APPLICABILITY OF GREEN CERTIFICATION SYSTEM FOR DOMESTIC CONSTRUCTION PROJECTS IN SRI LANKA

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Abstract: Consistently, researchers have noted that 20 to 30 percent of damage to the environment can be attributable to residential construction. There are a plethora of green certification systems available for implementation throughout the construction phase in Sri Lanka, and the number of adoptions has increased in recent years to lessen the impact on the environment. Even if there has been progress in the implementation of green certification systems, the procedure and associated expenses have been a major concern in the business community. Consequently, the objective of this study is to identify the best appropriate green certificate system for Sri Lankan residential construction projects. The literature review was conducted and analysed using "NVivo." Initially, a questionnaire was deployed to collect primary data, which was subsequently confirmed through interviews with subject matter experts. Sixty-nine professionals with 10 to 15 years of industry experience responded to the survey, and five specialists with more than 30 years of professional experience validated its results. Both the significance of adopting the green certification system and the hurdles that developed during its adoption were addressed in the study. It was recommended that state assistance, social awareness, and continuous education for professionals could facilitate in overcoming the obstacles. Finally, it was determined that the LEED system is the most appropriate green certification system for residential development because it generates environmentally and user-friendly sustainable products.

Keywords: *Green certification, Sustainability, Domestic construction, Sri Lanka*

1. Introduction

The construction industry has been recognized as an economic regulator of any nation due to its substantial contribution to the nation's Gross Domestic Product and its economic multiplier effect. (Giang, D. T. H. and Sui Pheng, L., 2011, Eskerod, P. and Duric, J., 2018). Even though construction is important to the national economy, it has a negative influence on the natural environment. These negative effects include construction noise, dust, traffic, congestion, water pollution, and disposal system (Zuo, J. and Zhao, Z.-Y., 2014). Furthermore, studies discovered that the construction industry consumes 36% of world energy and produces 40% of greenhouse gases that contribute to global warming (Weerasinghe, A. S. et al., 2021). Because of these factors, it is critical to consider sustainable construction approaches. As a result, green buildings are regarded as one of the most important measures to reduce the negative influence on the environment. The concept of "Green Building" has become a prominent and crucial topic in the construction industry at present (Zhang, Y. et al., 2017, Casini, M., 2022a). According to studies, green buildings reduce energy usage by 19% and CO2 emissions by 36% when compared to conventional structures (Weerasinghe, A. S. et al., 2021).

Furthermore, green buildings reduce carbon emissions by 35%, water use by 40%, and energy consumption by 50% (Li, X. and Zhang, Y., 2018, Makandar, S. S. and Sanadi, N. A., 2019, Casini, M., 2022a, Casini, M., 2022b). Green buildings have been shown to have a substantial impact on sustainability. Green certification and rating systems have been identified and are being used in building construction projects to assess environmental friendliness and sustainability, as well as to help the building construction process achieve sustainability (Tang, K. H. D. et al., 2020, Chen, X. et al., 2021). Despite the fact that numerous techniques have been devised for building construction projects to reduce carbon footprint, it is extremely difficult to improve existing sustainability levels through domestic house construction projects without actively using these techniques (Zimmermann, R. K. et al., 2019, Tang, K. H. D. et al., 2020).

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The aim of this research is to identify a suitable green certification system to domestic construction projects in Sri Lanka. To achieve mentioned aim, five objectives were defined, including to identify the importance of adapting green certificate system for domestic buildings, identify most suitable criteria's to be cover in a domestic project to get the green certificate, discover the barriers that arise while adapting green certificate system, suggest solution to overcome the barriers and identify the most suitable green certificate system for domestic projects in Sri Lanka.

2. Literature Review

2.1. IMPORTANCE OF GREEN CERTIFICATE

First and foremost, green buildings are advantageous to the environment in multiple ways (Ashuri, B. and Durmus-Pedini, A., 2010). One-fourth of all greenhouse gas emissions are caused by construction energy (GHGs). Green building certification can decrease energy consumption in newly constructed buildings by at least 25% and in conventional building operations by at least 16%, according to studies (Waidyasekara, K. G. A. S. and Fernando, W. N., 2011). The usage of hydraulic technology and equipment by green buildings will reduce water consumption by 15% (Nalewaik, A. C. C. E. M. and Venters, V. C. C. C., 2009). Up to 23% of air pollution is a consequence of construction, which also generates a significant amount of waste. Green builders utilize recycled materials that are more likely to preserve trees and less wasteful by repurposing materials. Greening will incur initial expenses, but long-term cost reductions are anticipated. An average of 30% of the building's energy consumption is wasted due to inefficient lighting and equipment. One of the most effective energy efficiency techniques that managers may implement is one with a payback period of 2.5 years and average energy savings in buildings of 38%, resulting in energy savings of 15-20% (Waidyasekara, K. G. A. S. and Fernando, W. N., 2011, US Green Building Council, 2014, US Green Building Council, 2020). Other approaches can generate significant savings. (Wickramasinghe, H., 2009). Green buildings provide significant health benefits: a healthier working environment promotes employee happiness, dedication, and productivity. Additionally, a healthy environment is likely to result in reduced absenteeism and lower turnover (Munasinghe, L. M. et al., 2018). By implementing air quality management and illumination management systems, one WELL-accredited organization achieved a positive return on investment within three months by analysing sick leave and turnover reductions (Scofield, J. H., 2013).

