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Development of Cambodia Green Building Guidelines and Certification (CamGCGB) for National Implementation: Criteria for New and Existing Buildings

Martin Schoch[1], Sunaree Lawanyawatna[1,*], Sokhai Nop[2]

[1]School of Architecture and Design, King Mongkut's University of Technology Thonburi, Thailand
[2]Ministry of Environment, Phnom Penh, Cambodia

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Abstract To address Sustainability, Cambodia's National Council for Sustainable Development (NCSD) is developing a national building rating system for possible implementation by the Ministry of Environment. This paper describes the objectives and framework for preparing the draft of this system. The study aims to develop guidelines and certification criteria for Cambodia's 'new buildings' and 'buildings in use'. The study reviews prevalent regionally and internationally used building assessment schemes and relates their outcomes to the local context. The resulting criteria framework further developed through stakeholder reviews and piloting projects, combines sustainable considerations in environmental, economic, and socio-functional sustainability categories, including process, communication, and site considerations. It incorporates feasible quantitative and qualitative criteria for implementation and evaluation using applicable indicators. The framework also foresees the development of training and operation manuals for the certification process. While adopting several criteria from existing rating schemes to become practical in Cambodia, such an approach requires a gradual adjustment due to the prevailing lack of local standards and related reference data and the lack of experience in sustainability in critical occupations of the industry. The significance of the study lies in its potential to promote sustainable development in the Cambodian construction sector; implementing a certification system will help the country achieve sustainable development goals.

Keywords Green Building Guidelines, Green Building Certification, Sustainable Development

1. Introduction

Cambodia faces numerous sustainability challenges, such as rapid urbanization, human health, resource depletion, and climate change impacts [1]. The construction industry significantly contributes to these challenges by consuming many resources, generating waste, and emitting pollutants and greenhouse gases [2].

Sustainable construction practices are crucial in Cambodia as they contribute to environmental protection, economic viability, and overall quality of life. Cambodia's National Council for Sustainable Development (NCSD) is developing a national building rating system that the Ministry of the Environment aims to implement to address these challenges [3]. In 2019, the "Guidelines and Certification Standards for Green Buildings in Cambodia" project was initiated to establish guidelines and certification procedures for green buildings in the country. The Cambodia Green Building Guidelines and Certifications (CamGCGB) system aims to promote resource-efficient and environmentally friendly construction methods that align with this vision. The guidelines aim to support building owners, developers, architects, engineers, contractors, and building material manufacturers in achieving green buildings nationwide.

This research offers a holistic view of the methodology, objectives, and anticipated achievements of the CamGCGB system in propelling sustainable development in the country. The study will review the regionally and internationally prevailing building rating systems and relate its findings to the local context regarding sustainability categories of environmental, economic, and socio-functional characteristics, as well as communication, process, and site-related aspects. The guidelines and certification criteria will be implementable and evaluable using relevant indicators and a developed certification process. The study draws on existing building rating systems, literature, and appropriate reports, and its limitations include the lack of applicable local standards and reference data and the lack of capacity for industry professionals with sustainability practices.

The methodology employed in this research comprises several crucial steps. It begins with a comprehensive desk review, gathering and analyzing information from diverse sources such as existing policies, regulations, scientific literature, and international systems relevant to green building practices. Subsequently, appropriate criteria and indicators are selected and adapted based on their feasibility and applicability within the Cambodian context. Feedback from stakeholders and experts is sought through consultations to address gaps and challenges in sustainability practices, ensuring alignment with industry needs. The developed criteria are then tested in pilot projects to evaluate their effectiveness, identify areas for improvement, and validate their real-world applicability. Finally, the CamGCGB system is refined and finalized through training programs, the creation of certification manuals, and stakeholder engagement to facilitate widespread adoption and successful implementation.

The primary objectives of this research are multifaceted. They include establishing a robust green building certification system tailored to Cambodia's context, promoting awareness and knowledge transfer on sustainable construction practices, facilitating the transition to resource-efficient construction methods, and enhancing the construction sector's competitiveness while creating employment opportunities in green technologies and services.

