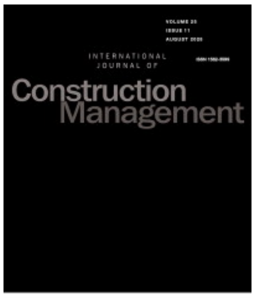

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International Journal of Construction Management

ISSN: 1562-3599 (Print) 2331-2327 (Online) Journal homepage: www.tandfonline.com/journals/tjcm20

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To cite this article: Cuong N. N. Tran, Phuong Th Pham, Thanh T. M. Tran, Vivian W. Y. Tam & I. M. Chethana S. Illankoon (2025) A practical approach to promoting sustainable development in the construction industry through the use of the LOTUS-Vietnamese green-building assessment tool, International Journal of Construction Management, 25:11, 1288-1299, DOI: 10.1080/15623599.2024.2411087

To link to this article: https://doi.org/10.1080/15623599.2024.2411087

Published online: 16 Oct 2024.

INTERNATIONAL JOURNAL OF CONSTRUCTION MANAGEMENT
2025, VOL. 25, NO. 11, 1288–1299
https://doi.org/10.1080/15623599.2024.2411087

A practical approach to promoting sustainable development in the construction industry through the use of the LOTUS-Vietnamese green-building assessment tool

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ABSTRACT

In the context of global climate change mitigation, building design optimization is crucial for effective and efficient resource management throughout a project's life cycle. This study addresses the challenge of assessing green building levels using a Vietnamese perspective. A survey of over 220 participants, including investors, consultants, contractors, and other stakeholders, was conducted to identify factors influencing green building assessments. Data analysis, employing SPSS software, explored 57 factors encompassing life-cycle economic optimization, energy and water conservation, material selection, project management, and strategic market benefits. The findings highlight effective energy management as a key determinant shaping sustainable building approaches and assessments. These results offer valuable insights for life cycle cost assessments and environmental impact evaluations during project implementation. Furthermore, the study emphasizes the importance of project developers prioritizing factors that influence the achievement of green building goals based on LOTUS green building rating standards in Vietnam. The predicted results demonstrate that governments should enforce legislation and establish clear green construction regulations to promote environmentally friendly growth, and that construction companies should use environmentally friendly materials and practices in their projects. This research contributes to the knowledge base for scholars, designers, and sustainability experts by systematically identifying factors that influence green building assessments under LOTUS standards.

ARTICLE HISTORY
Received 3 June 2024
Accepted 19 September 2024

KEYWORDS
Green building rating systems (GBRSs); life-cycle assessment; life-cycle energy consumption; life-cycle greenhouse-gas emissions; life-cycle cost; LOTUS

Introduction

The global issue of environmental pollution, including air pollution and the loss of the ozone layer, poses a significant danger to the well-being of everyone globally (Bodansky 2001). In addition to the discharge of automobiles, the manufacture of industrial goods, and the collecting of wastewater that has not been treated, the operations of the construction sector are another significant source of air pollution (Holman 1999; Dar et al. 2022).

According to a study undertaken by the American Green Building Council, it was determined that buildings inside the United States contribute to approximately 38% of carbon dioxide emissions, 71% of electricity consumption, 39% of overall energy usage, 12% of water consumption, and 40% of non-industrial waste generation. The facts indicate that the building sector exerts a substantial influence not alone on the environment, but also on the economy and society (USGBC. 2008). According to another publication from the European Construction Sector Observatory (ECSO), the building and construction sector in the 27 EU countries and the United Kingdom plays a substantial role in contributing to the overall energy consumption and CO2 emissions of these nations. (European Construction Sector Observatory 2018). Greenhouse gas (GHG) emissions in South-East Asia are predominantly contributed by the five biggest economies in the region, namely Singapore, Thailand, the Philippines, Malaysia, and Indonesia, which collectively account for about 90% of these emissions (Triani et al. 2023). It is anticipated that the carbon dioxide (CO2) emissions originating from this particular region will surpass those of all other global regions within the present decade. It is projected that the energy-related CO2 emissions originating from ASEAN countries will experience a substantial increase from 1.26 billion tonnes in 2014 to 3.14 billion tonnes by the year 2040 (Munir et al. 2020; Islam et al. 2022).

The process of construction might potentially contribute to the depletion of natural resources. Numerous instances may be cited to illustrate the significant utilisation of global raw materials in construction activities, amounting to approximately 40% annually. These materials encompass a range of resources, including raw stone, gravel, sand, and old-growth timber (Ahmed et al. 2022). The construction industry has embraced the implementation of green building practises as a prevailing norm in light of the global environmental crisis and the challenges posed by climate change (Pham and Nguyen 2021). Governments worldwide are encouraging their citizens to devise innovative approaches to mitigate and minimise the environmental impacts on urban areas, with the dual objective of preserving the environment and enhancing human well-being in a manner that aligns with ecological principles. The three pillars of sustainability, namely economic, environmental, and social well-being, collectively form an integrated system. The interconnectedness of society, economics, and ecology implies that the disruption of

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any of these elements will result in a state of imbalance within the entire system. The interconnection between environmental challenges and economic progress is evident, as is the correlation between social well-being and the conservation of the natural world. To achieve environmental and social sustainability, it is imperative that solutions are economically viable.

The significance of the United Nations' 17 Sustainable Development Goals (SDGs) in tackling global challenges and inequalities is widely recognised by the international community (General Assembly 2015). Sustainable development, as a conceptual framework for development, entails the judicious utilisation of resources to fulfil the present requirements of society while safeguarding the ability to meet future demands without detriment. The Sustainable Development Goals are a comprehensive framework that encompasses the pursuit of social, environmental, and economic sustainability in the development process. In order to attain the Sustainable Development Goals, there is a notable focus on the implementation of innovative approaches, clean production strategies, and sustainable technologies.