Climate change is becoming a major investment concern, and as a result, investors are withdrawing investments from companies with unfavourable impacts on the environment. One of the benefits of green construction is that it is sustainable for investors, and standard investment firms place greater attention on the economic, social, and managerial data of businesses, with an emphasis on the environment. If businesses maintained a higher level of environmental adaptability, they would be significantly more competitive in the marketplace (Plebankiewicz, E. et al., 2019). Green buildings have a distinctive building quality that ensures the effective use of water, energy, and other resources. Green buildings reduce energy consumption in lighting systems by adopting a task-lighting strategy in conjunction with natural light, allowing consumers to save up to one-third of their energy costs. Due to the fact that a facility can be operated and maintained for 80% of its lifetime, minimizing these expenditures substantially enhances the revenue of building owners. Green building construction using conventional technology is significantly more expensive than non-green building construction. However, studies have shown that reduced operating and service expenditures make it significantly cheaper in the long run (Waidyasekara, K. G. A. S. and Fernando, W. N., 2011).

The designers of green buildings are attempting to decrease their reliance on non-renewable energy sources such as coal, gas, and other fossil fuels. Using a variety of strategies, designers are attempting to maximize the utilization of natural resources. These steps assure a greater reliance on renewable energy sources as opposed to non-renewable energy sources. Energy harvesting techniques, such as the usage of solar panels and hybrid lighting systems, are examples of such techniques (Haq, S. et al., 2012). The character of the indoor working environment of the facility is determined by the capabilities of the building's support services, which include lighting, ergonomics, temperature, and air quality. Good indoor environmental quality safeguards the health, reduces stress, enhances the quality of life, and even extends the life expectancy of a building's occupants. On the other side, studies have shown that recycled materials contain and release significantly less toxicity than virgin ones, and green buildings are intended to achieve these objectives through promoting environmental harmony, minimizing the use of toxic materials, and boosting support services (Wong, J. M. W. et al., 2010). The efficacy and efficiency of water use, as well as water conservation, will ensure that present and future generations have a secure supply of clean water. The architecture of green building design permits direct and indirect water conservation techniques. Utilizing alternate water sources, such as rainwater, surface water, and recycled water, is one example of direct conservation strategies. Examples of indirect water conservation strategies include pressure management and the use of efficient fixtures (Eskerod, P. and Duric, J., 2018). Due to the performance of the materials used to construct these structures, residents of green buildings enjoy numerous health benefits. For instance, ecologically aware builders avoid using hazardous items such as plastic by-products and paints containing lead. Toxic compounds such as carcinogens not only create severe respiratory issues, but also cause cancer (Smit, A. M. and Toit, F. d., 2015). The efficiency and effectiveness of material utilization are exemplified by the application of physical procedures to ensure minimal consumption without compromising the quality of the product. Green construction businesses have embraced sustainable techniques to obtain optimum material, recycling, and reuse, as well as constructing structures in a way that facilitates the use of less materials, which all adds to an increase in material utilization (Lee, W. L. and Burnett, J., 2008, Wong, J. M. W. et al., 2010). Green

buildings contribute to maintaining a healthy atmosphere by reducing the energy consumption and the rate of climate change by decreasing carbon dioxide emissions (Nalewaik, A. C. C. E. M. and Venters, V. C. C. C., 2009, Mattoni, B. et al., 2018). Furthermore, using technology and methods that improve water and energy efficiency, green buildings can alleviate this burden (Burnett, J. et al., 2008, Lee, W. L. and Burnett, J., 2008).

2.2. TYPES OF GREEN BUILDING ASSESSMENT SYSTEMS

There are a number of Green Building Assessment systems available to enhance the sustainable development (Brick, K. and Visser, M., 2011). These systems are introduced by several green building councils around the world (Zuo, J. and Zhao, Z.-Y., 2014). The selection of Green building evaluation system is discretionary, which implies that anyone can utilize developed assessment system to coordinate sustainable development.

