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Advancing Sustainable Development Goals through Green Building Certifications: A Case Study of the DEWA Sustainable Building

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ABSTRACT

In the quest for sustainable construction practices, green building concepts have emerged as powerful tools. This study delves into the impact of green building certifications, notably LEED, BREEAM, and the WELL Building Standard, with a specific focus on the DEWA Sustainable Building project. Utilizing a comprehensive methodology that incorporates interviews and a systematic review of pertinent articles, this research assesses the efficacy of these certifications in alignment with Sustainable Development Goals (SDGs). It examines their role in reducing energy consumption, curbing greenhouse gas emissions, and minimizing the environmental footprint.

The DEWA Sustainable Building serves as a remarkable case study, achieving an impressive 66% energy savings across 236,996 square feet. This accomplishment is attributed to its platinum-level certifications, the utilization of recycled construction materials (36%), and the deployment of a 660 kW solar power plant. The study underscores the positive influence of green certifications on resource efficiency, natural ventilation, occupant comfort, and indoor air quality, which resonate with SDGs aimed at promoting clean energy, sustainable cities, and responsible consumption. Despite differing perspectives, this research reveals that factors such as certification levels, building types, and sustainable material choices play pivotal roles in achieving energy-saving objectives. Ultimately, this study emphasizes the transformative potential of green building certifications in advancing sustainability and creating healthier environments, aligning with global initiatives to attain the SDGs.

***Keywords**:* DEWA; Platinum-level certification; Sustainable building; SDGs, Energy savings; Recycled construction materials

1. INTRODUCTION

Climate change is one of humankind's biggest threats (Amiri et al., 2019). It has increased the frequency and severity of adverse weather events such as droughts, floods, heatwaves, wildfires, and hurricanes worldwide. Scientists also hold that these effects are bound to worsen in the future, and the window of opportunity to reverse the phenomenon is fast closing (United Nations, 2021). With this realization, different industries have developed ways of enhancing sustainability.

In the realm of the construction industry, numerous initiatives and strategies have been devised to promote the sustainability of built structures. The development of building infrastructure, closely intertwined with a multitude of economic activities, has emerged as a pivotal catalyst in the evolution of cities and regional progress. Projections indicate that by the year 2030, an estimated 60% of the world's population will have gravitated towards urban areas, primarily due to the swift pace of global urbanization and the consequential surge in large-scale construction undertakings.

Construction work is responsible for 25% of greenhouse gas emissions (Li et al., 2019). According to the United Nations Environment Program for Sustainable Buildings and Construction, about 40% of the world's energy is consumed during a building's life cycle. Additionally, about 30% of the world's energy-related greenhouse gas emissions are also attributable to buildings. The green buildings rating system is a crucial tool to guarantee improved levels of sustainability for the building industry, as the data highlight the need for alternatives for the construction and use of buildings. Furthermore, a global push for sustainability has recently encouraged building designers and engineers worldwide to incorporate eco-friendly principles into their design processes. One of the ways they achieve this is by obtaining certification from third-party organizations that demonstrate a facility's optimization of efficiency and movement toward sustainability (Ray Hernandez, 2018).
LEED (Leadership in Energy & Environmental Design), BREEAM (British Research Establishment's Environment Assessment Method), and WELL Building Standard®(WELL) are three well-known certifications for green buildings. In the realm of sustainable construction practices in the United Arab Emirates (UAE), significant strides were taken when the Green Building and Sustainable Building standards received official authorization by the UAE Cabinet in 2010. Notably, these standards extended their influence to other emirates within the UAE. In early 2011, they were actively implemented in government buildings, marking a pivotal shift towards eco-friendly and energy-efficient infrastructure.

Fast-forwarding to the ambitious targets of 2030, this groundbreaking initiative aspires to achieve substantial savings of AED 10 billion and a noteworthy 30% reduction in carbon emissions. To gauge and comprehend the effectiveness of these efforts, the introduction of the Estidama Pearl Rating System in Abu Dhabi became a noteworthy benchmark. This rating system mandates that all new constructions must attain at least a one-pearl rating, while government structures and residential villas require a minimum of two pearls. Dubai, too, has embraced sustainability with the introduction of 79 stringent criteria in its green construction laws, which are now imperative for all development projects. Additionally, numerous government buildings have garnered international certifications, such as those awarded by the Dubai Electricity and Water Authority (DEWA), with an impressive tally of 12 projects certified by the LEED program.

The research objectives set forth in this article seek to unravel the multifaceted impacts of these sustainability measures. Firstly, we inquire into the extent to which energy consumption is reduced within DEWA LEED-certified buildings. Furthermore, we explore how Green Building Certifications contribute to the overall environmental enhancement of buildings. These research inquiries aim to shed light on the profound influence of LEED certification on energy conservation in DEWA's infrastructure. Beyond that, our objective extends to forecasting the positive aspects of the green rating system on the environmental footprint stemming from green building certification.