The increasing popularity of green building construction is driven by the goal of achieving The Sustainable Development Goals. The concept of green construction encompasses an evaluative methodology that demonstrates human endeavours in achieving comprehensive sustainable development. In the pursuit of sustainable development, the concept of green building has emerged as a significant transformation in the construction industry worldwide. This paradigm shift is characterised by a heightened sense of accountability towards natural resources, environmental preservation, ecological considerations, and the enhancement of human well-being. This comprehensive approach encompasses various facets, including design, construction, equipment manufacturing, technology, materials, policy, and finance. The benefits of green building have been demonstrated in various dimensions, including environmental efficiency, social advantages, and apparent economic gains.

The identification of factors influencing investment decisions in commercial projects is a crucial task for construction management in order to estimate and analyse construction investment expenses throughout the project's lifespan in accordance with established standards. The incorporation of green building practises into construction management is a fundamental aspect. This approach enables the evaluation of the financial gains associated with a project according to green building standards, hence facilitating investors in promoting investments aligned with such standards (Chegut et al. 2014). Green building rating systems (GBRSs) that contribute to increasing productivity, enhancing health, conserving energy, making efficient use of resources, and reducing operational costs pose new marketing strategies and a new appearance for businesses (Diyana and Abidin 2013).

For more than twenty years, green building rating systems have been employed to advance sustainable development and provide a comprehensive assessment of sustainability across all stages of a building's lifespan (He et al. 2024). The Building Research Establishment Environmental Assessment Method (BREEAM) was the pioneering sustainability assessment method that first originated in the United Kingdom (UK) and subsequently demonstrated its suitability in the European context (Poveda and Lipsett 2011). However, The Leadership in Energy and Environmental Design (LEED) certification, initially introduced by the United States Green Building Council (USGBC) in 1998, has gained substantial acclaim as a prominent global certification system (Sánchez Cordero et al. 2019). This recognition stems primarily from its widespread adoption and the successful completion of numerous projects that have achieved LEED certification. The Green Mark, introduced by Singapore's Building and Construction Authority in 2005, holds the distinction of being the inaugural green building rating system in South-east Asia, specifically designed for tropical climates (Heinzle et al. 2013).

Vietnam exemplifies a developing nation located in the Southeast Asian region. An excessive proliferation of urban areas along with its significant economic expansion since the 1990s have led to adverse impacts on the natural environment (World Bank 2016). The Vietnam Green Building Council (VGBC) introduced the LOTUS (Local Operation Towards Urban Sustainability) rating system in 2007 as a means of evaluating green buildings in Vietnam. This system was developed to address the specific building conditions in the country, following a substantial period of utilising LEED and GreenMark for this purpose (Vietnam Green Building Council 2019). Currently, the research gap indicates that the adoption of a single green building assessment standard in Vietnam is not well-defined due to the absence of obligatory or voluntary regulations for construction projects in this nation. The primary categories of evaluation elements in the generally used standards in this nation are to Indoor Environmental Quality, Energy and Materials, which align with popular standards, i.e. BREEAM, LEED, CASBEE, and Green Star, etc.

Research objectives and framework

The examination of the correlation between the green building evaluation criteria employed and the political and economic attributes of Vietnam represents a noteworthy area of investigation. Hence, this research endeavour aims to investigate and ascertain the variables that exert an influence on LOTUS approach within the context of sustainable development in the construction industry of Vietnam.

The primary objectives of this study are as follows: (1) To conduct a thorough investigation into the green building standards that have been implemented in various countries worldwide in recent years; (2) To conduct a comparative analysis between the characteristics of the LOTUS standard and other prominent green building assessment standards, with the aim of assessing the potential effectiveness of the LOTUS standard in Vietnam and neighbouring regions that share similar geographical characteristics.

The study commenced by undertaking a comprehensive review of existing literature in order to compile a comprehensive inventory of the various impacts associated with green building rating tools. Subsequently, this study ascertained the most pivotal factors of influence through the solicitation of input from a cohort of 220 professionals. The application of exploratory factor analysis was utilised to examine latent components and gain insight into the underlying structure of green building rating tools. This study conducted a comparative analysis of impact preferences pertaining to different impacts associated with green building rating systems, as previously indicated by prior research. This study makes a valuable contribution to the existing body of knowledge on green building by identifying key factors that influence the environmental impact of construction projects and by offering a clear and comprehensive assessment of the impacts associated with such projects. The findings have the potential to enhance the project management procedures in construction projects, thereby making a significant contribution to the advancement of sustainable building practises in Vietnam and other developing nations.They may then use these findings to determine which standards are optimal for their developing projects in order to improve both their economic and environmental performance.

The present paper is organised in the following manner. Section 1 provides a comprehensive introduction to global green building rating systems and presents a concise summary of the criteria utilised in the LOTUS green building rating tool, which serves as a prominent component of this particular rating system. Section 2 of the paper outlines the objectives and conceptual framework of the study. Section 3 elucidates the research methodology employed to investigate international green building standards on a global scale. Section 4 of this paper examines the key factors that influence the advancement of green buildings, as well as the comparison between the LOTUS rating system and other tools used to assess green buildings. In Section 5, the application and effects of the LOTUS standard in promoting the trend of sustainable development in Vietnam are discussed. In Section 6, the paper provides a summary of the contributions made and limitations encountered throughout the study.

Research methodology

Sustainability is a multifaceted and intricate field that is constantly evolving. The purpose of green building certifications is to define and verify that a building satisfies specific criteria and provides an ecological advantage. Various product labels and certification programs employ multi-attribute approaches by certifying buildings based on lifecycle parameters. The parameters comprise energy consumption, recycled ratio, as well as air and water emissions associated with the building's whole life activities. Some programs focus on a specific attribute, such as water usage, energy consumption, or chemical emissions, which have a direct influence on Indoor Environmental Quality (IEQ) (Reeder 2010; Vierra 2016).

