and approaches of different countries regarding sustainability. Thus, the green building topic is a global issue that requires regional solutions. In fact, warming, climate change, and all environmental concerns confronting the world cannot be addressed with a single system. Instead, solutions must consider local conditions—not only primary climate characteristics but also regional policies. This paper aims to review and compare major green building certification systems from the perspective of sustainable architectural principles.

Keywords: Sustainable buildings, Green building rating systems, Environmental impact

Introduction

Buildings have a significant economic impact on society. They also account for a major portion of material and energy consumption and the production of greenhouse gases, both nationally and globally. Given these factors, the construction industry has received increasing attention from the standpoint of sustainable architecture. Sustainable buildings, which emphasize high energy efficiency, are a key component in the development of a sustainable and environmentally responsible future. Sustainability is a broad and complex concept that has become one of the most critical industrial issues. The ultimate goal of sustainability is to enhance quality of life. Consequently, those involved in the construction industry have paid more attention to controlling and mitigating environmental damage. Architects, designers, engineers, and other stakeholders in the building industry are increasingly seeking to reduce environmental impacts by implementing sustainability goals during various phases of a building project. Green certification systems aim to reduce environmental impact, including lowering

greenhouse gas emissions, minimizing water consumption, and promoting responsible material use . The green building movement, which focuses on energy efficiency and environmentally conscious design, has led to the development of green building certification systems such as LEED, established by the U.S. Green Building Council (USGBC) in 2008.

Previous studies show that no independent work has been conducted so far under this specific title in the field of architecture or visual arts. This study attempts to provide a resource by reviewing green building rating systems and identifying the general aspects and principles of sustainability in the construction industry. Green building is gaining momentum globally, as evidenced by rising LEED-certified square footage, increasing government incentives, and stronger public awareness of climate-resilient design. It aims to assist in the development of sustainable architecture and ensure that all steps of sustainable construction are based on reliable sources. While some research has been conducted in the area of rating systems, this study focuses on the principles of sustainable buildings and the dimensions of sustainability, as well as sustainability strategies and holistic approaches. A holistic approach in sustainable architecture refers to integrating environmental, social, and economic considerations into every phase of the building process—from site planning and design to construction, operation, and end-of-life reuse. Various rating systems have been fully explained. This research can serve as a comprehensive reference for individuals active in this field. Furthermore, this study answers the question: What are the dimensions of building sustainability and the strategies and methods for achieving sustainable buildings? In this regard, rating systems have been reviewed and analyzed. The study also clarifies which system is more applicable and flexible across different countries and explains the reasons for the effectiveness or limitations of each rating system.

The LEED system provides strategic guidance for the design and construction of sustainable buildings, awarding certification to projects that achieve specific sustainability goals. The main reason for using such strategies is to turn sustainability objectives into clear and actionable steps. Even if a new project does not fully align with these strategies, tools like BREEAM and BEES have been developed to evaluate environmental and economic performance. These systems continue to evolve and expand, aiming to integrate sustainability goals more comprehensively into building design, energy use, and environmental impact.
Recent studies further reinforce these sustainability goals by examining the integration of smart systems, materials, and data-driven environmental analysis into building design. For instance, Shafa's research (Shafa,2024(a)) on smart building design factors underscores the significance of efficient energy management systems and renewable resources in shaping intelligent, responsive environments. Her complementary work on smart materials (Shafa,2024(b);Shafa,2025), including ETFE and phase change materials (PCMs), demonstrates how innovative materials can enhance energy performance, comfort, and environmental adaptability—key qualities emphasized in sustainable architecture. Moreover, the integration of machine learning-based drought classification models into environmental assessments offers a new layer of intelligence in site planning and geotechnical analysis (Saghaei, 2025). These contributions align with the broader objectives of sustainable construction by turning abstract sustainability principles into practical, locally responsive design strategies that inform material choices, energy use, and environmental planning.

The main objective of sustainable buildings is to minimize their effect on human health and the environment through efficient use of energy, water, and materials. Green building certification systems like LEED help raise awareness among designers and developers and serve as effective marketing tools to meet client expectations and economic demands. However, some researchers believe that due to various regional needs and environmental factors, a one-size-fits-all certification system is not ideal. Instead, alternative systems or localized

adjustments to LEED could better address specific environmental conditions.