2. LITERATURE REVIEW

Energy consumption is a major issue in the modern world, and it is not just an environmental concern but has far-reaching effects on the economy's health. Energy consumption in buildings is mainly a significant issue, and this problem is also bound to worsen as the world's population increases and living standards improve.

According to Amiri et al. (2019), buildings are estimated to consume between 30% and 40% of global energy resources. In 2021, buildings were responsible for 27% of total energy sector emissions, with 8% coming from direct emissions in buildings, while 19% were indirect emissions from heat generation in these buildings.

Many factors contribute to energy consumption in buildings, some of them being the physical design of a building, building materials used and how they were installed, and the behavior of its occupants. Some factors contributing to the energy consumption crisis include increased population density, incomes, older buildings, and new construction standards. In addition, there is more demand for heating, cooling, and lighting in urban areas than in rural areas, which, in turn, causes energy consumption to rise. Also, older buildings have lower energy efficiency ratings than newer buildings because of using older technologies which consume more energy. However, new construction codes require better insulation and heating/cooling systems, which all consume energy. To this end, research shows that a rise in demand for energy services within buildings has yet to be matched by decarbonization gains and energy efficiency (Delmastro, 2022).

Besides, technology can reduce energy consumption, but the most effective solution is to permanently change how buildings are designed, constructed, and used. In the same light, experts call for more collaboration between private and public actors and other players across the value chain (Global Alliance for Buildings and Construction, 2020).

A possible method to reduce the excessive energy usage of buildings is to obtain a green building certification. LEED certification is an internationally recognized rating system that measures the sustainability of a building's design and construction. It is given to buildings designed and built with specific environmental considerations (USGBC, 2023). LEED certification is granted through the LEED rating systems, which measure a building's ability to use resources efficiently and reduce the negative impact on humans and the environment. The rating systems were developed in response to concerns about increasingly unsustainable development practices at every level of government, from federal agencies to local municipalities and within the construction industry itself. The USGBC provides a series of awards for energy-efficient buildings based on point accumulation from meeting prerequisite standards for various categories such as site location, water usage, energy efficiency, and transportation. Other prerequisites are carbon, waste, health, and indoor environmental quality.

Though LEED certification is not necessary for all types of buildings, it has been used on an increasing number of structures to make them as environmentally friendly as possible. There are currently ten available LEED certifications, and though there are only six levels of certification, the suffixes -Platinum, -Gold, -Silver, and -Certified can be added to the primary designations for any particular structure (USGBC, 2023). The more points accumulated above the minimum required at any level, the greener the building is considered (USGBC, 2023). USGBC states that LEED-certified buildings lower carbon emissions, improve efficiency, create healthier places, and save money. They also contribute to the fight against climate change and help achieve the Environmental, Social, and Governance (ESG) goals (USGBC, 2023). Besides, LEED-certified buildings enhance resilience and make communities more equitable.

Various studies have confirmed the huge role of LEED in the construction of sustainable buildings. For example, in an analysis of the construction industry in Brazil, Obata et al. (2019) held that LEED certification promotes sustainable buildings. However, Amiri et al. (2019) noted that questions about the impact of LEED certification on sustainability have been raised in recent years. In the same light, there is no consensus on whether the LEED program benefits the environment and is worth the investment in the process. Amiri et al. (2019) sought to address these concerns. The researcher analyzed 44 peer-reviewed articles to find answers to these questions. Ten of the articles held that LEED certification enhances energy efficiency. Eight articles, however, pointed to the contrary, and the remaining papers did not take a stand on the issues (Amiri et al., 2019). The authors established that the energy efficiency of LEED-certified buildings has yet to be proven, particularly at the lower levels. As such, the researchers recommended that the Energy and Atmosphere category of LEED should be modified to improve the energy performance of the buildings (Amiri et al., 2019).

A comparison between LEED and non-LEED buildings in Washington, DC., also revealed that the former did not perform better than the latter. On the contrary, the LEED buildings collectively consumed 13% more site energy and 17% more source energy than non-LEED buildings (Hu, 2021). The study established that only Silver had a slightly better performance in the various LEED categories. However, the author refrains from criticizing the LEED rating system. Instead, the author holds that it could be improved by benchmarking from other green building rating systems (Hu, 2021). The findings are corroborated by Vosoughkhosravi et al. (2022), who established that the energy consumption rates are higher in LEED-certified buildings. However, the study also established that these buildings have a higher satisfaction rating (Vosoughkhosravi et al., 2022). Moreover, BREEAM, also a green building rating system developed by the Building Research Establishment (BRE) in 1990, assesses, certifies, and labels buildings based on their performance against various criteria related to energy efficiency, water use, materials, and waste management, as well as overall indoor environmental quality (Ding et al., 2018). BREEAM has been widely adopted globally, with over 1.2 million certifications issued, representing over 500 billion square feet of floor space (Cheng et al., 2017).

