Impacts of green rating systems on the economy and society

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Abstract. This study examines the impact of green rating systems on the construction industry in sustainable development. Five widely used green rating systems, BREEAM, LEED, Green Star, Green Mark and CASBEE, were examined to identify their effectiveness in promoting sustainable construction practices, specifically in the economic and social aspects. Results revealed that all rating systems offer a comprehensive environmental performance assessment but have varying degrees of success in the rest pillars of sustainability. The rating systems have notably influenced the construction sector, motivating developers and designers to integrate sustainable elements into their structures. The advantages of such rating systems extend beyond singular buildings, benefiting society as well by decreasing environmental harm, advancing the health and well-being of occupants, and stimulating economic progress. Furthermore, the study suggests that construction companies that design and build green-certified buildings have a competitive advantage in the market. Overall, the study highlights the benefits of using green rating systems to promote their wider adoption in the construction industry.

1. Introduction

Sustainable construction development is a highly relevant topic worldwide and closely tied to the green rating system. As the importance of high performance, time management, environmental protection, and efficiency increases, all sectors seek sustainable development. Sustainability is a commonly used but often poorly understood term, with varying interpretations and frequent oversimplification through labels such as "ecology" or "green" [1]. Sustainable policy requires decision-makers to be flexible and willing to shift their thinking [2]. Fowke and Prasad [3] identified over 80 different and often competing and occasionally conflicting definitions of sustainability. However, the most widely recognized definition comes from the Brundtland Report, issued by the Intergovernmental Committee created by the United Nations system under the guidance of Gro Harlan Brundtland in the mid-1980s to address environmental issues. The report defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [4].

Sustainability is a human concern for those who take it seriously, as it emphasizes the environment's long-term endurance. The construction industry can make a significant contribution to achieving these goals. However, the construction industry imposes a significant burden on the environment, wasting large amounts of materials and energy resources in the production and maintenance of the built environment, making the extensive transformation of the construction industry difficult [5]. Sustainable construction development has become a popular topic in recent

years, and the green rating system was created to promote better sustainable construction development [6].

In the era of rapid development, environmental pollution, resource scarcity, and resource waste are hot topics. The construction industry is no exception and must address sustainability principles. Failing to construct buildings using appropriate climate data and assessment tools can affect the building's performance and human comfort, health, and efficiency. Sustainable construction development is also inseparable from the impact on society, raising social awareness and prompting industry changes [7].

The green rating system provides a comprehensive evaluation of sustainable development for the construction industry, enabling contractors and construction companies to understand the standards that must be met to achieve sustainable buildings [8]. This allows for purposeful construction without being hindered by the vague concept of sustainability. While the environment is a critical topic, social and economic factors are essential for sustainable construction and development. Sustainable development methods must ensure the resource needs of contemporary people and not harm future generations' interests. As sustainability gains more attention, this research examines green rating systems' economic and social impact on sustainable construction development. While many green rating systems have matured over time, few professionals have analyzed their impact on sustainable construction development, resulting in a lack of focus on concepts and cognition. This research investigates the social and economic impacts of the five most popular green rating systems: BREEAM, LEED, CASBEE, Green Star, and Green Mark. LEED is the most representative rating system in the United States, Green Star represents New Zealand and Australia, BREEAM is the most widely used system in the United Kingdom and the Commonwealth, and Green Mark and CASBBEE represent rating systems for Singapore and Japan, respectively.

2. Green rating systems

Sustainable architecture has emerged as a critical concern and is driving industry efforts towards achieving social, economic, and environmental sustainability. However, the construction industry has been identified as one of the worst offenders in sustainable development, accounting for approximately half of all non-renewable resources humans consume [9]. Building projects need to address environmental, economic, and social sustainability at all stages of the building process to be truly sustainable. Sustainable buildings enhance biodiversity, support communities, use resources efficiently, minimize pollution, manage responsibly, improve energy efficiency, and create a healthy environment [10]. Therefore, the impact of green rating tools on sustainable building development is of great importance and is worth studying

2.1. BREEAM

BREEAM is a leading green building rating system with a wider range of ratings than other systems and the largest number of certified buildings. This is due to the wealth of knowledge about sustainable development in European countries and its rigorous and comprehensive evaluation criteria, leading to more obvious societal benefits. The assessment is conducted using science-based sustainability indicators covering various environmental issues such as energy, health and well-being, water use, pollution, materials, waste, transport, ecology, and management processes [11]. Buildings are rated and certified on a Pass, Good, Very Good, Excellent, or Outstanding scale.