US Green Building Council's Leadership in Energy and Environmental Design (LEED) certification program is one of the most prominent green building assessment system. The LEED certification system offers two distinct certifications. LEED for commercial structures and LEED for residential construction (Rodrigo, A. S. and Jayarathne, M. C., 2012) .The program for LEED certification of single-family homes is known as LEED house. LEED for houses is one of the most demanding green building standards that takes into account by many countries significantly more environmental variables than other green construction initiatives (Rakha, T. et al., 2018). To be recognized as a LEED-certified house, a minimum of 40 points must be earned from the listed green features. A minimum of 80 points must be obtained for a house to be LEED Platinum-certified. A third-party examination with accreditation would test and certify families (Rodrigo, A. S. and Jayarathne, M. C., 2012, US Green Building Council, 2014, US Green Building Council, 2020). Green housing requirements are incorporated into the LEED guidelines. In general, they concentrate on energy consumption and atmosphere, climate change mitigation (Regional Priority), high performance, indoor air quality, location and transportation, innovation, sustainable management, and efficient water management. In addition, the Qualification Program includes restrictions for site selection, public transportation access, the use of certain construction materials based on the source and type of used woods, rainfall control, landscaping, and the avoidance of invasive plant species (Torkaman, T. and Zhouson, S., 2015, Makandar, S. S. and Sanadi, N. A., 2019, US Green Building Council, 2020). The Building Research Establishment Environmental Assessment Method (BREEAM) which is on both environmental and social dimensions of sustainability established by the United Kingdom (Tai-Yi, et al., 2019). The economic factors are 5%, which is more than any of the certificates analysed. This credential's most important sustainable components are capital, environmental impacts, and well-being (Agha, A. et al., 2020). BREEAM is applicable to a vast array of building types and contextual factors. The initial stage is to identify the appropriate certification system; communities, new buildings, in-use or under refurbishment, existing commercial buildings, and urban regions. Secondly, communicate with a BREEEAM assessor who will supervise the certification procedure (Makandar, S. S. and Sanadi, N. A., 2019). BREEAM has six adjective categories to describe a project's success: outstanding (above 85%), excellent (70% -85%), very decent (5% -70%), and good (5% -40%), good (5% -76%), good (30% - 45%), and appropriate (Under 30%). These adverbs are supplemented with one to six stars. Less than one percent of newly constructed non-residential buildings in the United Kingdom are rated W2 as excellent (Rezaallah, A. et al., 2012). There are BREEAM certifications throughout the world, however no "extraordinary" certifications have been given outside of Eurasia since March 2018. The BREEAM rating benchmark levels enable the client or other stakeholder to compare an individual building's performance as well as the sustainability performance of refurbished domestic buildings against BREEAM-rated buildings in the United Kingdom (Agha, A. et al., 2020). Building features that have an impact on human health and well-being may now be measured, certified, and tracked for the first time due to the WELL building standard. The International WELL Building Institute created it to promote better working, living, shopping, and playing environments by examining factors such as nutrition, exercise, mood, sleep, and performance (Scofield, J. H., 2013). The certification is extensively utilized around the world, with the United States and China accounting for more than two-thirds of all WELL-certified projects. Around 32 nations, WELL certificates have been issued for buildings such as new buildings, interiors, refurbishment, existing buildings, and urban environments. Silver, Gold, and Platinum are the three degrees of WELL accreditation (Burnett, J. et al., 2008). In comparison to other systems, the WELL certification is expensive, which is supposed to demonstrate a commitment to obtaining it. The cost of full certification, including registration, begins at 11,100 euros for modest buildings and increases further based on the location and size of the building (Peters, S. T., 2018, Andersen, M. A., 2021). Furthermore, Green Star is an Australian built environment sustainability rating system designed by the Green Building Council of Australia for new buildings (except single-family dwellings), interiors, renovations, and existing buildings (Rakha, T. et al., 2018). The GREEN STAR grading system assesses the entire performance of a development based on its design, delivery, and ongoing performance. It is applicable to all types of construction projects, from large-scale construction to small-scale development. The technology is currently use in Australia, New Zealand, and South Africa, with plans to expand throughout Africa (Peters, S. T., 2018, Andersen, M. A., 2021). The Green Star rating system is based on a range of one to six stars, with the lowest rating being one star and the highest rating being six stars. A minimum of four stars is required for a project to get Green Star certification. Seven countries have awarded approximately 2,254 certifications to various projects. Green Star certification costs range from 4,700 to 34,800 euros based on the nature of the project (Ashuri, B. and Durmus-Pedini, A., 2010). Active House is a new and a holistic certification that considers the environmental sustainability of a building and the impact on its occupants. The Active House system can apply to buildings up to 2,000 square meters, with intends to increase the evaluation to include larger workplaces (Gupta et al., 2018, Tang et al., 2020). Active House is a pass/fail certification that also offers the opportunity to obtain an Active House Radar rating. In 2017, these criteria switched into a verification framework