Anticipated achievements from the successful implementation of the CamGCGB system include improved building performance, reduced environmental footprint, increased adoption of sustainable design practices, recognition and certification of green buildings, market differentiation, collaboration among stakeholders, and overall advancement of sustainability practices in the construction industry.

Accordingly, this research aims to contribute substantially to Cambodia's sustainable development agenda by supporting green building initiatives, fostering innovation, and promoting a resilient and environmentally friendly built environment for present and future generations. Introducing a certification system will help Cambodia achieve sustainable development goals such as reducing resource consumption, promoting green jobs, and improving the population's quality of life. The results and recommendations obtained can then feed into the national construction industry's policy and practice and contribute to the scientific discourse on sustainable building rating systems.

2. Background

Green building is a fast-growing field focused on environmentally responsible and sustainable construction [4]. Its goal is to reduce environmental impact while providing healthy and comfortable environments for occupants. The concept has evolved without a universally accepted definition or standard [5]. The history dates to the 1970s when energy crises led to energy-efficient design [6]. Efforts expanded in the 1980s to improve indoor air quality and use non-toxic materials. The 1990s saw the rise of sustainable building certification programs, such as the US Green Building Council's LEED, which assesses buildings based on energy efficiency, water usage, and material selection [7]. Green buildings reduce energy consumption, operating costs, and environmental impact while improving indoor air quality [8]. They also provide comfortable living and working spaces, increasing productivity and satisfaction. Green building has increasingly emphasized social sustainability by addressing equity, accessibility, and community engagement [9]. This extension includes promoting physical activity, fostering social interaction, and providing affordable housing.

Integrating green building practices across different building types is essential to achieve a more extensive range of benefits. Cambodia can achieve comprehensive sustainable development by following green building guidelines and certifications, including resource conservation, climate change mitigation, improved health and well-being, economic benefits, and increased social awareness, all contributing to a greener and more sustainable future.

2.1. Green and Sustainable Building certification systems

As green buildings become more popular, several international and national rating systems and standards exist to guide the design, construction, and operation of green buildings. The following overview examines some international green building rating systems and standards reviewed in this study.

2.1.1. International Certification Systems

Likely, the most widely recognized green building rating system is the Leadership in Energy and Environmental Design (LEED) program developed by the United States Green Building Council [7]. LEED certification builds on a point system that evaluates a building's performance in various categories, such as energy efficiency, water conservation, indoor air quality, and sustainable materials. The LEED rating system has been adapted and used in several countries worldwide [10]. Regarding the international applicability of criteria and indicators, LEED has proven its adaptability and has been successfully implemented in various countries worldwide. Such indicates that its criteria and indicators can effectively apply in different contexts, such as in many less developed countries that have used the system as the basis of their national assessment systems by mainly reducing the number of criteria indicators and the ambitious evaluation to become locally applicable. Cambodia's neighboring countries, such as Vietnam or Thailand, made such adoptions with their systems.

The "Deutsche Gesellschaft für Nachhaltiges Bauen" (DGNB) is a German organization that has developed a thorough system for sustainable building design and construction [11]. DGNB evaluates buildings on six criteria: ecological quality, economic quality, sociocultural quality, technical quality, process quality, and site quality [12]. The DGNB system is considered one of the most rigorous and comprehensive green building rating systems [11]. It has gained international recognition and is used in other countries, especially Europe, as it offers a local adaptation of criteria. In some countries, partner organizations have established country-specific systems on their basis.

The International Finance Corporation (IFC) developed the Excellence in Design for Greater Efficiencies (EDGE) system to provide a standardized method for evaluating the environmental performance of buildings in emerging markets [13]. EDGE evaluates buildings' energy efficiency, water conservation, and materials [14]. The system is expressly designed for use in developing countries worldwide and intends to be accessible and cost-effective for small and medium-sized projects. A supporting online assessment makes EDGE highly relevant and applicable globally. A disadvantage is the system black box approach, in which significant calculation and evaluation bases are sometimes not transparent enough to allow government recognition.

2.1.2. Regional Certification Systems

The Green Mark program developed by Singapore's Building and Construction Authority (BCA) evaluates buildings' environmental impact and performance [15]. It focuses on energy efficiency, water conservation, sustainable materials, and the quality of indoor environmental conditions. The Green Mark system has been widely implemented in Singapore as all new buildings and major retrofit projects must undergo assessment and obtain a Green Mark certification [16].