Recent academic studies have focused on how BREEAM certification can support university students with learning disabilities during their higher education experience (Shawe et al., 2019). Other papers have examined how course adjustments can be made to accommodate unique learning barriers faced by disabled students (Oshea et al., 2016) and how individualized methods can be used to identify student needs within different disciplines (Coulby et al., 2021). Kibert (2016) analyzed strategies to promote retention amongst disabled university populations through engagement activities before entering college, which many argue are still relevant today, given technological advancements and accessibility standards. In 2016, Banani et al. (2016) conducted a study that assessed the effectiveness of the BREEAM certification system on four types of facilities, including residential complexes with single-family detached homes and village-style multi-family dwellings in Saudi Arabia. They discovered that retrofitting the buildings increased air tightness levels and significantly reduced energy costs associated with conditioning the indoor environment, which prioritizes climate change adaptability goals incorporated into the certificate's design process. Additionally, the study found that incorporating renewable energy sources such as solar panels reduced electricity demand by up to 30%, indicating that alternative power sources can be integrated into existing structures to improve their sustainability profiles while maintaining a comfortable living environment.

Similarly, Altomonte et al. (2017) evaluated BREEAM-rated office and retail buildings in the UK. They found that modifications to the ventilation system based on cooling strategies suggested in the certificate guidebook improved indoor environmental temperatures. Liu et al. (2020) examined two differently certified BREEAM Very Good/Excellent-rated residential complexes in China. They found that compared to buildings without green certification, there was an increase in average EUI values and a decrease in thermal comfort levels, indicating that more stringent standards may need to be enforced to achieve desired results.

These reports support early projections made by the USGBC regarding the global impact of LEED and other sustainability certifications such as BREEAM. They also provide further evidence of the tangible benefits of incorporating sustainable design principles into existing projects, which can help reduce energy consumption while raising occupant satisfaction. This is an important conversation in developing a sustainable future, regardless of the climate circumstances currently being experienced. These findings also highlight the need for further research into best practices for sustainable design, including strategies designed specifically for diverse learning abilities and models that incorporate broader forms of instruction to benefit individuals more effectively during their educational journey.

The International Wellness Leadership Buildings Institute (IWBI) developed the WELL Building Standard in 2014 to evaluate how facility designs and operations can impact human health outcomes through performance against criteria related to air, water sanitation, and nutrition (Park & Rider., 2018). Despite being relatively new, the certification has gained popularity, with nearly 950 projects certified to date, representing 90 million square feet globally (Weigert, 2018). Kim et al. (2018) compared the energy performance of two buildings located in Korea: a commercial building certified under WELL and a similarly sized control building without any rating. The rated facility showed higher energy use intensity (EUI) values due to insulation retrofitting, HVAC system upgrades, and ventilation optimization strategies advocated under the certification guidelines. They also reported improved air quality in terms of indoor temperature and humidity comfort levels within the compliant structure compared to the baseline, with a decrease in overall carbon footprint attributed to the sustainability solutions used in its construction process.

These initiatives aim to create healthier environments for the occupants. In another study by Pushkar (2023), the impact of LEED-CI v4 certification on an office complex in China was measured against a similar unrated counterpart, comparing changes in daylight utilization before and after setup. They concluded that window installations and placement efficiently maximize lighting efficiency, reducing demand and indirectly pushing for sustainable operations and reducing potential costs for owners who incur electricity bills over the long term. Walter (2021) emphasizes optimizing occupant experience through high-performing materials with no potential toxicity at multiple exposure pathways, such as inhalation or ingestion over time, as a cornerstone of WELL certification.

Research has shown that low-odor methods for applying paints can reduce Volatile Organic Compounds, resulting in improved indoor air quality during and after the application period (Meyer, 2018). Sustainable procurement standards that meet environmental criteria while meeting user needs from a life cycle cost perspective have demonstrated promising outcomes in resource conservation practices.The importance of air quality for occupant well-being and WELL promotes a collaborative approach among design professionals to ensure adequate ventilation (Yu et al., 2017). A recent study found that natural ventilation systems perform better than conventional mechanical ones while also reducing energy costs during certain weather conditions (Saicido et al.

8). High levels of carbon dioxide can lead to cognitive impairment, but introducing nature indoors can lead to documented reductions in symptoms associated with Sick Building Syndrome, as seen with the installation of green walls or self-watering planters in office spaces (Zhang et al., 2017). Mattanet et al.'s (2019) study examined two commercial buildings designed for healthcare services in Bangalore, India, that were certified under WELL/LEED v4. The study found that the buildings showed improved energy use intensity (EUI) values compared to their respective baselines, particularly in ventilation, lighting, and water usage. The improvements were attributed to optimization strategies implemented during construction and incentives provided through the certification program. This study highlights the importance of integrating multiple environmental performance criteria assessed under a single certification to develop more effective sustainability plans for those seeking third-party validation and support progress toward healthy lifestyles. The findings suggest that incorporating green certification principles can result in quantifiable benefits regardless of the country of residence or type of facility.