This study provides a comprehensive analysis of the evolution and present state of green building standards used in the construction industry: Energy Efficiency, Indoor Environmental Quality, Materials and Resources, Water Efficiency, Site and Land Use, Emissions and Pollution. To achieve this aim, the article utilizes a combination of techniques, including a literature review and legislative and regulatory analysis, and the collection of pertinent data and information.

The research methodology to assess green building standards globally involves a systematic and comprehensive approach to gather and analyse data on the various green building standards and rating systems used worldwide. This usually consists of a study of the existing research, a survey of key stakeholders, and an evaluation of the performance of green buildings in different nations. The gathered data is then used to assess the performance of the various green building standards and to identify best practises and areas for improvement. A comparative examination of the various standards and the production of suggestions for encouraging the adoption of sustainable building practises internationally may also be part of the process.

Collect data on construction projects that have been and are being implemented according to green building standards. In this study, data collection was carried out on questionnaires from experts related to the LOTUS green building standards to analyze and evaluate based on project life cycle cost criteria. The absolute minimum sample size N is a rule of thumb, suggesting that any $N > 200$ provides adequate statistical power for data analysis (Hoe 2008; Singh et al. 2016). Although it is difficult to set a minimum sample size in Structural Equation Modeling (SEM) research, the average sample based on research assessments is $N = 200$ (MacCallum and Austin 2000; Kline 2015). This study has 42 observed variables, so the minimum required number of observed samples is 220, meeting the minimum condition of ≥ 200 in accordance with previous studies. Exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were utilised to evaluate the gathered data using a two-index approach applied in model acceptability calculation based on goodness-of-fit (Goudarzian et al. 2023).

The method of this study is quantitative based on data collection, including numerical information that can be analyzed using statistical techniques. (Malthus 2017). Questionnaire surveys are the most frequently employed method by researchers for data collection due to their affordability, simplicity, and rapidity. A questionnaire was created in this research to investigate the project management factors that influence the success of green building projects. The first section of the questionnaire requested general information about the respondents, including their position in a construction project and their relative work experience. The second section comprised 42 factors classified into 6 main categories identified in the literature review that influence the success of green building projects, as illustrated in Table 1.

The relative significance of these factors was determined on a Likert scale of 1 to 5, with 1 point denoting factors that have no impact on project success and 5 points denoting factors that have a significant impact. In order to ascertain the validity of the proposed questionnaire, a pilot study was carried out with the involvement of academic experts and construction experts prior to administering the official questionnaire to the target group. The purpose of this study was to make the requisite modifications to the questionnaire to ensure that it was compatible with the local construction terminology that was incorporated and rephrased.

Literature review

Table 2 introduces the most prevalent green-building rating tools employed worldwide in alphabetical order. There is vast evaluation systems mobilized in many countries. Some of them become major tools to assess green-building projects. LEED is the Leadership in Energy and Environmental Design rating system is the most widely used worldwide (Ferrari et al. 2021; Ur Rehman et al. 2022). LEED v4.1, the latest version of this tool, was released in 2018 and builds upon the previous version, LEED v4, by offering new and updated requirements and credits to support the design and operation of high-performance, sustainable buildings.

More than 70 countries currently use BREEAM (Cheng et al. 2017), and several European nations have even established their own BREEAM schemes, run by National Scheme Operators (NSOs). NSOs that are part of BREEAM currently include: BREEAM DE run by the German Institute for Sustainable Real Estate (DIFNI) (Nelson et al. 2010); BREEAM ES run by the Instituto Tecnológico de Galicia (Bisquerra Femina 2011); BREEAM NL run by the Dutch Green Building Council (Bolhack et al. 2013); BREEAM NOR run by the Norwegian Green Building Council (Nordnes 2016) and BREEAM SE run by the Swedish Green Building Council (Ravasio et al. 2020).

In the European context, there is also another system for assessing the environmental impact of buildings. Miljöbyggnad (MB), also known as 'Environmental building' in English, is the most prevalent system for environmental certification of

Table 1. Factor group analysis by categories.