that permits the quantification and assessment of building sustainability. In Denmark and China, this certification system used for large buildings and also the price includes validation and a sample test (Scofield, J. H., 2013). Deutsche Gesellschaft fur Nathalie's Bauen (DGNB) is a certification system developed by the German Sustainability Council and primarily utilized for new buildings, interior renovations, and existing structures in Germany and neighbouring countries (Doan, D. T. et al., 2017). Platinum, gold, silver, and bronze are the different attainment levels of the DGNB certification system, with 80%, 65%, 50%, and 35% achievable points corresponding to the respective benchmark levels. Moreover, Indian Green Building Council (IGBC), launched this green certification system in 2001 as solution to reduce the environmental impact in India. To meet national objectives, the IGBC has established the IGBC Green Homes Rating System (Gupta, R. et al., 2018, Tang, K. H. D. et al., 2020). The IGBC formed the Green Homes Core Committee including constructors, developers, homeowners, architects, consultants, building science specialists, manufacturers, and industry representatives to focus on the residential sector. The different experiences and professions of the committee members give a comprehensive perspective to the rating program (Gupta, R. et al., 2018, Tang, K. H. D. et al., 2020). The Green Homes Rating System tackles the most important national concerns, including water conservation, waste management, energy efficiency, reduced use of fossil fuels, less reliance on virgin materials, and tenant health and well-being (Zhang, Y. et al., 2017, Tang, K. H. D. et al., 2020). All dwellings that satisfy the required criteria and minimum point requirements are eligible to apply. Various levels of green building certification are granted based on the overall number of points obtained (Andersen, B. et al., 2016, Peters, S. T., 2018, Andersen, M. A., 2021). In Japan, the Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) was established in 2001. This system is based on the life cycle of a building, the assessment methods are classified into four categories: pre-design, new construction, existing buildings, and renovation (Makandar, S. S. and Sanadi, N. A., 2019). CASBEE is an innovative evaluation method that isolates environmental burden from building performance quality. By connecting these two characteristics, CASBEE results are given as an indicator of Eco efficiency or Building Environmental Efficiency (BEE). On a graph with environmental load on one axis and quality on the other, the best facilities will be positioned in the section with the lowest environmental load and the highest quality. Each criterion is awarded between one and five points (Makandar, S. S. and Sanadi, N. A., 2019). In 2010, the Sweden Green Building Council designed a qualification scheme for green buildings named as Miljöbyggnad (MB). Both new construction and existing structures are eligible and once the projects meet the requirements can awarded certificates in three levels as gold, silver, and bronze (Johnson, 2015). Today, over a thousand houses are certified with MB system, which focuses on environmental aspects. In addition, MB's Energy theory emphasized components of wealth and a material principle, with a focus on other environmental aspects. Through the concept of an indoor setting, MB's social sustainability is attained with a high degree of concentration. After conducting research projects and seminars with the assistance of national and international experts, the Green Building Council of Sri Lanka (GBCSL) has developed a "homegrown" green environmental rating system for Sri Lanka that adheres to all leading rating system standards (Wickramasinghe, H., 2009). Because of the development of the construction industry and its greater contribution to the nation's gross domestic product, the green certification system has gained prominence, resulting in rapid economic expansion (Rodrigo, A. S. and Jayarathne, M. C., 2012). GREENSL rating system developed through a transparent, consensus-based approach in accordance with the requirements of a varied community includes the building industry professionals and specialists (Bandara, C. et al., 2018). The GREENSL Credit Rating System is a collection of performance, operation, and maintenance criteria for both public and private existing, commercial, industrial, and residential buildings of all sizes (Mattoni, B. et al., 2018, Tang, K. H. D. et al., 2020). The goal of this system is to promote high-efficiency, safe, sustainable, and cost-effective ecologically sound practices, and to encourage building owners and managers to embrace sustainable practices and limit the negative impacts caused throughout the operational phase of buildings (Li, X. and Zhang, Y., 2018, Mattoni, B. et al., 2018). The requirements and credits of the current GREENSL rating system address eight factors. These can be classified as management, sustainable site, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation and design process, and social and cultural consciousness (Andersen, B. et al., 2016, Peters, S. T., 2018, Andersen, M. A., 2021).

As per the literature stated by many researchers clearly illustrates the usefulness of the different types of green certification / assessment systems that currently implementing by different countries around the world. The below table shows a summary of a green certification systems and the usefulness of each of the system.

Table 1 – Summary of usefulness of the green certification systems

Certificate System	Focus
LEED	Compliance with the LEED certification system results in exceptional indoor air quality, comfortable and stable temperature and humidity, sturdy construction, minimal maintenance requirements, a lower cost of homeownership, a contribution to the mitigation of climate change, being environmentally friendly, being exceptionally energy efficient, high-performance, incurring fewer energy expenses, and promoting healthy indoor environments.
BREEAM	Enhance sustainable use of Energy, Health and Innovation, Land use, Materials, Management, Pollution, Transport, Waste, and Water are the BREEAM's fundamental principles.
WELL	WELL concentrates on Air, Water, Nourishment, Light, Fitness, Comfort, Mind, and Innovation for facilities.

Active House	This accreditation can be used for both new building construction and building renovation. Existing structures and their accompanying concepts include comfort, energy, and environmental aspects.
Miljöbyggnad (MB)	This system is primarily concerned with indoor air quality, energy consumption, and resource utilisation.
GREENSL	The purpose of the GREENSL system is to promote high performance in existing buildings along with safe, sustainable, and cost-effective environmental measures.