The LOTUS rating system developed in Vietnam evaluates buildings into seven categories: sustainable site development, water conservation, energy efficiency, material efficiency, indoor environmental quality, cultural and community impact, and innovation [17]. The developed system promotes sustainable building practices in Vietnam and was utilized in several projects in the country.

The Thailand Green Building Institute developed the TREES rating system to evaluate the environmental performance of buildings in Thailand [18]. TREES considers eight categories: energy efficiency, water conservation, materials and resources, waste management, indoor environmental quality, site and transportation, social and cultural, and innovation [19]. TREES has been widely adopted in Thailand and recognized by international organizations such as the World Green Building Council.

The G-SEED system, developed by the Korea Institute of Civil Engineering and Building Technology (KICT), is a notable sustainable building system used in South Korea. It focuses on promoting green and energy-efficient design principles to enhance the sustainability performance of buildings [20]. The G-SEED approach emphasizes energy efficiency, water conservation, indoor environmental quality, and renewable energy sources [21].

2.2. Benefits of Green Building in Cambodia

Less developed countries are increasingly interested in green buildings to address environmental and social issues [17, 22]. More resources and infrastructure are needed for green buildings in such countries [23, 24]. Lack of awareness and education among stakeholders is another significant challenge, leading to a limited understanding of the benefits of sustainable building practices [25]. Lack of government policies and regulations may further hinder development [25]. However, green buildings offer opportunities for poverty alleviation, job creation, and environmental benefits [26, 27]. They contribute to sustainable development goals and improve citizens' health and well-being [28]. Green building promotes local economies using local resources and materials [29].

In Cambodia, green buildings can improve living conditions by enhancing indoor air quality and thermal comfort [30]. They also reduce energy and water use, providing cost savings to occupants, particularly low-income households [23]. Water-efficient systems help alleviate water scarcity issues. Green building practices support economic growth and poverty alleviation and help achieve sustainable development goals in Cambodia [31, 32].

Financially, investing in green buildings in Cambodia offers significant long-term economic benefits [1]. Energy-efficient buildings typically command higher property values and have lower operating costs. They create job opportunities, promote healthy indoor environments, and are more resilient to climate change impacts [33]. Governments may offer financial incentives to encourage green building initiatives. Adopting green building practices can enhance Cambodia's attractiveness to international investors, demonstrating a commitment to responsible development [34].

2.3. Existing Green Building Initiatives in Cambodia

Although there are few green building projects in Cambodia's construction industry, the existing certified buildings result from investments made to offer high-quality real estate using international building assessment programs [1]. These programs, like LEED, allow investors to rent their newly constructed properties to foreign companies at higher, globally oriented market prices. However, implementing the CamGCGB system, geared towards the local construction industry's more national-oriented development, has not yet been realized. Besides the present work of the Ministry of Environment [3] addressing such local concerns, a private sector organization called Cambodia Green Building Council [33] is also working towards introducing green building guidelines and certifications in Cambodia. In addition, the Global Green Growth Institute (GGGI) Cambodia aims to increase readiness for green building investments by supporting like-minded projects and exploring investment opportunities as part of its Readiness for Green Building project [34].

There is also the international financing company, which provides the EDGE standard systems for buildings for developing countries, and international non-governmental organizations that provide advisory services and public awareness campaigns to advance Cambodia's transition to sustainable construction practices, such as Build4People, a research project to promote sustainability and improve the quality of life in cities in Cambodia [35]. Despite these efforts, the adoption of green building practices in Cambodia remains low, mainly due to limited awareness, lack of incentives, and financial constraints. For instance, building materials certified as environmentally friendly, such as low-emission paints, energy-efficient appliances, and sustainable wood products, are scarce and expensive in Cambodia [36]. Additionally, the cost of construction of green buildings is often higher than that of conventional buildings, which limits their adoption by developers and homeowners [37].

2.4. Gaps and Challenges in Sustainability Practices in Cambodia

Cambodia's proposed green building guidelines and certifications are crucial for sustainability and reducing environmental impact.