1. Principles of Sustainable Buildings

It is estimated that by the year 2056, global economic activity must increase fivefold, while the world population is expected to grow by more than 50%. Consequently, global energy consumption must nearly double, and global production activity must at least triple (Matthews, 2000). The building sector is undoubtedly one of the most energy-intensive sectors at the global level. Compared to other sectors, the building industry is rapidly growing in terms of energy consumption and the use of fossil fuel resources. This issue is currently a major concern due to problems such as the depletion and limited availability of fossil fuels, emission of pollutants like carbon dioxide, global warming, and environmental changes (Ilha, 2009).

Since 1990, the production of building materials has increasingly consumed energy. During the construction phase, buildings consume a significant amount of energy for production, transportation, and lighting. Furthermore, during operation, energy consumption continues. Therefore, the building sector is considered a major contributor to environmental pollution (Kukadia, 2004).

Table 1: *Issues Related to Sustainable Buildings*

Title	Main Topic	Main Issues
Economic Sustainability	Maintaining a high and sustainable level of economic growth and local employment Project improvement and delivery Increasing profitability and efficiency	Improving productivity; sustainable profit growth; employee satisfaction; customer satisfaction by minimizing defects, reducing completion time, and providing cost-effective and efficient services that deliver customer value; emphasis on customer-oriented commerce and joint development.
Environmental Sustainability	Effective protection of the environment Pollution prevention Conservation and strengthening of biodiversity Transportation planning	Minimizing pollutant emissions; preventing disturbances from noise, dust, and improper storage and management of materials and waste; removing pollutants and avoiding environmental damage; creating health and environmental systems; establishing protective and sensitive environmental monitoring systems; green transportation planning; and integrating commercial activities with environmental concerns.
Energy Sustainability	Conservative use of natural resources Improved energy efficiency Efficient resource use	From an energy consumption perspective, reducing energy usage in warehouses and sites; using local materials; designing for longevity and reusability; using recyclable and reusable products; reducing water consumption and

		improving water use efficiency; applying design and construction strategies that lower operational and life-cycle energy costs.
Social Sustainability	Social advancement that meets everyone's needs Respect for workers Cooperation with local communities and road users Participation	Providing education and effective communication; enabling tools for public participation; preserving public comfort and safety; minimizing traffic disturbances and maintaining communication; supporting the local economy and job creation; strengthening local culture and heritage; and creating relationships based on energy value to develop commerce focused on shared customer interests.

The sustainable building approach is considered a path for the construction industry that, by taking into account environmental, social, and economic issues, can lead development toward sustainability. As shown in Table (1), this direction is clearly illustrated. These factors serve as a roadmap for outlining the industry's responsibility in protecting the environment (Ofori, 1998; Shen et al., 2010).

2. Strategies for Constructing Sustainable Buildings

Greater use of renewable resources in buildings

There is a need to use more renewable energy sources to achieve higher electricity generation. This is one of the most important and fundamental steps toward the adoption of renewable energy. Utilizing natural resources efficiently not only meets human needs more effectively but also helps establish a balance between human demands and optimal resource usage, minimizing harm to the environment. The use of renewable energy itself is a core principle of environmental sustainability (Good et al., 2015).

Figure 1: *Solar-powered building at the University of Science and Industry of Iran*

- **Use of natural and local materials**
  Natural materials are renewable, require less processing, and cause less environmental harm. When natural materials are used in construction, they are more likely to be sustainable products. Locally produced materials help reduce environmental loads; as a result, transportation is reduced, which significantly lowers air pollution (Cabeza et al., 2014).

- **Increasing the durability of materials and components in construction**

  Today, synthetic materials are less durable than natural materials, which have greater strength and higher resistance under harsh environmental conditions. A strong and durable structure must be built with a proper understanding of materials and their characteristics. If unsuitable materials are used, the lifespan of the building is reduced and the structure will be damaged in the short term (Cabeza et al., 2014).
- **Considering material life-cycle in construction**

  The construction industry is one of the largest producers of waste. Environmental, social, and economic problems, along with unwanted materials and increased costs, have made waste reduction essential. Waste in residential construction can be significantly reduced by using recyclable materials (Akadiri et al.(a), 2012).
- **Reusing recycled materials** (Prior recycling in buildings)

  Recycling is essential from an environmental perspective. If the fuel used in recyclable materials and their transportation is compatible, it will reduce emissions. Recycling building materials on-site is ideal; however, if unavoidable, off-site recycling should be considered (Gu et al., 2007).