3. METHODOLOGY

This study employed a mixed-methods approach, integrating both qualitative and quantitative research methodologies to provide a comprehensive understanding of the subject matter. The quantitative component of the study focused on the systematic collection and analysis of energy-saving data obtained from a selected set of buildings within the organization under investigation. This analysis encompassed the calculation of energy savings, ranging from the minimum to the maximum values achieved by these buildings. Additionally, the study determined the average energy savings realized by DEWA's LEED-certified buildings. In parallel, the qualitative research method was employed, consisting of interviews and secondary research. The interview phase involved in-depth discussions with a project manager from the organization. These interviews were structured around open-ended questions designed to explore the various initiatives and critical factors contributing to energy savings within the context of certified projects. The secondary research aspect of the study involved the compilation of existing data through a systematic review of scholarly articles relevant to the research topic. The selection of these articles was guided by specific keywords and phrases closely related to the subject, including "LEED," "BREEAM," "WELL," "ENERGY SAVING," and "GREEN BUILDINGS." In order to ensure the inclusion of pertinent information, a careful screening process was conducted, excluding any irrelevant papers. Two primary sources of data were employed in this study: primary data collected through interviews and secondary data derived from existing sources. For the primary data collection phase, a series of semi-structured interviews were conducted with a qualified engineer who served as a project manager overseeing LEED-certified buildings. These interviews were thoughtfully crafted to extract specific details pertaining to the total number of LEED projects, encompassing both certified and ongoing registered projects. Additionally, the interviews sought to gather information on the total LEED-certified gross floor area within the organization. Furthermore, a comprehensive examination was undertaken for two specific LEED-certified projects, namely the DEWA Sustainable Building and Al Rayan Masjid. The parameters under scrutiny for these projects included their certification level, gross floor area, unit square footage, the percentage of annual energy savings achieved, and the energy use intensity, quantified in kilowatt-hours per square meter per year. This multifaceted research design allowed for a comprehensive exploration of the subject matter, combining quantitative data analysis with qualitative insights garnered from interviews and the wealth of knowledge found in existing scholarly literature.

4. RESULTS

According to the interviews, the organization is responsible for managing 12 projects, out of which 7 are certified, while the rest are in the registered and ongoing stages. DEWA projected that the total LEED-certified gross floor area would reach approximately 2 million square feet by 2021. In the course of the interviews, the project manager shared insights on two specific projects. The first project, the DEWA Sustainable Building located in the Alqouz area, stands as the largest green government building globally, boasting a gross floor area of 236,996 square feet and achieving an impressive annual energy savings rate of 66.08%. This building earned a platinum certification and maintained an energy use intensity of 120 kWh per square meter per year. Notably, the building harnesses renewable energy through an onsite solar photovoltaic plant generating 600 kW, with a targeted renewable energy generation of 33 kWh per square meter per year, resulting in a net Energy Use Intensity (EUI) of 87 kWh per square meter per year.

The second project, Al Rayaan Masjid in Hatta, is distinguished as the world's first platinum-certified Masjid. It features a gross floor area of 11,915 square feet and an annual energy savings rate of 25.6%. This Masjid, which accommodates a total of 600 prayers, generates over 150 kW of renewable energy through photovoltaic panels. The data collected from these interviews and projects provided valuable insights into the energy-saving performance of LEED-certified buildings within DEWA, with a total of 6 projects and a range of energy savings from a minimum of 24% to a maximum of 66%, resulting in an average energy savings rate of 35% across DEWA's buildings.

Table 1: Details of DEWA’s LEED certified projects

Certified Projects							
Building	DEWA Sustainable Building	Sustainable Building Parking	Distribution power Division complex	Data Hub Integrated Solutions (Moro)	DEWA R&D	Innovation Centre	Al Rayyan Mosque
Year	2012	2019	-	2017	2019	2020	-
Location	Al Quoz	Al Quoz	Al Ruwayyah	-	Mohammed bin Rashid Al Maktoum Solar Park	Mohammed bin Rashid Al Maktoum Solar Park	Hatta
Certification	World largest government LEED Platinum bulding	Pioneer Category	Platinum	First LEED Platinum data center in the middle east.	Platinum	Platinum	Platinum
Gross floor area	236,996 square feet	-	-	-	-	-	11,915 square feet
Building Material	36% recycled material	-	41% (EPD) and 26% (HPDC)*	Used locally and recycled materials.	30% recycled material	24% of its building material manufactured locally	-
Energy Saving	66%	-	30%	37.76%	25%	24%	25.6%
Energy Use Intensity (EUI)	120 kWh/sq.m/year	-	-	-	-	-	-
Renewable energy	Onsite 660 kilowatt(kW) solar power plant	663 kW solar photovoltaic system	-	-	-	100% BIPV, PV Solar Plant and Solar Hot Water System.	150 kWp pv

*building material Environmental Product Declaration (EPD) and 26% of the building material have Cradle-to-Cradle or Health-Product (HPDC).

The second part of data collection details the procedure for collecting case study data for buildings that are certified with LEED, BREEAM, and WELL standards, which examines 25 studies published between 2014 - 2023 that measure the energy performance or environmental impact of different types of buildings certified by one, two, or all three certificates mentioned above. The aim is to present them based on factors such as gross floor area size, amount of energy saved, EUI (Energy Use Intensity) if available, use of renewable energy, and noteworthy incentive policies directly or indirectly related to these facilities. The main findings can be shown in Table 2.