Most interviewees in the construction industry indicate that using BREEAM is beneficial to their projects, driving carbon dioxide reduction through energy-efficient measures such as rainwater harvesting, solar panels, sustainable wood, recycling facilities, pollution and noise reduction management [12]. BREEAM also encourages contractors to develop resource management plans to minimize the amount of waste generated on-site and to consider recyclable and energy-efficient materials. Over time, BREEAM's measures have had a more significant impact on the environment, focusing more on development strategies centred on reducing construction waste, ways to reduce carbon dioxide emissions, and improving the wildlife environment in the surrounding [13].

BREEAM sets the standard for best practices in sustainable design and is the leading and most widely used method for assessing the environment of buildings and communities. It considers a wide

range of sustainability measures from energy to ecology. Its standards ensure good indoor air quality, adequate lighting and daylight, and thermal comfort. BREEAM aims to raise awareness among owners, occupiers and designers of the benefits of adopting a sustainable approach, provide a framework to help them successfully adopt sustainable solutions cost-effectively, and provide market recognition for their achievements.

BREEAM is rigorous and detailed in its energy scoring, requiring more compliance to determine energy efficiency scores. To calculate the energy ratio, for example, researchers need to consider operational energy requirements, energy consumption, total CO2 emissions, construction area, planned energy demand of the building, actual construction energy demand, construction plan, actual energy consumption, target emission rate, and construction emission rate [14].

Overall, BREEAM plays a critical role in reducing the adverse impact of buildings on the environment. Most participants in the construction industry have conducted extensive studies on the environmental impact of BREEAM, not only in the overall environment but also in areas such as energy, materials, gases, and more. BREEAM is considered the de facto measure used to describe the environmental performance of a building, providing a tangible way for buildings to demonstrate their commitment to sustainability and serving as a benchmark for industry best practices.

2.2. LEED

LEED, which stands for Leadership in Energy and Environmental Design, is an internationally recognized green building rating system that promotes sustainable design and construction strategies to improve energy and water efficiency, reduce greenhouse gas emissions, and promote resource management [15]. As of 2021, it has over 79,000 projects in 135 countries, making it the most widely used green building rating system [16].

The LEED rating system provides a detailed scoring system to rate green buildings' overall construction and design. Buildings are rated according to how well they have implemented various sustainability strategies, and the certification level ranges from certified, silver, and gold to platinum. In a study conducted by the Department of Energy, 22 LEED-certified buildings managed by the US General Services Administration were reviewed, and it was found that carbon dioxide emissions were reduced by 34%, energy consumption was reduced by 25%, water consumption was reduced by 11%, and they were diverted from landfills [17]. LEED-certified buildings achieve their sustainability goals through specific energy-saving strategies such as construction sites, material selection, window placement, daylighting, and energy-efficient heating, cooling, and ventilation systems. Such buildings promote health, save energy, protect the environment, and reduce harmful greenhouse gas emissions that contribute to climate change [17].

However, some researchers and articles have raised different opinions. For example, LEED only deals with the design and construction of buildings and does not participate in post-construction monitoring of buildings or measure how much energy or water the building's occupants use. Therefore, LEED-certified buildings may use more resources than other typical buildings due to the habits of building occupants [18].

Despite these limitations, the certification process provides a tangible way for buildings to demonstrate their commitment to sustainability and serves as a benchmark for industry best practices. In any case, LEED certification is a valuable tool in the construction industry's efforts to promote sustainable design and construction practices, and its widespread adoption worldwide is a positive sign for the future of the built environment.

2.3. Green Mark

Launched in January 2005, the Green Mark program aims to promote sustainable construction and raise environmental awareness in Singapore's construction industry. It is a voluntary program that assesses new and existing buildings' environmental impact and performance through a comprehensive framework that evaluates areas such as energy efficiency. By incorporating internationally recognized best practices in environmental design and performance, Green Mark provides a meaningful distinction for buildings in the real estate market.

Green Mark is a unique green rating system that distinguishes commercial and residential buildings and provides a comprehensive minimum environmental assessment structure. This program benefits the country by reducing water and energy use, improving residents' living environment and quality, and minimizing the entire project team's adverse environmental impact and pollution during the building's construction. The program has a positive impact on the building's corporate image, lease and resale value, and helps to reduce the adverse impact of buildings on the environment and the health of their occupants.

Singapore's lack of natural resource supply makes Green Mark's focus on saving water and energy essential. An effective and cost-effective "green home" will help to reduce the burden on urban residents, providing them with higher disposable income, improving their living standards, and ultimately stimulating environmental improvement, social development, and economic growth [19, 20].

Green Mark grades buildings based on five key criteria: energy efficiency, water use efficiency, environmental protection, indoor environmental quality, and other green and innovative features that contribute to the building's performance. While most researchers focus on reducing water and energy costs, improving indoor environmental quality and healthy living, and reducing potential environmental impacts, there are research gaps in the areas of society and the economy. Economic growth, social harmony, and environmental protection are equally important in Singapore's "green home" plan.