  Waste has been called "black gold" due to its high potential for energy generation. The materials in waste can be burned to produce heat energy. This thermal energy can be used to boil water and create steam and pressure to turn turbines and generate electricity. Moreover, burying waste can also yield a reasonable amount of biogas for industrial applications.
- **Resource Conservation** (Reducing Resource Consumption)

  Using natural resources in a way that provides maximum benefit for current generations while preserving their capacity for future generations is essential. Protecting renewable resources plays a significant role in building projects. Sustainable development relies on proper energy management of resources such as water. Energy production from water, extraction of raw materials, and other processes can result in environmental damage and pollution. Additionally, construction and product manufacturing and transportation generate air pollutants like sulfur dioxide, acid rain, and smoke (Akbari et al.(b), 2010).

Air pollution not only lowers air quality but also negatively impacts human health (Cabeza et al., 2014). Reducing air pollution ensures cleaner air for employees, residents near service locations, and workers. Using appealing and shaded pedestrian paths encourages people to walk or bike, improving health while also reducing fuel consumption. Therefore, designing energy-efficient transport systems helps improve air quality and reduce noise and vibration. Using eco-friendly public transport systems plays a vital role. If cities offer well-developed public transport, reliance on private vehicles will drop to a minimal level.

To encourage sustainable road construction, the use of electric or hybrid vehicles must be prioritized, as well as strategies to reduce traffic congestion and air pollution (Akbari et al. (b), 2010).

The principles of sustainable development in the environment have encouraged researchers to focus more on efficient buildings. As a key factor, the building's facade plays a vital role in protecting indoor environments and regulating the interaction between indoor and outdoor spaces. However, conventional building facades can lead to low natural ventilation, insufficient daylight, and poor thermal comfort, which can result in increased energy consumption. These issues are often significant in modern spaces with large glass surfaces. Glass causes excessive sunlight absorption, leading to high heat and increased energy use for cooling (Shameri et al., 2011). In contrast, proper thermal insulation of walls and facades significantly reduces energy consumption.

Therefore, the building facade is considered an effective solution to improve indoor-outdoor

Table 2: *Sustainability Rating Systems (Source: Fowler et al., 2006)*

Number	Name
1	BREEAM (Building Research Establishment's Environmental Assessment Method)
2	CASBEE (Comprehensive Assessment System for Building Environmental Efficiency)
3	GBTool
4	Green Globes™ U.S.
5	LEED® (Leadership in Energy and Environmental Design)

interaction and energy management (Peng et al., 2013). These two aspects must be properly designed to achieve optimal interaction between the interior space and external environmental conditions. The amount of energy stored depends on the façade's design and material selection (Gratia et al., 2004).

3. Evaluation of Green Building Rating Systems Based on GSA

Among green building rating systems and sustainable design tools, there is a package known as GSA that includes effective technical criteria for building design. In this section, a classification of sustainable building rating systems based on U.S. federal drivers and GSA is presented, as detailed in Table (2).

GSA has identified that rating systems must consider the following elements:

- A system applicable to large-scale and complex federal buildings.
- A sustainability rating system that evaluates building performance without being overly sensitive to fluctuations.
- A system that tracks quantitative achievements in sustainable design.
- A third-party evaluation by an approved, independent assessor.
- A system that is currently recognized and used in the marketplace.

Further explanations about how sustainable building rating systems operate are provided in Table (3).

Table 3: *Characteristics of Sustainable Building Rating Systems by Source Systems*

No.	Rating System	Description
1	BREEAM	• Has a long history in the UK • Widely used in the UK • Not widely used by U.S. design professionals • Can be used for all types of GSA projects • Requires annual licensing • Not freely available for public purchase • Must be purchased through a licensed distributor • More professionals are familiar with sustainable design through BREEAM • Many sustainability systems have used BREEAM as their base model
2	CASBEE	• A relatively new system • Targeted for Japanese market,