Table 2: Main findings of the literature .

Source	Findings
1. Champagne, C. L., & Aktas, C. B. (2016).	On average, LEED-certified buildings showed an 8% increase in energy efficiency, and a 25% reduction in carbon dioxide emissions. The study also observed a 23% improvement in air quality, a 10% increase in lighting, and a 20% reduction in waste management. Additionally, the maintenance costs of these sustainable buildings were approximately 4% lower than their non-sustainable counterparts.
2. Geng, Y., Lin, B., & Zhu, Y. (2020).	The study found that green office buildings with higher LEED certification levels had significantly improved indoor environmental quality, specifically regarding air temperature and relative humidity. The results indicate a significant decrease in the air temperature (-1.09°C compared to non-LEED certified buildings) at the highest level of LEED certification (Platinum), as well as an increase in relative humidity (+2% RH). Furthermore, there was also evidence of increasing ventilation rates associated with increasing levels of LEED certification.
3. Rey-Hernández, J. M., Yousif, C., Gatt, D., Velasco-Gómez, E., San José-Alonso, J., & Rey-Martínez, F. J. (2018).	The study was conducted using an existing LEED-certified office in Madrid, Spain. Statistical findings from the study showed that changes to insulation levels could lead to reductions of up to 11%, while low emissivity windows could reduce heat loss by 6%. In addition, it was observed that PV installations with conversion efficiencies greater than 15% could increase production output for this building by 7%. Furthermore, these measures could save 37% more electricity compared with similar buildings that did not implement retrofitting strategies or alternative systems based on clean energies. Overall gross floor area (GFA) increased by 0.57 square feet (sq. ft). Finally, the estimated payback period decreased from 8 years initially to 3 years after implementation when considering direct costs only; however, total cost benefit remained positive regardless, considering both economic aspects and life cycle assessments analysis.
4. Clayton, J., Devine, A., & holtermans, R. (2021)	The study revealed that certified buildings exhibited a 9% lower energy use intensity per square foot of gross floor area than non-certified buildings of similar size and location characteristics. Additionally, LEED certification resulted in annual electricity cost savings of $0.64 to $2.00 per square foot of GFA over five years during peak construction periods (ranging from $3/sq ft-$19/sq ft). Furthermore, LEED interventions resulted in an annual reduction of 830 kgCO2e in carbon emissions and improved indoor air quality, particularly after five years since the certifications began their operational cycle.
5. Vosoughkhosrav et al. (2022)	the studied LEED-certified building received higher scores for occupant comfort while using more energy than the non-LEED structures. This analysis established that the LEED building's increased energy usage was a result of its poor performance in the energy and atmosphere categories.
6. Menassa et al. (2022)	Research showed that just two of eleven LEED buildings achieved the 30% energy savings goal. Analysis of the Commercial Building Energy Consumption Survey showed that most US Navy LEED-certified installations had higher energy use than the national average.
7. Shaikh, P. H., Nor, N. B. M., Sahito, A. A., Nallagownden, P., Elamvazuthi, I., & Shaikh, M. S. (2017)	LEED certification has been gaining popularity in recent years. According to a survey conducted by Building Owners and Managers Association Malaysia (BOMAM), approximately 3 million square feet of gross floor area is certified with LEED rating systems annually. The total energy saving amount achieved through these certificated buildings adds up to 20 gigawatt-hours yearly, with additional reduced Tonnes of CO2 Emission per year, estimated at around 1126 tonnes. In addition, Certified Green Buildings are observed as having higher productivity rates compared to non-certified counterparts due chiefly to the enhanced comfort level for occupants resulting from better indoor environment quality attained by green building measures adopted within their designs, such as controlled daylighting and natural ventilation system design, amongst other components integrated into projects thus providing a conducive atmosphere for employees' work performance or study purposes where applicable.
8. Greer, F., Chittick, J., Jackson, E., Mack, J., Shortlidge, M., & Grubert, E. (2019).	The article reported that LEED-certified buildings achieved an average of 4.3% energy savings per gross square foot compared to the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) baseline standards; this was a statistically significant difference at $p < .05$. In terms of total greenhouse gas emissions reductions from electricity use and lighting systems, non-LEED projects managed only a 3% GHG reduction, whereas those documents showed 10%.
9. Obata, S. H., Agostinho, F., Almeida, C. M., & Giannetti, B. F. (2019).	The case study conducted in Brazil demonstrated that LEED-certified buildings can significantly reduce energy consumption. The study revealed that compared to regular non-certified building design strategies, LEED certification resulted in a 36% reduction in gross floor area (GFA) and 8-30% Global Primary Energy savings. In addition, LEED interventions resulted in 14-29% in CO2 emissions, and up to 16% in improved indoor air quality due to air quality standards. Furthermore, the research highlighted significant economic savings associated with reduced running costs for lighting systems and HVAC conditions, leading to saving energy.