Policymakers and industry stakeholders can promote the widespread adoption of sustainable systems in construction through regulatory measures that include implementing sustainable building codes and standards, environmental impact assessments, green certification programs, and education and training—supported through initiatives that involve launching public awareness campaigns that outline benefits, facilitating collaboration among stakeholders, supporting research and development efforts, showcasing successful sustainable construction projects, and creating market incentives to prioritize green construction practices.

By setting national standards for design and construction, they can promote consistency in the industry and increase awareness among professionals and the public. A local certification program for sustainable building practices would also provide marketing benefits and recognition [38, 39].

However, there are several gaps and challenges in green building in Cambodia, including limited awareness and understanding of green building concepts among stakeholders, lack of incentives, scarcity and high cost of green materials, higher construction costs, insufficient policies and regulations, and the need for capacity building and skills development [1]. Addressing these challenges requires a comprehensive approach, including adapting existing rating systems to fit the Cambodian context while considering local conditions and engaging stakeholders in analyzing the situation. Yet, it also needs to develop robust regulatory frameworks, offer training and financial mechanisms for green building projects, and promote inclusive and participatory approaches to sustainable development. By overcoming these challenges, Cambodia can accelerate its transition towards a more sustainable built environment.

3. Methodology

The CamGCGB system defines a set of criteria and indicators as part of a certification system that describes an overall assessment structure. (Figure 1) A step-by-step methodology establishing the development of the CamGCGB system illustrates the stages that define the system development strategy. It includes (I) a desk review collecting, categorizing, and analyzing information, (II) a criteria selection through adaptation, (III) a consultation and review to improve the proposed system, (IV) piloting for CamGCGB implementation testing, and (V) CamGCGB Draft Finalization.