According to the above literature summary table, all the green certification systems brings out similar uses for the buildings. Apart from all of them LEED, BREEAM, and GREENSL goes hand in hand by mentioning the same type of relatability that includes in each certification system.

2.3. BARRIERS ARISING WHEN ADAPTING GREEN CERTIFICATION SYSTEM

Even though implementing green technology results in lower operational costs, there are several barriers to adopting a green certification system, according to researchers. One of the largest challenges is the requirement to spend significantly more money up front than for a typical construction. In many regions of the United States, the lack of availability of eco-friendly materials utilized in green buildings is also a significant factor (Cidell, J., 2009). Although the lack of eco-friendly materials is not a major issue in large cities, residents in smaller towns and remote areas will find it incredibly difficult to obtain these materials (Makandar, S. S. and Sanadi, N. A., 2019). It is widespread knowledge that green buildings do not degrade the environment and are far more energy efficient than conventional buildings. However, some disadvantages have been associated with the technology, such as the difficulty to control temperature, lux levels, and humidity, due to a greater degree of integration with the natural environment (Andersen, B. et al., 2016, Peters, S. T., 2018, Andersen, M. A., 2021). Moreover, green buildings designed to harvest sunlight must be aligned perpendicular to the sun's rays, which could lead to issues such as the need for more blinds and shades than in a conventional home to block the sun's rays, and issues between the homeowner and his neighbours if the sunbeam is deflected.

Certain areas in the United States have special restrictions that all structures must adhere to when being constructed, such as the use of prohibited materials or technologies. In some instances, locating a qualified construction company capable of performing the work will be difficult. In general, green construction requires more time than conventional construction, and in some instances, scheduling constraints may lead to the premature abandonment of a project (Cidell, J., 2009). When it comes to commercial green buildings, their commercial value or ability to liquidate in a short period of time is questionable, so investors may not be willing to finance or give a loan for a non-traditional building, financial difficulties, and they may choose for a conventional building instead (Mattoni, B. et al., 2018). Comparing green building to conventional buildings there is a requirement of guidelines or measures to be fulfilled such as environment quality measures, types of materials which by bringing the need of train and educate people to acquire to the work. (Agyekum, et al., 2019) has also mentioned that the lack of trained labourers, consultants and contractors acts as a barrier in adopting green certification system in many countries.

3. Methodology

NVivo was utilised to conduct and evaluate a literature review. To achieve the stated objectives, a prototype survey was conducted to determine the questions based on available data, and initial survey questions were prepared and distributed to industry experts via a pilot questionnaire survey for validation. Questionnaires were used to gather primary data, which was subsequently confirmed through interviews with subject matter experts. Sixty-eight practitioners with one to twenty-five years of industry experience filled out the questionnaire, and five industry experts with more than thirty-five years of expertise participated to the validation process. To analyse the data, both qualitative and quantitative methods were employed. Closed-ended questions were designed to elicit quantitative data from industry practitioners, whereas open-ended questions assisted obtain qualitative data by allowing practitioners to express their thoughts and opinions. To analyse qualitative data, thematic classification and statistical analysis were utilised. Using Microsoft Excel, a spreadsheet tool, the predominant technique for data analysis was basic percentage analysis. The data was represented graphically using tables.

4. Data Presentation

4.1. QUANTITATIVE DATA PRESENTATION OF QUESTIONNAIRE SURVEY

4.1.1. Respondent analysis

Table 1 displays the total number of respondents including Architects (27), Engineers (23), Quantity Surveyors (17) and other professionals such as teacher (1). These above respondents are currently engaging in the construction projects in Sri Lanka, and, they were the people who manage construction projects at a senior level in all categories of construction firms which under Client, Consultant and Contractor. After analysing the respondents' profession, as a requirement for the research the second necessity was to identify their professional qualification and the working experience in the construction industry, which was beneficial to analyse the main objectives of the research, as the respondents' attitudes become differ according to their qualifications and working experience. Year of experience in construction is one of the main aspects that need to search out before analysing the other objectives relates with the research area. As per the information gathered from this type of a question, falls under collecting facts from the

responses. This survey found 12% of respondents has 10-20 year working experience, followed by 15% who possessed working experience more than 20 years. The minority group is about 26% of respondents with less than 05 years and 47% of 10-20 years of experience. Same time, there were 12% respondents' who were achieved in charted level as well as respondents, who have completed diploma level. 10% of under graduated respondents and most respondents have achieved their bachelor's level (44%) and 22% in master's level.