	Policy (P)		**Experience, Qualifications, Skills (EQS)**
A.1	Tax reduction, fees, and subsidies (Ming 2013; Díaz-López et al. 2021)	B.1	Experience, skills and qualifications in designing (Elforgani and Rahmat 2012; Ahmad 2023)
A.2	Grants, loans, and reimbursements (Ibrahim et al. 2014; An and Pivo 2020)	B.2	Experience, skills and qualifications in constructing (Pittayasoponkij et al. 2021)
A.3	Property tax credit incentives (Shazmin et al. 2016; Joachim et al. 2017)	B.3	Experience, skills and qualifications in maintaining (Ismail 2020)
A.4	Policies, mechanisms, and capital support incentives (Ding, X et al. 2022; Tran, T et al. 2020)	B.4	Experience, skills and qualifications in procuring materials, equipment, and machinery (Eze et al. 2021; Hwang, BG & Tan 2012)
A.5	Low stamp duty (Onuoha et al. 2017)		**Energy Savings (ES)**
A.6	Voluntary and mandatory green building certification (Vierra 2016; Li et al. 2019; Zhang et al. 2024)	D.1	Energy efficiency (Alwisy et al. 2019)
	Motivation to Optimize Lifecycle Economic Performance (LC)	D.2	Passive design (Chen et al. 2015)
C.1	Cost savings in design (Hwang et al. 2015; Li et al. 2019; Hu and Skibniewski 2021)	D.3	Building envelope (Sadineni et al. 2011; Scherz et al. 2022)
C.2	Cost savings in construction (Hwang et al. 2015; Li et al. 2019; Hu and Skibniewski 2021)	D.4	Cooling systems (Ali and Akkaş 2023)
C.3	Cost savings in maintenance (Hwang et al. 2015; Li et al. 2019; Hu and Skibniewski 2021)	D.5	Reducing energy consumption for artificial lighting systems (Beniwal and Kumar 2020)
C.4	Cost savings in demolition, waste management, and material reuse (Hwang et al. 2015; Li et al. 2019; Hu and Skibniewski 2021)	D.6	Energy consumption monitoring (Beniwal and Kumar 2020)
	Water Savings (Ws)		**Materials & Resources (MR)**
E.1	Water efficiency (Ding et al. 2018)	F.1	Minimizing the use of concrete (Taemthong and Chaisaard 2019)
E.2	Ability to limit domestic water consumption for garden irrigation (Van Mechelen et al. 2015)	F.2	Limiting environmental impact from the extraction and production of raw materials (Xu et al. 2022)
E.3	Awareness of the actual water usage needs of the building (Huo et al. 2017)	F.3	Reuse, salvage, and recycling of waste during demolition and construction (Lu et al. 2019)
E.4	Application of sustainable solutions to reduce domestic water consumption (Rashidi et al. 2015)	F.4	Reducing operational emissions by applying effective waste sorting methods and equipment for recycling (Wibowo et al. 2018)
	Health & Comfort (HC)		**Market Strategy Benefit Motivation (MS)**
G.1	Limiting the harm of passive pollution to building occupants (Banerjee et al. 2021)	H.1	Effective management, providing standardized systems for design, architecture, operation, and performance (Soares et al. 2017)
G.2	Ensuring good indoor air quality during the usage phase (Banerjee et al. 2021)	H.2	Raising awareness and knowledge of sustainability issues within the community (Gomez and Yung 2018)
G.3	Minimizing the negative impact of harmful substances in building materials (Abdelaziz et al. 2019; Wang 2023)	H.3	Minimizing stress on local infrastructure and reducing demand for urban utilities (Carter et al. 2015)
G.4	Integrating natural elements in building design to create a connection between people and the natural environment (Abd Elghany Morsy and Abdelrahman Moustafa Emam 2019)	H.4	Promoting creativity and corporate social responsibility (Mehmood and Hanaysha 2022)
G.5	Optimizing natural lighting while balancing multiple factors: solar radiation absorption, glare, lighting levels, visual comfort, and user requirements (Liu et al. 2023)	H.5	Create value in the market (Darko et al. 2017)
G.6	Enhancing users' connection with the external environment by ensuring views of the surrounding area (Hou et al. 2023)	H.6	Reduce advertising costs for the building (Alamsyah et al. 2020)
G.7	Ensuring thermal comfort for users (Paul and Taylor 2008; Brown and Cole 2009)	H.7	Meet the increasing demand of users (Zhang, Y et al. 2019)
G.8	Acoustic comfort (Field 2008; Elnaklah et al. 2021)	H.8	Enhance the image, brand, awards, and reputation of the investor (Yang and Zou 2014)

buildings in Sweden. MB was developed as a voluntary environmental rating tool to evaluate all new buildings in Sweden as a joint project between the Swedish government, companies in the building and construction sector, several municipal governments, insurance providers, and academic institutions (Malmqvist et al. 2011; Wallhagen et al. 2021). The VERDE Environmental Certificate from Green Building Council España (GBCe) also shows that the building has less of an effect on the environment than a standard reference building, which is designed using the minimum requirements set by law and common practice (López-Manzanares et al. 2018). The WELL Building Standard is a performance-based system for measuring, certifying, and monitoring features of the built environment that impact human health and well-being, developed by the International WELL Building Institute (IWBI). The first version of the WELL Building Standard (v1) was released in 2014 and the updated one is V2 Pilot was published in 2018 (International WELL Building Institute (IWBI)) 2018).

For the purpose of Australian sustainable development approach in generally and Green-Star in particularly to estimate LCA of the buildings, construction projects should be assessed consistently with the requirements of the Building Energy Analysis Software protocol in Australian Building Code Board (Tran, CN et al. 2020). Other green building tools are used nationally in the country are Building Sustainability Index (BASIX) and Nationwide House Energy Rating Scheme (NatHERs). They are two examples of mandatory green building regulations in Australia. BASIX is a requirement for all new residential buildings in New South Wales (NSW), while NatHERs is a mandatory system for assessing the thermal efficiency of homes. Both BASIX and NatHERs ratings can be used to earn credit points in the Green Star Environmental Rating System. This shows the interconnectivity and integration of various green building rating systems and the importance of using them to meet regulatory requirements and improve sustainability performance in the built environment.

Middle East countries have developed their own local rating system, such as ARZ Building Rating System (Lebanon), Green Building Guideline and Rating System of Jordan Green Pyramid Rating System (Jordan), Qatar Sustainability Assessment System

Table 2. Common green-building rating tools worldwide (alphabetical order).

Green-building rating tool	Country of Origin	Organisation	Lastest version	First Published year
Alta Qualidade Ambiental (AQUA)	Brazil	GBC Brazil	2018	2007
ARZ Building Rating System	Lebanon	The Lebanon Green Building Council	2011	2011
BREEAM	UK	BRE	2016	1990
CASBEE	Japan	JSBC	2002	2015
DGNB (Deutsche Gesellschaft für Nachchaltiges Bauen)	Germany	DGNB - German Sustainable Building Council	2021	2009
Ecology, Energy Saving, Waste Reduction, and Health (EEWH)	Chinese Taipei	Taiwan GBC	2017	1999
EDGE		International Finance Corporation - World Bank Group	2015	2010
Green Building Guideline and Rating System of Jordan	Jordan	Jordan National Building Council	2015	2009
Green Mark	Singapore	Building and Construction Authority (BCA).	2010	2005
Green Pyramid Rating System (GPRS)	Egypt	Housing and Building National Research Center	2017	2009
Green Star	Australia	GBC Australia		
LEED	US	USGBC	2018	1998
LOTUS	Vietnam	Vietnam Green Building Council (VGBC).	2020	2009
Miljöbyggnad	Sweden	Swedish Green Building Council (SGBC)	2022	2003
Nordic Swan Ecolabel	Nordic bodies	Nordic Swan Group	2022	1995
Pearl Rating System's Building Rating System	United Arab Emirates	Abu Dhabi Urban Planning Council	2010	2010
Qatar Sustainability Assessment System (QSAS)	The State of Qatar	The Gulf Research and Development Organisation (GORD)	2011	2009
Selo Ambiental Colombiano para las Edificacionis (SACE) [Colombian Environmental Seal for Sustainable Building]	Columbia	Colombian Green Building Council (CCV)	2010	2010
VERDE	Spain	GCB España		
WELL	US	IWBI	2018	2014