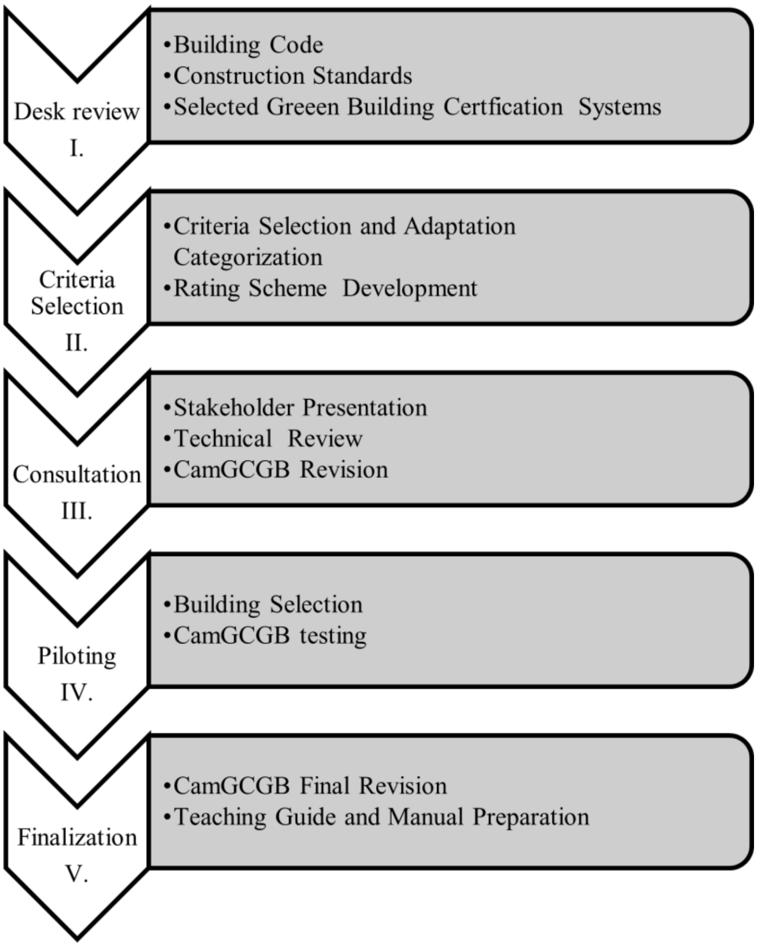

Figure 1. CamGCGB System Development Methodology

I. Desk Review: The desk review involves gathering and examining information on existing guidelines and relevant practices to identify relevant themes and gaps for developing the initial draft of the CamGCGB system. Primary sources are respective laws, such as Cambodia's existing building code and available construction standards; secondary sources include academic literature, reports, and case studies. Moreover, the certification system for green building in Cambodia is developed by reviewing neighboring and international approaches to understanding current practices and identifying areas adaptable to Cambodia's context. During the review process, the criteria of assessment schemes are examined for their applicability to the country's existing regulatory frameworks, knowledge, and construction practices. The study also examines alignment with the United Nations Sustainable Development Goals (SDGs) and government interests. Suitable criteria are classified into two implementation groups: moderate effort, which requires minor adjustments, and demanding effort, which necessitates alternative and simplified approaches.

II. Criteria Selection: The selection of relevant criteria and indicators for CamGCGB is crucial, necessitating an assessment for required adaptation and development. Adapting criteria foresees establishing feasible objectives for implementation and evaluation using applicable quantitative or qualitative indicators due to the limitation of local standards, reference data, and experience in critical industry occupations. These are selected based on their relevance and ability to identify quality standards or accurately measure building performance reliably. An overview then separates criteria into environmental, economic, and socio-functional sustainability categories. This classification also allows for establishing a holistic-oriented rating system and differentiating residential and non-residential building types.

III. Consultation and Revision: The revision of the initial draft involved a participatory approach, gathering feedback from consultants and stakeholders to identify and address gaps and challenges in sustainability practice. The Korean Institute of Civil Engineering and Technology (KICT) was the technical consultant. Stakeholders include relevant ministries, non-governmental organizations, academia, civil society, and industry representatives. Due to the COVID-19 pandemic, conducted online consultations collected feedback and recommendations. The revision of the CamGCGB draft integrated these results. Technical Working Group (TWG) meetings discussed the presented CamGCGB. The TWG consists of professionals from the fields of construction, architecture, and urban planning, as well as related scientists and technical authorities from various institutions, including the Ministry of Land Management, Urban Planning and Construction (MLMUPC), the Cambodian Constructors Association (CCA) and the Institution of Technology (ITC). The TWG focused on technical aspects of green and sustainable building. The further revised CamGCGB framework included and addressed constructive feedback and technical comments.

IV. Piloting: The initially planned pilot studies were an integrative part of this study. Two pilots were to test their applicability and readiness for future implementation of the CamGCGB system. The first pilot project was a newly planned and built single-family house in Phnom Penh to investigate the criteria and indicators of the NB system. The second pilot focused on the existing Ministry of Environment office building in Phnom Penh, which also represented the BIU system criteria.

V. CamGCGB Finalization: Training and certification manual preparation: With a finalized revision of the certification process, a regional workshop shared results and experiences with the Mekong Foundation and the Korean Institute for Civil Engineering and Technology (KICT) of the Republic of Korea and stakeholder representatives from neighboring countries; this included preparing teaching materials and a CamGCGB system manual, guiding sustainable practices and certification processes. It outlines criteria, indicators, and step-by-step guidance for certification. The training program equips professionals, owners, and users with knowledge and skills for implementation.

4. Results

The following describes the result of the CamGCGB system creation and development for a sustainable guideline and building assessment certification system for new buildings (NB) and buildings in use (BIU).

4.1. CamGCGB System Development

The desk review was completed in a comprehensive and collaborative process, followed by the first drafts of the two criteria systems. The creation of the CamGCGB system primarily selects and adapts the German Sustainable Building Council (DGNB) assessment criteria and the Korean G-SEED system of the Korean Institute for Civil Engineering and Technology (KICT). The revision of the first draft involved a participatory approach, gathering feedback from KICT's technical advisors to address gaps and challenges in sustainable practices. While comments and suggestions were primarily positive, they also included requests to simplify the assessment and calculation process and a more descriptive approach to guiding subsequent criteria implementations. The draft was more comprehensive than the initially established targets, which focused primarily on energy, water, and material resource consumption in buildings, which was also a positive aspect. The feedback was incorporated into the revised CamGCGB draft and discussed in Technical Working Group (TWG) meetings, which focused on the technical aspects of green and sustainable construction and resulted in a further revised CamGCGB framework incorporating constructive feedback and technical comments.