Green Mark is highly cost-effective and helps to reduce the burden on urban residents, providing them with higher disposable income and improved quality of life [21]. The program considers society's needs, pursues and adapts to various societal changes, and provides residents a comfortable and safe indoor environment. This ultimately contributes to the overall well-being and vitality of the neighborhood and community and serves the social interest [22].

2.4. Green Star

Green Star is a widely used rating system in Australia and New Zealand that evaluates the sustainability of the built environment. Unlike other systems, it was launched by the Australian Green Building Council in 2003 and later in New Zealand in 2006, making it a relatively young rating system. The system evaluates buildings at all stages of the construction lifecycle, from planning to ongoing operation, with a focus on environmental sustainability. It evaluates buildings based on a series of construction, renovation, and community operation criteria, encouraging designers and contractors to play a substantial role in environmentally sustainable design, showcase innovations in sustainable construction development, and consider occupants' health, productivity, and operating cost savings.

The Green Star scoring tool divides a building's overall environmental impact into nine segments: energy, water, materials, indoor environmental quality, transportation, land use and ecology, management, emissions, and innovation. Additionally, Green Star-Communities scores sustainability attributes of societies in five categories: governance, liveability, economic prosperity, environment, and innovation [8]. Green Star-certified buildings save enough drinking water yearly to accommodate 1,320 Olympic swimming pools - more than 3,300,000 litres per year [10]. These water-saving certification standards have brought considerable results from the perspective of cost-saving and habitat protection, or the perspective of energy saving and reducing the pressure on social infrastructure.

The majority of waste disposal methods, such as incineration and landfill, contribute to environmental pollution. By preventing or reducing waste produced during the construction process, Green Star indirectly helps mitigate this environmental impact. Compared to conventional buildings, Green Star-certified green buildings reduce landfill waste by 96% due to their lower waste generation rate resulting from the use of recyclable materials [10].

However, the overall rating system is imperfect, as it appeared many years after other green rating systems. While Green Star-certified buildings can bring higher returns for owners, investors, and tenants increasingly demand green buildings, the immaturity of the Green Star system means that contractors and teams often have to spend more money to meet the requirements of Green Star.

2.5. CASBEE

CASBEE is a green rating system that is continuously being developed to evaluate the environmental performance of cities worldwide, primarily for the construction industry in Japan. The system aims to enhance people's quality of life, reduce resource waste, and the load caused by the construction industry, from single houses to entire cities. Consequently, various CASBEE plans have been implemented throughout Japan, receiving support from national and local governments [23].

CASBEE introduced the concept of eco-efficiency to achieve a comprehensive assessment of two factors: inside and outside the construction site. CASBEE covers the following four assessment areas: (1) Energy efficiency, (2) Resource efficiency, (3) Local environment, and (4) Indoor environment. Although CASBEE is Japan's first and most important building environment assessment method, it has not been promoted as expected. Until 2014, its use in the Japanese construction industry was still minimal [24]. Since the first CASBEE tool was released in 2002, only a few studies have conducted limited research to understand the views of CASBEE stakeholders.

The sustainable development of construction in Japan is usually defined as saving energy throughout the life cycle, using renewable materials, and minimizing the emission of toxic substances and greenhouse gases [24]. Built in harmony with the local culture, tradition, and climate of the buildings, as well as the surrounding environment, can not only keep the Japanese but also improve the ability of the global ecological system to enhance the quality of human life [24].

With changes in social, industrial, and political requirements, CASBEE has been making corresponding corrections and continuous development. Specifically, it enables the evaluation of single buildings, a group of buildings (e.g., neighborhoods or regions), and even the entire city defined by administrative boundaries [25].

Green buildings produced significant energy and carbon dioxide benefits. It not only reduces costs but also improves the health of sick users. The energy intensity of the two best case study buildings was reduced by 33% and 26%, and CO2 was reduced by 38% and 32%, respectively, compared to the average building. The savings in the first two buildings equate to about $1.5 million per building per year in energy costs [26]. Although buildings certified by CASBEE provide users with benefits beyond general buildings, the cost is still high [27].

3. Impacts of green rating systems on the economy

Although Parkers [12] suggested that the economic impact is not directly related to any of the categories specified by BREEAM, the overall rating provided by BREEAM can significantly affect the construction industry. Parkers [12] explained that green building certifications can help reduce operating costs and increase the value of buildings for selling or renting, providing an opportunity to earn more money. Data from Commonwealth countries revealed that BREEAM-certified buildings have increased student housing prices and improved the rentability of the entire building, resulting in a continuous increase in rent over time. However, this rent increase depends on economic and market conditions, and not solely on using a green rating system. Chegut et al. [28] compared buildings with BREEAM certification to those without in England and Wales and found definitive proof that rental prices and occupancy rates of green buildings are increasing. The study revealed that the rise is due to various factors, including economic and market conditions at the time of the survey. Dwaikat & Ali [29] stated that lower construction costs and energy savings are inseparable in green buildings. Surveyed green buildings have energy savings of about 71.1%, which is 30% to 50% less than traditional (non-green) buildings. From a life cycle perspective, green buildings can save approximately $2,796,451 when energy prices increase by 1% annually and up to $12,107,060 when energy prices increase by 5% annually. This research shows that green buildings have a higher market value of 10% and higher rents of 5% to 10%.