(Qatar), the Pearl Building Rating System (United Arab Emirates) (Shareef and Altan 2016; Mukattash and Hyarat 2023). Likewise, Asian nations, like Japan and Singapore, have created their own green building evaluation systems. The Green Mark is a green building rating system in Singapore developed and managed by the Building and Construction Authority (Hatmoko et al. 2017). The Green Mark system is widely used in Singapore and has been successful in promoting sustainable design and construction in the country. Meanwhile, Comprehensive Assessment System for Built Environment Efficiency (CASBEE) is a green building rating system in Japan developed and managed by the Japan Sustainable Building Consortium (Hatmoko et al. 2017).

As a new player in the region, LOTUS has recently been adopted as a green building evaluation tool in Vietnam. In 2009, the Vietnam Green Building Council (VGBC) adopted LOTUS (Leadership in Energy and Environmental Design) in Vietnam as a tool for evaluating green buildings (Pham and Nguyen 2021). Since then, the VGBC has been promoting the use of LOTUS and other green building rating systems in the country and supporting the implementation of sustainable design and construction practises within the building and construction industry (Tran et al. 2022). The adoption of LOTUS in Vietnam reflects the country's increasing interest and dedication to sustainability, as well as the VGBC's efforts to promote the use of green building evaluation tools and reduce the environmental impact of the built environment.

Comparison of LOTUS, an emerging green building rating tool in Vietnam with others in the industry

In many nations, green building policies have become an integral component of the reform of development policy. Currently, several green building evaluation methods have been developed on a global scale (Illankoon et al. 2019). Numerous studies suggest that LEED, BREEAM, DGNB (Deutsche Gesellschaft fur Nachchaltiges Bauen), and Green Star.certified green commercial buildings are more valuable commercially, socially, and ecologically than other grading systems.

Previous researchs on the economics of green buildings in the United States, United Kingdom, and Australia determined that green buildings may attain greater sales prices, acquire higher rentals, and have a higher occupancy rate than buildings without green building certifications. In addition, studies indicate that industry validation of 'green value' is beginning to have an effect on property prices through decreased building running costs, ease of sale and renting, and tenant retention. occupants and increasing total occupancy (Pitts 2008; Ellis 2009; GBCA. 2012).

Table 3 introduces some major factors that recent research have shown to influence the development of green buildings. These factors include aspects relating to social, economic and environmental impacts. Schleich et al. (2009) points out that the factors affecting investment motivation for real estate investors. Green certification is one of the primary elements considered while developing green construction projects. This form of certificate allows real estate investors greater leverage in assessing the property's future worth.

Economic profit is also a factor mentioned by Isa et al. (2013), along with social and environmental benefits. The study mentions other factors affecting green office building in Malaysia specifically including cost savings for project activities, building occupancy rate, building rental value and market value. In addition to these factors, Joachim (2017) suggests that the development of green buildings can be influenced by the following: Available green building skills, Benefits in market strategy, Motivation, awareness, and responsibility of the business, tax incentives, government interest, and Green building certification policies and motivations.

Vietnam has a high rate of urbanisation in major cities, and the influx of migrants to urban areas is rising, putting a pressure on infrastructure, housing, and workplaces. Vietnam's metropolitan areas use 30 to 35% of the country's total energy, 60% of the country's natural resources, 30% of the country's clean water supplies, and 30% of CO and CO2 emissions. LOTUS is the first voluntary green building criteria system designed particularly for the Vietnamese construction sector, carrying on the advantages of the LEED and Green Mark systems. It was established by the Vietnam Green Program (VGBC - LOTUS) in response to an initiative by the Green Cities Fund, an American non-profit

Table 3. Aspects influencing the development of green buildings mentioned in recent studies.

No.	Author	Research's topic	Factors affecting the development of green buildings
1	Schleich et al. (2009)	Environmental sustainability - drivers for the real estate investor	• Green certification • High market value • High rental income • Cost savings • Image benefits • Government encourages
2	Isa et al. (2013)	Factors Affecting Green Office Building Investment in Malaysia	• Occupancy rate, market and rental value • Profit • Cost savings • Social and environmental benefits
3	Joachim (2017)	Modeling demand-supply dimensions of green commercial properties	• Tax incentives • Available green building skills • Incentive for cost savings in the project lifecycle • Motivation for environmental protection, • Benefits in market strategy, • Economic and financial dynamics • Motivation, awareness and responsibility of the business • Government interest • Green building certification policies and motivations • Expected rate of return of developers.
4	Onuoha and Finbarr (2020)	Analysis of the factors affecting green building investment in imo state, NIGERIA	• Market readiness (size, trends and investment costs market, access to market information) • Economic and financial factors (profitability/expected profit margin, construction cost/green building construction cost) • Policy to encourage the purchase of green buildings) • Government policies (mandatory/voluntary policy for green building development) • Relevant laws and regulations
5	Song et al. (2021)	Factors affecting green building development at the municipal level: A cross-sectional study in China	• Geographical location • Local financial revenue and real estate investment • Mandatory regulations and incentive-based policies • Local design standards

organisation. VGBC - LOTUS is a standard and goal-setting tool for developing ecologically and health-friendly buildings with reduced running costs.