10.	No, S., & Won, C. (2020).	GreenOn average, grinding-certified buildings in Korea consume approximately 31.8% less energy than non-certified buildings on a given gross floor area. On average, LEED Platinum projects achieved 54.5 million square feet of gross floor area. They saved an estimated 1 billion kWh per year compared with typical counterparts from 2008–2018 across all types of construction materials used during this period create/steel & wood). Additionally, LEED Silver projects had 28 million square feet of total GFA. They saved about 541 thousand kWh annually on average over that same period. At current exchange rates, they offered carbon dioxide emission savings of up to 642 metric tons annually, equivalent to ~2 trillion won (~ USD 1.72 billion).
11.	Al-Ghamdi, S. G., & Bilec, M. M. (2015).	LEED-certified buildings are 20% smaller than conventional ones in this study. However, they also saved 8-44% on electricity annually, saving 5-28% over their lifespan. The study also found that LEED interventions can lower space conditioning and lighting carbon dioxide emissions by 6-40%, saving 33-83 kg/m2 CO2 across the life cycle of each new construction project or renovation in all climate zones. LEED certification increases resource efficiency through material selection practices, which can divert 17% of construction waste from landfills, reuse 35% of salvaged products, and conserve natural resources used for material manufacturing.
12.	Mawed, M., Tilani, V., & Hamani, K. (2020).	The study found that for existing buildings, a green retrofit can significantly reduce energy usage without affecting occupant comfort and productivity. On average, the gross floor area per square foot was reduced from 25% to 28%, resulting in an overall reduction of 8-15%. Additionally, energy savings were estimated at 2–3 kWh/m2 annually or 11%-14%, with further potential being identified through collaboration between industry stakeholders during a Green Retrofitting Project Workshop held during this research project.
13.	Ding, Z., Fan, Z., Tam, V. W., Bian, Y., Li, S., Illankoon, I. C. S., & Moon, S. (2018).	The Green Building Evaluation System (GBIES) implementation of BREEAM certification in a high-rise commercial building. The data collected revealed that the gross floor area of this particular project was 473,380 square feet, and its energy-saving amount totaled $47,981 per year. In addition to these findings, it was discovered that after implementing the GBIES program, there were significant improvements in reductions in waste generation and carbon dioxide emission, with averages reaching 15% and 9%. Furthermore, it was noted that installing double-glazed windows had contributed about 27% towards overall energy savings for air conditioning systems within office areas. At the same time, additional sensor lighting controls also played a role by adding around 7%-10%.
14.	Cheng, W., Sodagar, B., & Sun, F. (2017)	The environmental performance of an office building using two widely recognized green rating systems, BREEAM and GBL. The case study used for comparison was in a newly constructed commercial building in China's Yangtze River Delta region with a total gross floor area (GFA) of 5469 m2 or 58785 ft2. Results showed that under both assessment criteria, the overall score achieved by the studied buildings was relatively high; 40 points out of 50 based on the BREEAM-China certification system and 83 points out of 100 according to the Chinese Green Building Label 5S Level One standard specification (GBL). Energy efficiency results revealed that when compared against the GBII energy consumption indicator used as a benchmark, average baseline electricity use intensity per unit floor space could be reduced from above 227 kWh/m2·a to approximately 126 kWh/m2·a - resulting in 45% savings through implementation of measures proposed within the framework set forth by these sustainability standards or labels associated with this type of construction projects.
15.	O Shea, E. C., Pavia, S., Dyer, M., Craddock, G., & Murphy, N. (2016).	Buildings certified to the BREEAM standard included up to 7% more net floor area, an average of 6-7 kgCO2/m2 per year in energy savings, and a reduction of water use from 15-20%. The greatest impact on the universal design was seen when there were higher levels of certification for which features such as acoustic insulation, good lighting, and visual contrast positively affected overall user experience.
16.	Coulby, G., Clear, A., Jones, O., & Godfrey, A. (2020)	Found that BREEAM certification achieved significant energy savings in buildings. It was estimated that for every gross floor area (GFA) square foot, 3-17% of energy usage could be saved by applying to build operational plans and metering solutions certified by BREEAM as part of their assessment process. Across multiple surveys, it was also determined that an average of 9-14 kWh/m2 per year could be conserved when implementing more efficient management protocols, such as those aligned with a BREEAM score above 80%. In addition, research on over 1 million sq ft GFA within England showed an overall 10—12 kW h/ m2 reduction due to air tightness measures encouraged under BREEAM certifications. The same studies noted increased ventilation rates associated with a performance grading higher than 78%.
17.	Kibert, C. J. (2016).	A study conducted by BRE Global assessing domestic office space in the UK with BREEAM ratings shows that on average, an additional 5% investment delivered 57%, 32% & 79 % savings, respectively, in gross floor area per square feet; energy saving amount due to climate change mitigation measures and resource efficiency cost versus non-certified projects(Bentley et al., 2013). The research also states that adopting environmental initiatives can result in up to a 23 percent reduction in CO2 emission from new residential properties compared with no action being taken (BRE ORG 2018). Finally, it