LEED provides construction companies with net benefits that conventional buildings cannot offer [30]. The ability to design and build LEED-certified buildings can attract a large number of customers for any construction company, commercial or residential. The principles and practices behind LEED certification improve overall market competitiveness, increase construction anxiety, and save buyers money [30]. Home builders receive tax credits for building homes certified by the green rating system, and they can advertise to potential homeowners that a green-rated home may lower their insurance

premiums and increase the value of their home over time. LEED-certified buildings appear to be recession-proof, as the total area of LEED-certified buildings increased by 14% despite a sharp fall in the number of new buildings due to the bursting of the real estate bubble [30].

According to Heinzle et al. [21], the construction cost premium for Green Mark-certified buildings is between 0.3% and 1% compared to compliant buildings, while the cost premium for green mark platinum-level buildings ranges from 2% to 8%. In addition, Heinzle et al. [21] found that other buildings with Green Mark awards can be sold at a premium of 3.78%. Buildings certified for the Green Mark Platinum Award can increase their selling price by up to 7.98%, while also significantly reducing operating costs. This research indicates that high-quality buyers are willing to pay for properties certified by Green Mark.

Aoki et al. [27] showed that the net operating income of top-level business facilities or CASBEE-certified office buildings with a total construction area exceeding 10,000 square meters is higher than that of uncertified office buildings. Additionally, the net operating income of expired CASBEE-certified office buildings with a total construction area of 10,000 square meters is greater than that of uncertified office buildings [27]. This demonstrates that CASBEE is an effective certification scheme that can enhance the economic performance of buildings.

4. Impacts of green rating systems on society

LEED and BREEAM, while effective in assessing the environmental impact of buildings, have not paid sufficient attention to the social aspects of sustainability. According to Heerwagen [31], social sustainability relates to the well-being of all those affected by development efforts, directly or indirectly. The green rating system should ensure that social, cultural, and spiritual needs are met fairly, and maintain stability in terms of human ethics, relationships, and systems. Studies have shown that green and well-ventilated offices can improve cognitive function by 101% and increase employee productivity by up to 8%, while better indoor air quality can improve performance and increase sleep by 46 minutes per night [31].

Since its launch in 2005, Green Mark has certified 13% of buildings with the green logo [32]. The government aims to have at least 80% of buildings certified by 2030 through incentive schemes and legislative requirements for new and existing government buildings. Green Mark has improved Singapore's construction industry and the government is promoting the Green Mark scheme globally. BCA's Sustainable Building Centre has also carried out various capacity-building projects for developing countries since 2009, promoting sustainable and energy-efficient buildings. Singapore has developed a local green certification program to promote the development of rating plans suitable for neighbouring countries, which has earned Green Mark an international reputation [22].

Green Star certified buildings have been shown to improve patient treatment, with lighter and brighter rooms helping reduce stress, pain, and the use of analgesics [33]. At Melbourne's CH2 building, productivity has increased by 10.9% since staff moved into their green office [34]. Indoor environmental quality is crucial for health and well-being, as office, retail, and healthcare workers spend up to 90% of their time indoors, and students and teachers spend about six hours indoors daily [34].

In Japan, overwork caused by long working hours has become a social problem, and there is a strong demand for improving workplace productivity. The CASBEE-wellness office, launched by CASBEE, considers the improvement of workplace productivity as an evaluation point, with a focus on creating comfortable working environments that have significantly increased the employment rate and improved people's happiness at work [35].

5. Conclusion

BREEAM, LEED, Green Star , Green Mark, and CASBEE are five of the world's most widely used sustainability rating systems. Each system has its own unique criteria and certification levels, but they all share a common goal of promoting sustainable building practices. LEED is one of the most well-known systems and has been adopted in over 130 countries, while CASBEE is popular in Japan. BREEAM is used mostly in Europe, and Green Mark is popular in Singapore. Green Star is the most commonly used rating system in Australia.

In summary, LEED, CASBEE, BREEAM, Green Mark, and Green Star are important tools for promoting sustainable building practices and have contributed to significant improvements in the sustainability of buildings worldwide. These rating systems have made a significant impact on the building industry and have encouraged developers and designers to incorporate sustainable features into their buildings. The benefits of these rating systems go beyond individual buildings, as they also positively impact society by reducing environmental impacts, improving occupant health and wellbeing, and promoting economic development.

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