Green building development is hampered by high investment costs, according to a number of studies (Landman 1999; Pitt et al. 2009; Nguyen et al. 2017). Determining the elements impacting investment choices in office projects is an essential responsibility of construction management to estimate and analyze construction investment costs for the project life cycle according to standards (Figure 1). Green building is an essential work of construction management; through which it is possible to estimate the profit provided by a project according to green building standards to assist investors stimulate investment in projects according to green building standards. green building standards (Chegut et al. 2014), contributing to enhancing employee productivity, improving health, conserving energy, managing resources wisely and minimizing operational expenses. branding and transforming the face of company (Diyana and Abidin 2013). In light of the aforementioned concerns, the paper outlines the elements influencing office project investment choices based on cost assessments throughout the project's life cycle in accordance with green building standards in Vietnam, where the LOTUS standard is used.

LOTUS is a green building certification system designed by the Vietnam Green Building Council (Vietnam Green Building Council) - an international non-profit organization, a member of the World Green Building Council (WorldGBC). After more than 8 years of development, LOTUS Certification currently contains 7 assessment systems, applicable to practically all kinds of construction projects such as non-residential structures, condos, commercial buildings, houses, individual dwellings, small-scale buildings and interior spaces. LOTUS acts as a guiding guideline and goal setting tool to create buildings that are favourable to the environment and inhabitants' health with reduced running expenses.

The score system, prerequisites (GAT), and criteria in the categories are all identical to those of LEED, Green Mark, Green Star, and other well-known green building certification schemes as can be seen in Table 4. In order to be the most appropriate green building certification standard for Vietnam's built environment, LOTUS differs significantly from LEED in several ways. Vietnamese regulations and norms are referred to throughout LOTUS.

Similar criteria for project performance are classified under Credits. The LOTUS project will pick and perform specific quantities and gain points for certification. In general, the more points a project receives, the larger the advantages LOTUS will provide. A higher grade denotes a building that is more energy efficient, uses less water, requires less maintenance, and is more pleasant for its occupants to use. Depending on the final result, the project will get LOTUS Certification at one of many levels. The lowest level of certification is established at 40% of the total score (LOTUS Certification) (LOTUS Certification). LOTUS Silver, Gold, and Platinum certifications are worth 55%, 65%, and 75%, respectively, of the overall score.

The development of green building evaluation system in Vietnam

Increasing pressure on energy consumption has resulted from Vietnamese building industry's recent yearly growth rate of roughly 9% and the urbanisation rate reaching 40.5%. As of the year 2020, there will have been a total of 743 commercial housing projects in Vietnam, providing over 232,000 licensed apartments, of which 288 will have been completed, yielding over 57,000 units. In terms of affordable housing, over 5.2 million

Figure 1. Impact factors to green-building development.

Table 4. Compare LOTUS certificate with green building certifications in the globe.

System	LEED	GREEN STAR	GREEN MARK	LOTUS
Rating	• LEED certified • Silver LEED • Golden LEED • LEED platinum	• 1 star 'Not eligible' – 6 stars: 'World leader'	• Green Mark Certification • Green Mark Gold • Green Mark Gold Plus • Green Mark Platinum	• LOTUS Certification • LOTUS Silver • LOTUS Gold • LOTUS Platinum
Version	LEED version 4 • Design and Build (BD + C), • Interior design and construction (ID + C), • Building Operation and Maintenance (O + M), • Regional Development (ND)	• Design and build • Interior • Public construction • Works of art	• Residential area - new construction • Residential - existing buildings • No housing - new construction • Existing non-residential buildings	• LOTUS NC v3, applicable to new construction or large-scale renovation projects with a total floor area (GFA) of 2500 m2 or more • LOTUS BIO, applicable to existing buildings • LOTUS Homes, applied to individual housing projects • LOTUS SB, applicable to non-residential projects with GFA less than 2500 m2 • LOTUS Interiors, applying interior finishing project • LOTUS Small Interiors, applying interior finishing project with GFA less than 1000 m2
Criteria	• Location and means of transportation • Sustainable websites • Efficient use of water • Energy and atmosphere • Materials and resources • Indoor environmental quality • Regional priority • Innovation	• Management • Indoor environmental quality • Energy • Transport • Country • Material • Land use and ecology • Emissions • Innovation	• Energy efficiency • Efficient use of water environment • Indoor environmental quality • Other green features	• Energy • Country • Materials & Resources • Health & Comfort • Location & Environment • Manage • Outstanding performance

square metres have been developed over 256 urban projects with a total construction size of over 104,200 units. Almost 11 million square feet of construction space is being spread among 264 ongoing projects. The average dwelling in 2020 will have a floor space of 25 square metres per inhabitant (General Statistics Office of Viet Nam 2022).

After more than a decade of growth since 2010, Vietnam today has slightly more than 200 green buildings. Compared to the number of operating projects and the potential and requirements for energy consumption, resource conservation, efficiency, and environmental protection, this amount falls well short of what is required.

Since 2012, Vietnam Ministry of Construction has cooperated with IFC-WB to review and issue a standard namely QCVN 09:2013/BXD and since 2015 has cooperated to develop tools for assessment and certification of energy use buildings, saving resources and energy according to EDGE certificate. The periodical study 'Vietnam Green Building Market Overview' in the third quarter of 2021 released by the UK Government, IFC (World Bank Group) and SGS demonstrates that the green building market in Vietnam is continually expanding. development, however it is still modest compared to the amount of building activities and the trend of greening in the area. Accordingly, in the first 3 quarters of the year, there were 201 certified green projects, with a total certified floor area of 5,327,242 m2. Specifically, 53 projects were given EDGE Green Building certifications, accounting for 26%; with a total floor area of 2,655,673 m2, accounting for 58%. It is recently reported that 113 projects have been awarded the LEED Green Building Certificate, which accounts for 56% of the total floor area, which amounts to 2,322,673 m2. There are 35 projects received LOTUS Green Building accreditation, accounting for 18%; total floor area reached 348,585 m2, accounting for 8%.