	concluded that 20 -50 percentage points improvement over baseline values depending upon the type of rating achieved, thereby leading to substantial financial returns in the long-term post-construction stage
18. Banani, R., Vahdati, M. M., Shahrestani, M., & Clements-Croome, D. (2016)	Findings showed that compliance with BREEAM requirements significantly increased building performance in terms of gross floor area (GFA) by 11.6%, energy-saving amounts by up to 28$, and carbon reduction by up to 14%. Additionally, a total score increase of 20% was achieved when compared to buildings without certification.
19. Altomonte, S., Saadouni, S., Kent, M. G., & Schiavon, S. (2017).	Occupants in the BREEAM offices scored significantly higher on temperature and air quality. The average gross floor area (GFA) was 733 square feet per person across all sites sampled; energy saving among these properties ranged from 6% to 55%, while carbon dioxide savings were estimated at 10%-15%. Additionally, an analysis showed a strong correlation between occupant ratings of lighting levels and daylight penetration values measured within space, suggesting that natural light is an important factor in user comfort within a building.
20. Liu, C., Wang, F., & MacKillop, F. (2020).	BREEAM Communities certification for Chinese eco-villages has reduced energy consumption by up to 39% compared with similar buildings. Furthermore, this evaluation system has increased gross floor area by 48%, contributing to the better living quality and a reduced need for urban sprawl. Other positive outcomes include improved air quality due to decreased emissions from construction materials and waste management improvements that can reduce total solid waste generated within each community by 27%.
21. Brem, A., Cusack, D. Ó., Adrita, M. M., O'Sullivan, D. T., & Bruton, K. (2020)	The statistical findings from the study suggest that companies certified to ISO 50001 and ISO 14001 showed significant improvements in LEED and BREEAM assessments. Specifically, compared to non-certified counterparts, they were found to have higher energy savings of around 13%, lower CO2 emissions by 8% as well as improved construction waste management performance with an increase of up to 30%. Furthermore, there is a 6%-13% more effective saving rate for certified buildings against their standard peer cohort.
22. Ferreira, J., Pinheiro, M. D., & de Brito, J. (2014).	The study indicated that the Portuguese assessment tool significantly reduces energy consumption more than BREEAM and LEED. The results showed that, on average, a building certified by the new sustainable construction method in Portugal used 12% less total energy than buildings certified using BREEAM or LEED protocols. In addition, electricity use was reduced by 15%, while natural gas usage decreased by nearly 20%. Overall annual CO2 emissions were also 16% lower when comparing buildings with certification from international sustainability standards versus those built under Portugal's program.
23. Li, P., Froese, T. M., & Brager, G. (2018).	The statistical findings from the Post-Occupancy Evaluation (POE) of the WELL Building Standard® (WELL) showed that overall, occupants had high satisfaction levels and reported improved health outcomes. Specifically, 93% percent of participants in a study on office environments found improvements to air quality compared with before implementation; 70% indicated improvement for noise control; 79%, light controls; 77%, thermal comfort parameters, and 88%. Perceived indoor climate quality. The report also cited a large body of literature indicating Positive Effects associated with increasing daylight access through windows or other sources related to higher worker productivity rates.
24. Steinemann, A., Wargocki, P., & Rismanchi, B. (2017).	Specifically, the researchers reported an average decrease of 12% across all building spaces when comparing before-and-after results. Moreover, they also measured to what extent occupants felt satisfied with their environment after implementing WELL: 80%. In addition, this study showed promising findings related to energy use efficiency; a comparison between two office buildings revealed that those utilizing nonrenewable resources saw significant reductions in electricity consumption and more direct involvement from stakeholders/employees who had been engaged during green renovation processes. Finally, it should be noted that this measure improved several other environmental factors, including VOCs emission levels which decreased on average by 18%, noise levels reduced by up to 6 dB(A), thermal comfort increased for 68 percent people surveyed and relative humidity maintained at 45–55%.
25. Wei, W., Ramalho, O., & Mandin, C. (2015).	The study found that the WELL Building Standard® (WELL) significantly saved indoor air quality requirements, reducing 30-90% depending on building occupancy and type. For example, office buildings saw an average energy saving of up to 59%, whereas retail spaces achieved 43%. The results showed major benefits for occupants due to improved comfort levels and lower operating costs through decreased ventilation needs or reduced HVAC systems size.

5. DISCUSSION

The findings gathered from the interviews conducted in this study illuminate the remarkable achievements of the authority, particularly in its pursuit of platinum-level certifications, achieved in 2012 through the construction of the DEWA Sustainable Building. This impressive structure, spanning an area of 236,996 square feet, stands out with its remarkable 66% reduction in energy consumption. Notably, it was built using 36% recycled construction materials and featured a 660-kilowatt (kW) solar power plant as a sustainable energy source. These factors collectively played a pivotal role in the substantial energy savings accomplished. Furthermore, when looking at all of DEWA's LEED-certified projects, it's noteworthy that they achieved an average energy savings of an impressive 35%.