		mostly in Japanese • Not widely used in the U.S. • Cannot be used for most GSA projects or unique U.S. buildings • Training required by Japanese specialists • Each level of the system must be learned separately • Not available in the U.S. market
3	GBTool	• A flexible system to evaluate environmental performance of buildings • Referred to in GSA project evaluations • Suitable for many project types, though butanent (local adaptation) is needed • Not widely available in the U.S. market
4	Green Globes™ U.S.	• Derived from Green Globes Canada in 2004 • Currently being customized for GSA project evaluation in the U.S. Information related to the design and construction of sustainable buildings for individual certification is submitted online through a certified green design plan and reviewed and approved by Green Globes experts. The **Green Globes™ US** rating system is generally not consistently available online. The official online version of the system was also not publicly accessible during the evaluation period. Although in recent years there has been extensive advertising about **Green Globes™ US**, particularly with the **Green Building Initiative**, and despite the promise of providing services, it has only registered 63 green-rated buildings. This suggests that its broader adoption may require further future development.
5	**LEED**	LEED® is currently the most widely used system in the U.S. and globally.

		With numerous markets around the world aligned, **LEED® rating systems** are currently available for use and applicable to all types of buildings and GSA projects. All major guides including **Product Development and Maintenance** are publicly available. The application of LEED® is straightforward, and its rating system is clear. At every development stage, from product selection to green building certification, **LEED®** provides defined steps and documentation. The U.S. Green Building Council (USGBC) oversees the process and ensures quality control. The registration system is clearly defined and publicly accessible. Each version of **LEED®** is updated approximately every 3 to 5 years. Users are informed of the release of new versions in advance, which gives them time to transition and adapt. Additionally, detailed guides for design, certification, and personal project certification are provided. With the development of the **LEED Online** tool by the USGBC, LEED® continues to expand and facilitate sustainable building certification processes. More than 400 LEED®-certified buildings currently exist in the U.S., and over 3,400 buildings have been registered for LEED certification.

Based on Table (3), which outlines the characteristics of sustainable building rating systems, the LEED® system is considered superior to other systems. Moreover, it currently dominates the U.S. market and has been widely accepted. In fact, as of 2024, there are over 195,000 LEED-certified projects across 186 countries, encompassing more than 29 billion square feet of certified space (USGBC, 2024). Below, we further elaborate on the advantages and significance of the LEED® rating system.

This study also attempts to compare the strengths and weaknesses of green building rating systems, especially in the context of information transparency, ongoing updates, and widespread accessibility.

Starting in the 1980s, with the expansion of environmental standards and global agreements such as the Kyoto Protocol, green building guidelines and certification systems were introduced in many countries. These systems aim to provide a clear roadmap and transparent process for developers and customers by respecting the environment and minimizing harmful impacts.

Project managers and developers now have the opportunity and time to improve their designs and follow the certification process, which ultimately leads to customer satisfaction. The transparency of these systems allows individuals to evaluate themselves and ensure that they are progressing toward sustainable goals. Such systems also help contractors communicate with clients and differentiate their services from others in the market. For instance, the LEED certification process allows for an online submission and review platform, which facilitates energy-efficient construction with minimal paperwork and supports environmentally conscious development.

Table (4) outlines the reasons various countries adopt and apply different rating systems.

***Table 4**: Countries' Approaches Toward Utilizing Rating Systems for Green Buildings*

No.	Country	Approach / Description
1	France	Reducing greenhouse gas emissions by protecting the environment and encouraging public participation. Part of the legislation requires that buildings consuming more than 472 kWh/m² (mainly non-residential buildings) be limited. Additionally, a fourth of the emissions must be reduced, and a priority is set for reducing energy consumption.
2	Scandinavian Countries	Focusing on renewable energies due to the limited global reserves of fossil fuels and their high environmental impact. Since September 2002, all housing-related construction projects must be registered with ART to comply with thermal regulations (RT 2000). These regulations cover all housing projects, including new and replacement buildings (residential and non-residential), and stipulate that the maximum energy consumption must not exceed 75 kWh/m². The goal is to gradually reduce the annual allowable energy use. New standards and building classifications have been introduced to encourage the construction of buildings that