Evaluation of economic efficiency is a problem that Vietnam's LOTUS green building evaluation system is still inadequate compared to other systems in the world and mainly utilised to evaluate the efficacy of investment projects. labor. First and foremost, LCCA (Life Cycle Cost Assessment), or any other economic evaluation technique, must identify the economic performance of various building designs and building systems, as well as the resulting consequences and monetary values.

LCCA is a method for evaluating an asset's total cost of ownership during its entire useful life, including the expenses of procurement, use, maintenance, and eventual disposal. The notion of life-cycle costs was first introduced in the mid-1960s to aid the US Department of Defense in procuring military hardware (Irwin 1996). Furthermore, comparing the life-cycle costs of various options is now widespread practice among US government organizations (Goh and Sun 2016). A life cycle cost is the present value of an asset's overall life-cycle cost (Addis and Talbot 2001). This cost covers the original capital cost, financing cost, operating cost, maintenance cost and ultimate disposal cost of the asset at the end of its life. All upcoming expenditures and benefits are lowered to current value utilizing discounting procedures. Using a green building approach, this is also an appropriate solution. Generally, it is the present value of all green building-related expenses during the life cycle in present value terms. A green building's life cycle costs can be calculated by adding up all the costs associated with the project's various phases (pre-construction through post-occupancy) and dividing them by the project's specified lifespan (in years) or a predetermined point in time (in percentage terms) to arrive at a life cycle cost estimate (WGBC n.d.).

Table 5. Group analysis by properties of each variable.

Group	Group description	Variability of Data (%)
1	Energy Savings (ES)	40.157
2	Experience, Qualifications, Skills (EQS)	6.876
3	Market Strategy Benefit Motivation (MS)	5.049
4	Health & Comfort (HC)	4.316
5	Policy (P)	3.624
6	Water Savings (Ws)	3.365
7	Motivation to Optimize Lifecycle Economic Performance (LC)	3.039
8	Materials & Resources (MR)	2.527

The study of groups of components by variable reveal that the data explains the variance 68.954% (Table 5). *Group 1*: The group of elements connected to 'Energy saving' is estimated to have the largest effect on project investment choices according to Lotus Green Building standards based on cost evaluation throughout the project life cycle. Having a variability of the data of 40.157%; *Group 2*: The group of variables connected to 'Experience, qualifications, skills' holds the second place in affecting investment choices with the variability of the data of 6,876; *Group 3*: The group of elements connected to 'The driving force that supports the advantages of the market strategy' holds the 3rd position with the variability of the data of 5,049; *Group 4*: Group of parameters connected to 'Health & Comfort' with data variability of 4,316; *Group 5*: Group of variables connected to 'Policy' with data variability of 3,624; *Group 6*: There are 3,365 variables connected to 'Water saving' in this group; *Group 7*: Group of elements connected to 'Project Lifecycle Economic Performance Optimization Dynamic' with data variability of 3,039; *Group 8*: There are 2,527 variables connected to 'Materials & Resources' use in this group.

Discussion

The hypothesis testing method and research model using the Structural equation modelling (SEM) method have the advantage of not only measuring measurement errors but also allowing the simultaneous integration of latent factors measurement with the theoretical model (Hulland et al. 1996). The SEM approach enables the examination of interactions between one or more dependent or independent variables (Zainudin 2012). SEM is a statistical tool that can analyse and quantify intricate interactions between multiple independent variables simultaneously. In this work, SEM was used to examine the patterns of interactions between unobserved structures, which are assessed by observed variables. The analysis focused on both the sequence and structure of these relationships. The adjusted SEM model in this research has parameters that all satisfy the condition of having P-values less than 0.05

As can be seen in Figure 2, The 'Policy' group's coefficient of effect with the value of 0.22 influences the economic performance of the project life cycle. In Vietnam, financial management instruments, including laws, norms, and standards pertaining to building, energy, water, health and amenities, location, and the environment, have been developed. In order to improve the quality assurance of works, these official norms and standards establish minimum and critical performance requirements for renewable and energy-saving energy levels that give a baseline quality guarantee for buildings from the beginning of the formation phase. However, Vietnam still lacks particular legislation directly connected to and impacting green building certification, lacks corporate support mechanisms, and green building development initiatives have not yet achieved widespread popularity.