Table 2 - Respondent Analysis

Qualification & Experience	Diploma		Undergraduate			Degree Qualification				Masters Qualification		Chartered Qualification		
Occupation and Profession	<5	5-10	<5	5-10	10-20	<5	5-10	10-20	>20	<5	5-10	5-10	10-20	>20
Client														
Architect	1	2					3				2		1	1
Engineer						1		1						
Quantity Surveyor					4									
Consultant														
Architect		3					2	1			4	1		4
Engineer			1	1		2	2		2	3	2			
Quantity Surveyor	1		1			4	1				2			
Contractor														
Architect											1			1
Engineer						1	4	1						
Quantity Surveyor						2			2					
Other occupations	1						1				1			

4.1.2. Importance of adapting green certificate system for domestic buildings

Observed findings shows that there are number of importance gained while adopting green certificate system to domestic buildings. According to the gathered responses despite of the experiences and qualifications 56% of respondents have mentioned that, Low Maintenance and Operation Cost.; Energy Efficiency.; Enhances Indoor Environment Quality.; Water Efficiency.; Better Health.; Material Efficiency.; Better Environment.; Reduces Strain on Local Resources.; Material availability; Low initial cost; Ease of documentation procedure; Sufficiency of technology and expertise takes the highest importance that gained by adopting green certificate system. Respectively Low initial cost; Ease documentation procedure; sufficiency of technological expertise proves as the further importance that gained by adapting green certificate system in domestic projects in Sri Lanka.

Table 3 – Ranking the Importance of adapting green certificate system

Importance of Green Building certificate for domestic projects	Rank
Low Maintenance and Operation Cost	1
Energy Efficiency	2
Enhances Indoor Environment Quality	3
Water Efficiency	4
Better Health	5
Material Efficiency	6
Better Environment	7
Reduces Strain on Local Resources	8
Material availability	9
Low initial cost	10
Simple documentation procedure	11
Sufficiency of technology and expertise	12

As per the above ranked table 2, 11% of Charted architects who has more than 20 years of experience have ranked the highest importance from 01 – 09. Similarly, 16% of architects who has completed master's level and having 5-10 years of experience, 8% of Engineers and quantity surveyors who has completed bachelor's and having 5-10 years of experience ranked the same set of importance which gained while adopting green certificate system.

4.1.3. Most Suitable Criteria's to be cover in a domestic project to get the certificate

It is well-known that certified green buildings create better living and working habitats. Even though by implementing a simple technique will cause a considerable impact in the respective building. As per the gathered 68 responses, professionals have selected criteria's which need to be in the domestic project to entitle for the green certificate system. Professionals have ranked order criteria as, Healthy and Wellbeing; Energy; water; Waste; Land use; Pollution; Materials; Manahgement; Transport; Innovation. Any type of a structure or a building has its impact on

nature like living beings. Green buildings do not cause any harm or stress to the environment during its entire life cycle. Hence, sustainability must be the centre piece of new designs for the well-being of inhabitants as well as ecology. Therefore, above stated criteria are a must to be included in a domestic project to be certify in the green certificate.

4.1.4 Barriers arise while adapting Green Certificate system

Circulated the questionnaire survey has included a provision to check the barriers that arise while adapting green certificate system in the domestic projects in Sri Lanka. Respondents have stated the barriers that they face by adapting the green certificate system. As per their views, introducing the green certificate system to Sri Lanka is always a challenging effort. Overall, 81% of professionals including Architects, Engineers, Quantity surveyors and other professionals stated that, 'Lack of awareness; Lack of technology and expertise; Complex and costly documentation procedure; High initial cost; Reluctant to change and take risks; High Life cycle cost; Lack of knowledge for maintenance to client; Lack of eco-friendly materials', are highest ranked barriers according to the collected data. 11% of charted architects who has more than 20 years of experience, 13% architects who has completed masters' level, and 11% of engineers who has experience between 5-10 years and completed their bachelors' have ranked above barriers as the main reasons that arise while adapting green certificate system to domestic projects in Sri Lanka.

4.1.5. Most suitable green certificate system for domestic projects

Green certificate system is the finest approach to showcase the sustainability of the individual project or building to relevant tenants. In this study, an exhaustive literature examination highlighted the various green certificate systems, including LEED, BREEAM, WELL GREEN STAR, Active House, DGNB, IGBC, CASBEE, GREENSL, and MB. 84% percent of participants selected the LEED system as the most appropriate green certification system, followed by 78% for the IGBC. 75% for BEEAM, 47.1% for GREEN STAR, and 31% for GREENSL. Active House, WELL, CASBEE, MB, and DGNB were determined to be the least appropriate green certification systems for domestic projects in Sri Lanka. Based on the facts shown above, it is evident that the LEED system is the best and suitable green certification system for residential projects in Sri Lanka.

5. Conclusion

The defined objectives have been accomplished, as explained further in the conclusion. The suggestions are intended to narrow the gap in the Sri Lankan construction industry pertaining to the applicability of the green certificate system for domestic projects. According to the data analysis, the first objective is to determine the significance of adopting the green certificate system for residential development in Sri Lanka, as shown in Table 2.

Achieved the second objective of this research study by identifying relevant criteria's to be covered in a residential project to obtain the green certificate. Domestic, commercial, and all other types of construction projects have both direct and indirect consequences on the environment. According to the comments of professionals, health and well-being, energy, water, and waste are the most prevalent important requirements that must be met by residential development to obtain green certification. The next two objectives of this study were to identify the obstacles and develop strategies for overcoming them. Literature and empirical evidence contributed in identifying ways for overcoming the cited obstacles. The table below demonstrates the obstacles encountered while adopting a green certificate system for residential construction, as well as the corresponding remedies.