		consume less energy and produce lower emissions. By 2020, new regulations require that all new buildings be nearly zero-energy and include renewable energy use. Norway has gone further by requiring public buildings to meet energy performance standards at least 50% better than the baseline requirement.
	Sweden	From an energy consumption perspective, like other European countries, Sweden complies with EU directives concerning building energy performance and aims to establish the necessary infrastructure for renewable energy and energy efficiency. The Energy Declaration Act of 2006 (SFS 2006:985) mandates the creation of an energy certificate for every building. This system allows for practical analysis of actual energy use and provides an opportunity to evaluate energy-saving measures. Due to the importance of sustainable housing development, the Swedish government has taken steps to promote green building practices. For example, financial incentives are offered to investors and developers for reducing CO_2 emissions. If a building's energy performance exceeds baseline standards, it will be eligible for government support. The goal of these programs is to gradually increase investment in energy-efficient residential buildings.
Denmark	Denmark's government acknowledges that buildings in a single energy zone may differ from those in various climate zones, which is why buildings often have very long lifespans. Denmark is one of the pioneers of green construction, where buildings around the world are often evaluated with Denmark's green standards. Therefore,	

	sustainability standards are emphasized in Danish construction. Denmark has launched the DGNB certification system to evaluate sustainability. Denmark has localized and adapted the international DGNB system to fit its own context. The country also uses its national DGNB license and adjusts the assessment criteria to match local environmental, social, and economic conditions. Denmark also issues building permits only for projects that meet at least the silver level of the DGNB rating.	
	Norway	The Norwegian Green Building Council has decided to develop **BREEAM-NOR**, an energy-efficient localized version of the UK-based **BREEAM** system to enhance compatibility with local environmental conditions. BREEAM is one of the most widely used and comprehensive building rating systems globally. Established in 1990 by **BRE Global**, BREEAM provides independent, third-party certification services. BREEAM performance evaluation tools are widely used for energy-efficient building design. These tools assess a building's energy and water consumption, indoor environment quality, transportation, materials, waste, land use, and pollution. The trusted BREEAM rating system continues to play a special role in evaluating sustainability.

4. Analysis of Green Building Rating Systems with a Sustainable Architecture Approach

The findings of this study indicate that sustainable building principles are directly tied to sustainable architecture. Emphasizing this connection, the research aims to identify how a sustainable building functions as a comprehensive system—one that should not only be economically viable (i.e., profitable and efficient), but also environmentally conscious to prevent pollution, and socially responsible to enhance community well-being.

In the next section of this study, sustainable building strategies such as use of renewable resources, recycled materials, and locally sourced materials will be evaluated. This is done in order to understand how these strategies improve energy efficiency, increase building lifespan, and reduce dependence on non-renewable materials in construction.

In addition, the research highlights the role of reusing construction materials (recycling from existing buildings), resource conservation, and use of renewable energy sources in sustainable construction. The study aligns with previous social research that supports the need for renewable energy and environmentally friendly solutions. Strategies such as minimizing construction waste, using recycled or natural materials, and increasing durability are considered essential for reducing pollution and addressing environmental concerns.

In this study, the rating systems examined included BREEAM, CASBEE, GBTool, Green Globes™ U.S., and LEED. Among these, LEED has been identified as one of the best green building rating systems, widely accepted and used in the United States. Many researchers and experts believe that LEED is one of the most successful systems currently available.

The development and success of the LEED system began in the United States but quickly gained global traction through its structured design methods, user-friendly interface, and comprehensive criteria. As a result, it has been used in numerous international and national projects, including significant developments in the Middle East. The World Green Building Trends 2016 report confirms LEED's influence and expanding use.

Over the past few years, the number of LEED-certified projects and buildings has increased significantly, showing that LEED, due to its comprehensive criteria and adaptability to local contexts, is a highly suitable model for sustainable design and construction and continues to grow.

Conclusion

In this study, building sustainability factors were fully examined. The research identified 7 key sustainability factors based on previous articles and scientific studies. Then, five different international green building rating systems were compared.

The results indicate that the LEED system is the most comprehensive and widely accepted both globally and across most countries.

Sustainable development and green building construction are global issues that require region-specific solutions. If the environmental problems like global warming continue, we need global strategies that also consider the unique conditions of each continent and region. Therefore, the path to sustainable development must include the characteristics of local climates and natural materials. In this context, governments should provide opportunities and responsibilities to local companies to align green building solutions with local realities. If local companies are unable to meet green building standards, they should be encouraged and supported through licensing systems or other incentives. Countries that export building products must adapt their standards to the markets they target. For example, BREEAM in the UK or LEED in Europe are among the most commonly used green building standards. Due to the global evolution of green construction, these countries have created green building systems that have evolved over several decades and align with their own local regulations. As such, each country should adopt or develop a sustainable green building system that reflects both international best practices and local regulations.

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