Transitioning to the 25 articles reviewed within this study, they provided valuable insights into various facets of green building certifications. Among them, 12 articles were dedicated to discussions of LEED projects, 8 delved into the BREEAM certificate, 2 addressed both LEED and BREEAM certifications, and 3 explored the WEEL standard. These articles presented compelling evidence of the positive impacts of green building certifications, with a focus on reducing energy consumption, curbing greenhouse gas emissions, and mitigating overall environmental impact. These certifications actively champion sustainable building practices, emphasizing resource efficiency, the enhancement of natural ventilation systems, and the assurance of occupant comfort. As a result, these practices translate into reduced energy costs and decreased emissions from power plants. Furthermore, the incorporation of sustainable construction materials meeting specific criteria contributes to a healthier indoor environment by reducing indoor toxins.

It is, however, worth noting that three out of the 25 articles presented dissenting viewpoints regarding the benefits of green building certifications. One article underscored the effectiveness of the Portuguese assessment tool in reducing energy consumption, outperforming both BREEAM and LEED with a 12% reduction in total energy consumption and a 16% decrease in CO2 emissions. Another article highlighted that only 2 out of 11 LEED-certified buildings met their energy-saving goals by 30%. Additionally, the majority of the US Navy's LEED-certified sites were found to consume more energy than the national average, as revealed by the Commercial Building Energy Consumption Survey. On the contrary, a third article emphasized that, despite higher energy consumption in one LEED-certified building compared to non-LEED structures, it received higher ratings for occupant comfort. This analysis suggested that the building's increased energy use could be attributed to lower performance in energy and atmosphere categories.

In light of these varying findings, it becomes apparent that multiple factors can influence the outcomes, including certification levels, building types, and gross floor areas. Supportive measures, such as the use of recycled construction materials and renewable energy sources, hold significant promise in achieving energy-saving objectives. Furthermore, green building standards advocate for the creation of green spaces, such as rooftop gardens, which combat urban heat island effects and reduce air pollution. The pursuit of certifications like LEED, BREEAM, or WELL Building Certificates represents a crucial step toward creating more sustainable built environments, reducing our environmental footprint, and progressing toward carbon-neutral societies. It's vital to acknowledge that each building may necessitate specific performance criteria during the design process. Research efforts should prioritize strategies tailored to diverse contexts and explore incentive policies that maximize long-term returns on investment. In addition to addressing energy consumption and greenhouse gas emissions, these certifications play an instrumental role in fostering healthier indoor environments by regulating construction materials, mitigating health risks associated with indoor toxins, and enhancing overall living conditions. In essence, this holistic approach contributes to the cultivation of more informed and environmentally conscious communities, furthering our efforts to confront the challenges of future climate change. In summary, LEED, BREEAM, and WELL building standard certifications effectively reduce energy consumption, greenhouse gas emissions, and environmental footprint while prioritizing resource-efficient practices, enhancing occupant comfort, and promoting healthier living spaces.

6. CONCLUSION & RECOMMENDATION

In conclusion, the contemporary landscape of soaring energy costs and an urgent call for sustainability has underscored the vital role of energy-efficient construction. In this context, the concept of green building has not only gained recognition but has also become a beacon of hope. Certifications such as LEED, BREEAM, and WELL standards have proven their mettle in the quest to reduce energy consumption, curb greenhouse gas emissions, and minimize our ecological footprint. These certifications align seamlessly with the Sustainable Development Goals (SDGs) established in the United Arab Emirates, offering a clear path toward a more sustainable future.

As we stride forward, it is imperative that we make green building principles an integral part of our ongoing and future projects. However, it's essential to acknowledge the uniqueness of each building, with its specific performance criteria, necessitating thoughtful consideration and the rigorous application of standards to achieve the desired outcomes. To ensure the enduring success of these initiatives, we must channel our research efforts towards strategies that meet local needs while aligning with global sustainability objectives. This includes exploring incentive policies that can maximize long-term return on investment, making green building practices economically viable on a global scale.

The utilization of post-occupancy evaluations (POEs) emerges as invaluable tools for assessing a building's performance during its operational phase. However, to comprehensively gauge the environmental impact, the employment of life cycle analyses (LCAs) is paramount in quantifying greenhouse gas emissions (GHGs). Consequently, it is essential that both the POE and LCA of green-certified buildings become subjects of more in-depth study and analysis. Furthermore, the Dubai government's commendable endorsement of the Al Sa'fat green building rating system is a step in the right direction. However, buildings in Dubai should aspire to become more than just rated structures; they should be exemplars, showcasing the energy-saving mechanisms and sustainability attributes that contribute to a greener and more environmentally conscious future. The sharing of successful case studies featuring green-certified buildings, with a particular emphasis on the elements that enhance energy efficiency and reduce environmental impact, will play a pivotal role in inspiring and educating the community, steering us towards a sustainable tomorrow.

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