Table 4 – Barriers and Solutions to overcome

Barrier	Solutions to overcome
Certain components of the green certification system's assessment criteria are incompatible with domestic construction projects in Sri Lanka.	• Requesting government support • Provide or adopt a relevant certificate for domestic construction in Sri Lanka.
Lack of awareness and understanding of society	• Aware the public regarding the benefits of using green certificates
Lack of technology and expertise in the industry	• educating experts and fostering industry leaders' collaboration
Complex and costly documentation procedure	• Provide online methods to obtain green certificates for domestic construction projects • Aware the public about the green certificate system
High initial & life cycle cost	• Providing loans from the Sri Lankan government to the public.
Reluctant to change form used behaviors and take up risks	• Aware the public regarding the benefits of using green certificates • Bring up supportive rules to the customers
Lack of knowledge to maintain the system	• Aware the public regarding the maintenance process

Unavailability of eco-friendly materials	• Motivate the suppliers to provide eco-friendly materials • Provide government support to the suppliers

This research's eventual purpose is to identify an appropriate green certificate system for residential projects in Sri Lanka. According to the results, across all phases of development, the adoption of a green certificate system might yield a wide range of benefits; however, the implementation of this system would be hindered by several obstacles. When examining the perspectives of professionals with their credentials and expertise, many of them recommend adopting a green certificate system for residential projects. Green certification has been implemented for building and residential construction projects in numerous nations. There is a green certificate for building construction in Sri Lanka called GREENSL, however its engagement in residential development is minimal. According to the findings, numerous professionals have identified LEED as the most appropriate green certification system that suitable for residential projects in Sri Lanka. In a similar vein, this study can infer that, despite the implementation of the green certification system, the adoption of eco-friendly environmental systems is an essential consideration of domestic construction.

6. Limitations and Way forward

To find out the most suitable green certificate system for domestic projects is only limited to work out within the Sri Lankan construction industry. While carrying out this study, it was identified some areas that need to be addressed in the further researches as, by introduce a new green accreditation schemes in Sri Lanka, as it is also a lacking area in the country to investigate as many of the projects are moving towards sustainable developments.

7. References

Agha, A., Shibani, A., Hassan, D. and Salmon, A. 2020. Building Research Establishment Environmental Assessment Methodology on the UK Residential Projects. *International Journal of Construction Engineering and Management,* 9**,** 183-189.

Andersen, B., Samset, K. and Welde, M. 2016. Low estimates – high stakes: underestimation of costs at the front-end of projects. *International Journal of Managing Projects in Business,* 9**,** 171-193.

Andersen, M. A. 2021. Affordable Housing Reimagined: In search of the neighbourly, spacious and rebuildable. *Architectural Research in Finland,* 5**,** 117–129-117–129.

Ashuri, B. and Durmus-Pedini, A. 2010. An overview of the benefits and risk factors of going green in existing buildings. *International Journal of Facility Management,* 1.

Bandara, C., Dissanayake, D. M. P. P., Karunasena, G. and Madhusanka, N. 2018. Mitigation of challenges in sustaining green certification in the Sri Lankan hotel sector. *Built Environment Project and Asset Management,* 8**,** 515-527.

Brick, K. and Visser, M. 2011. Green certificate trading. *Journal of Energy in Southern Africa,* 22**,** 1-16.

Burnett, J., Chau, C., Lee, W. and Edmunds, K. 2008. Costs and financial benefits of undertaking green building assessments.

Casini, M. 2022a. Holistic building design approach. *In:* Casini, M. (ed.) *Construction 4.0.* Woodhead Publishing.

Casini, M. 2022b. Toward a new building era. *In:* Casini, M. (ed.) *Construction 4.0.* Woodhead Publishing.

Chen, X., Chang-Richards, A. Y., Pelosi, A., Jia, Y., Shen, X., Siddiqui, M. K. and Yang, N. 2021. Implementation of technologies in the construction industry: a systematic review. *Engineering, Construction and Architectural Management,* 29**,** 3181-3209.

Cidell, J. 2009. Building Green: The Emerging Geography of LEED-Certified Buildings and Professionals. *The Professional Geographer,* 61**,** 200-215.

Doan, D. T., Ghaffarianhoseini, A., Naismith, N., Zhang, T., Ghaffarianhoseini, A. and Tookey, J. 2017. A critical comparison of green building rating systems. *Building and Environment,* 123**,** 243-260.

Eskerod, P. and Duric, J. 2018. Motivations for and comparisons of green certificates within the hotel industry. *Universal Journal of Management,* 6**,** 179-189.

Giang, D. T. H. and Sui Pheng, L. 2011. Role of construction in economic development: Review of key concepts in the past 40 years. *Habitat International,* 35**,** 118-125.