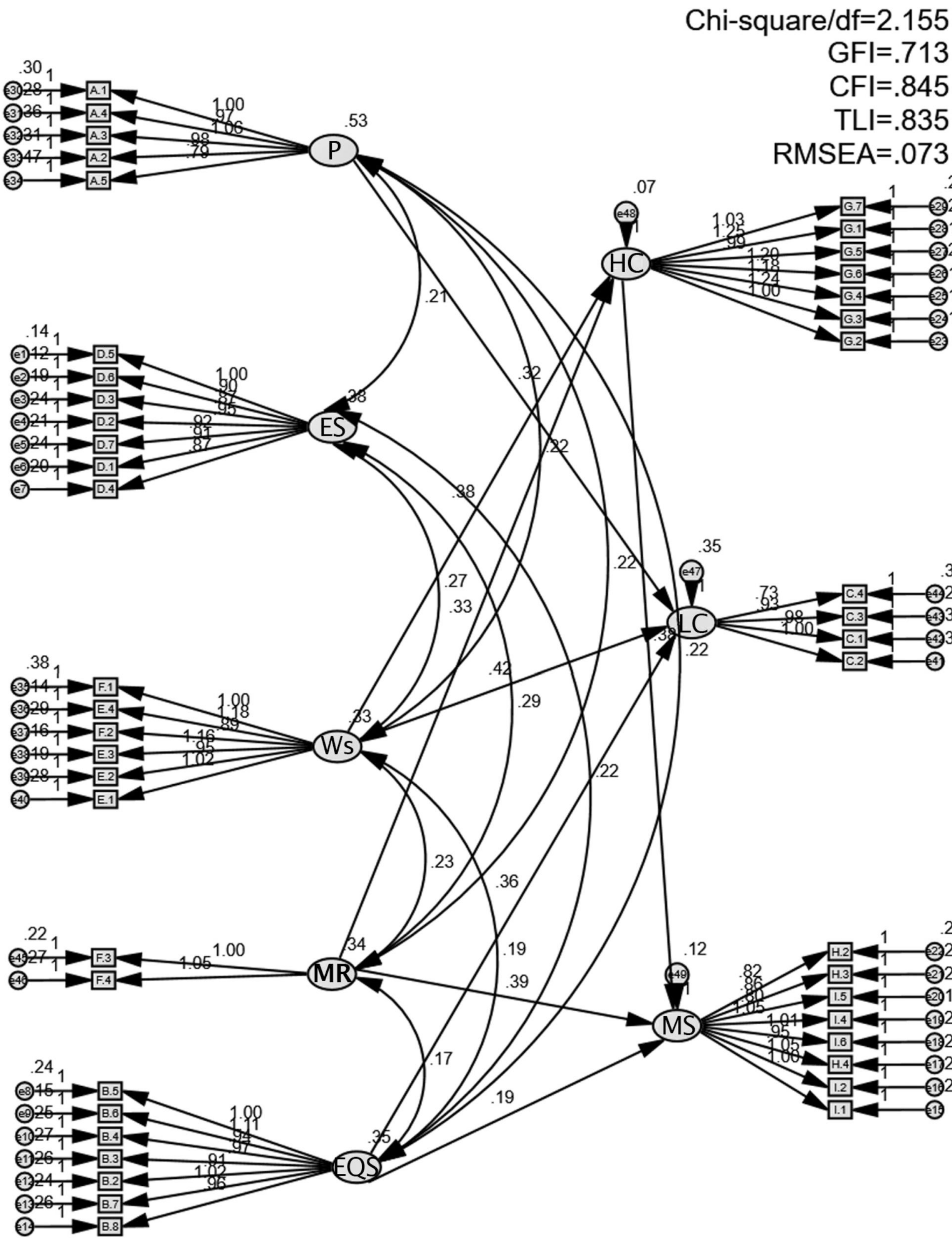

Figure 2. Diagram of the factor's relationship.

Variable and extensively applied, the projects that have been and are being constructed in accordance with green building standards are mostly funded by private or foreign capital; state budget initiatives in the direction of green buildings have not yet been implemented.

The group of experienced factors with the coefficient of impact on the economic performance of the project life cycle is 0.36 ranked first according to the influence diagram in Figure 2. Sustainable design and sustainable development principles are playing an increasingly important role by architects and engineers, construction contractors and especially real estate developers.

Green building development, construction, and operation need a design approach that exhibits a strong commitment to health and environmental concerns, the integration of architectural ideas and landscaping into the design process to decrease energy consumption, and other factors. Design approaches to lower construction costs, lifespan expenses, and the environmental effect of mining. Manufacturing of materials and components; Construction; Operation and maintenance while in use. Finally, decide whether to reuse, recycle, or dispose. This needs a team of engineers and architects that are familiar with and understand green construction standards. The development of green buildings is hampered by a lack of technical understanding. As a result, stakeholders must be trained and certification examinations must be administered. Governments should continue to promote energy-saving technology research and activities to enhance technical communications and operational facility management.

The influence coefficient related to the group of dynamic water-saving factors affecting the project life cycle economic performance is 0.29, ranked second according to the influence diagram in Figure 2. Water is one of the essential and indispensable needs in human life. In construction, water is used throughout the construction and operation of the work. Reducing water consumption and protecting water quality are the main goals of green buildings. According to Crawford and Pullen (2011), buildings account for around 12% of total world water usage, including material manufacturing. Water efficiency in green building may be characterised broadly as the reduction and removal of superfluous water usage and waste while causing the least amount of harm to the environment, society, and economy (Waidyasekara and Silva 2014).

Conclusion

To encourage environmentally friendly growth, governments need to employ strict enforcement of the law, well-defined green building rules, and a number of other strategies. construction companies to encourage them to use environmentally friendly building materials in their present and future projects. Green building evaluations will be impacted by a variety of important aspects, according to this research, including groups of variables linked to 'Experience, qualifications, skills', Group of factors related to 'Motivation to maximise economic performance of the project life cycle', 'Energy saving', 'Water saving', 'Materials & Resources', 'Management', 'Motivation to promote the advantages of market strategy'. Energy-saving management is the first category of criteria that influences the approach and evaluation of a green building. Furthermore, this will have an impact on future assessments of green buildings, such as life cycle cost analysis and environmental impact assessments undertaken throughout the project's construction. It is critical to identify and prioritise the components that influence the construction of a green building. It will provide more precise project development approaches to academics, designers, and practitioners.

LOTUS is clearly an energy-oriented environmental evaluation method, with the building's energy use score receiving the most weight. Hence, LOTUS-certified buildings prioritise energy efficiency over other environmental impacts. Design guidance programs differ from performance-based rating systems. However, a project's green rating should take into account land ecological value, material life cycle evaluation, and greenhouse gas emission reductions throughout the building's life cycle, among other things. To quantify and rate the performance improvement of green buildings, a strong database is required. The performance-based approach to environmental impact assessment in LOTUS needs to be based on a comprehensive database tailored to the reality of Vietnam. Vietnam is still in the early stages of development to support its application, and more work remains to be done. At this level, measures-based green building assessment is considered a good technique for nations that are just starting to review green buildings, such as Vietnam; nevertheless, in order to improve design results, the following stage requires changing from measures-based to performance-oriented ratings.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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