Gupta, R., Gregg, M., Manu, S., Vaidya, P. and Dixit, M. 2018. Customized performance evaluation approach for Indian green buildings. *Building Research & Information,* 47**,** 56-74.

Haq, S., Mir, N. and Buhroo, Z. 2012. Green Building Development for Sustainable Environment with Special Reference to India.

Lee, W. L. and Burnett, J. 2008. Benchmarking energy use assessment of HK-BEAM, BREEAM and LEED. *Building and Environment,* 43**,** 1882-1891.

Li, X. and Zhang, Y. 2018. Problems and countermeasures of green building development in cold areas. *IOP Conference Series: Materials Science and Engineering,* 399**,** 012030.

Makandar, S. S. and Sanadi, N. A. 2019. Limitations of Green Building Rating Systems–A case of LEED and GRIHA. *no. May***,** 6798-6803.

Mattoni, B., Guattari, C., Evangelisti, L., Bisegna, F., Gori, P. and Asdrubali, F. 2018. Critical review and methodological approach to evaluate the differences among international green building rating tools. *Renewable and Sustainable Energy Reviews,* 82**,** 950-960.

Munasinghe, L. M., Gunawardhana, T. and Ariyawansa, R. Green Rating Systems for Built Environment and its Implications for Real Estate Valuation: A Review of Literature. 2nd International Conference on Real Estate Management and Valuation (ICREMV), 2018. 120-124.

Nalewaik, A. C. C. E. M. and Venters, V. C. C. C. 2009. Cost Benefits of Building Green: a Publication of the American Association of Cost Engineers. *Cost Engineering,* 51**,** 28-34.

Peters, S. T. 2018. Shapes Architecture Performance. *Computing the Environment: Digital Design Tools for Simulation and Visualisation of Sustainable Architecture*.

Plebankiewicz, E., Juszczyk, M. and Kozik, R. 2019. Trends, costs, and benefits of green certification of office buildings: a Polish perspective. *Sustainability,* 11**,** 2359.

Rakha, T., Moss, T. W. and Shin, D. 2018. A decade analysis of residential LEED buildings market share in the United States: Trends for transitioning sustainable societies. *Sustainable cities and society,* 39**,** 568-577.
Rezaallah, A., Bolognesi, C. and Khoraskani, R. A. LEED and BREEAM; Comparison between policies, assessment criteria and calculation methods. Proceedings of the 1st International Conference on Building Sustainability Assessment (BSA 2012), Porto, Portugal, 2012. 23-25.
Rodrigo, A. S. and Jayarathne, M. C. 2012. Aoptability of LEED Green Building Rating System inSri Lanka. *National Energy Symposium-2012.* MICH-Colombo, Sri Lanka.
Scofield, J. H. 2013. Efficacy of LEED-certification in reducing energy consumption and greenhouse gas emission for large New York City office buildings. *Energy and Buildings,* 67**,** 517-524.
Smit, A. M. and Toit, F. d. 2015. Investigating the financial benefits of green buildings. *Environmental economics,* 6**,** 61-71.
Tang, K. H. D., Foo, C. Y. H. and Tan, I. S. 2020. A review of the green building rating systems. *IOP Conference Series: Materials Science and Engineering,* 943**,** 012060.
Torkaman, T. and Zhouson, S. 2015. A study of the perceived benefits of LEED certification by tenants.
US Green Building Council 2014. LEED v4 for building design and construction. *USGBC Inc*.
US Green Building Council 2020. LEED v4. 1: Residential BD+ C Multifamily Homes. *US Green Building Council (USGBC): Washington, DC, USA*.
Waidyasekara, K. G. A. S. and Fernando, W. N. 2011. Benefits of adopting green concept for construction of buildings in Sri Lanka. *Sustainable Built Environment 2012 Proceedings of 2nd International Conference ICSBE.* Sri Lanka.
Weerasinghe, A. S., Ramachandra, T. and Rotimi, J. O. B. 2021. Comparative life-cycle cost (LCC) study of green and traditional industrial buildings in Sri Lanka. *Energy and Buildings,* 234**,** 110732.
Wickramasinghe, H. 2009. Sri Lanka Country Report on Energy Effiency Improvement & Conservation.
Wong, J. M. W., Thomas Ng, S. and Chan, A. P. C. 2010. Strategic planning for the sustainable development of the construction industry in Hong Kong. *Habitat International,* 34**,** 256-263.
Zhang, Y., Wang, J., Hu, F. and Wang, Y. 2017. Comparison of evaluation standards for green building in China, Britain, United States. *Renewable and Sustainable Energy Reviews,* 68**,** 262-271.
Zimmermann, R. K., Skjelmose, O., Jensen, K. G., Jensen, K. K. and Birgisdottir, H. 2019. Categorizing Building Certification Systems According to the Definition of Sustainable Building. *IOP Conference Series: Materials Science and Engineering,* 471**,** 092060.
Zuo, J. and Zhao, Z.-Y. 2014. Green building research–current status and future agenda: A review. *Renewable and Sustainable Energy Reviews,* 30**,** 271-281.