The pilot projects were an integral part of the study, and testing the applicability and readiness of the CamGCGB building rating systems for future implementation was foreseen. The first pilot scrutinizing new building (NB) system criteria and indicators indicated the need to reassess individual and overall weight settings for assessing some criteria groups, specifically the economic and site sustainability categories; this is also in light because site considerations in rural locations may face more difficulty in achieving a positive assessment of existing infrastructure. The second pilot assessing the BIU suggested a minor revision describing the need to guide the scheme's goal-setting process more clearly. Both pilots highlighted the systems' potential applicability, the need for minor modifications, and the importance of expert involvement for practical implementation.

Following these pilot projects, the development of the CamGCGB system and a concluding round of system improvement-based recommendations from KICT were incorporated into a final revision to enable strategic adjustments for integration into subsequent government regulations. The focus was on prioritizing individual criteria to identify and highlight their importance to the overall system.

4.2. Guidelines and Certification Criteria for New Buildings and Buildings in Use

The following presents an overview of the result of the CamGCGB system creation for a sustainable guideline and building assessment certification system for new buildings and buildings in use.

The CamGCGB sustainable building certification system aligns with the United Nations Sustainable Development Goals and allows adjustments to suit local conditions. The criteria have varying levels of adaptation effort, and some offer simplified methods for fulfillment based on local constraints and capabilities. The certification process involves pre-assessment and a final assessment with construction completion. Spreadsheet tools support and streamline the assessment processes, and the certification criteria include minimum and optional requirements adaptable to different building types and sizes. Specific goals with respective indicators are defined within each category, and progress towards these goals is measured using appropriate indicators such as quantitative performance targets or qualitative fulfillment factors.

4.2.1. New Building (NB.)

The CamGCGB NB system aims at all stakeholders involved, such as developers, owners, operators, and building users, in developing a sustainable and climate-protection-oriented real estate strategy for new buildings, currently classified as Residential or Non-Residential types. The system encompasses various assessment criteria and indicators evaluating environmental, economic, social, and communication qualities. (Table 1) It comprises 25 criteria and 112 indicators and overviews the specified categories, criteria, weight distribution (WT), and significance (SIGNIF).

Table 1. Overview and Weight Distribution of CamGCGB NB Scheme

CATEGORY	CODE	CRITERIA	WT	SIGNIF
Environmental Sustainability 22.5%	ENV1	*Construction Material and Local Environmental Impact*	4.5%	High
	ENV2	*Sustainable resource extraction*	2.3%	High
	ENV3	*Energy efficiency assessment*	9.0%	High
	ENV4	*Water efficiency use and wastewater volume*	2.3%	High
	ENV5	*Land use and urban planning*	3.4%	High
	ENV6	*Biodiversity at the site*	1.1%	High
Economic Sustainability 22.5%	ECO1	*Life cycle cost*	11.3%	High
	ECO2	*Flexibility and adaptability*	11.3%	Moderate
Socio-Functional Sustainability 22.5%	SOC1	*Indoor air quality*	8.7%	High
	SOC2	*Building visual and thermal comfort*	5.2%	Moderate
	SOC3	*Quality of indoor and outdoor spaces*	3.5%	Low
	SOC4	*Design for all*	5.2%	Moderate
Technical Sustainability 15%	TEC1	*Fire safety*	2.7%	Low
	TEC2	*Quality of building envelope*	5.5%	High
	TEC3	*Ease of cleaning building component*	1.4%	Low
	TEC4	*Ease of Recovery and Recycling*	5.5%	High
Communication Sustainability 12.5%	COM1	*Project information brief*	3.1%	Moderate
	COM2	*Construction process*	3.1%	Moderate
	COM3	*Systematic commissioning and operation*	3.1%	Moderate
	COM4	*User communication*	2.1%	Moderate
	COM5	*Facility management*	1.0%	Low
Site Sustainability 5%	SIT1	*Local resilient environment*	1.1%	High
	SIT2	*Influence on the district*	1.1%	Moderate
	SIT3	*Transport Access*	1.1%	Moderate
	SIT4	*Amenity Access*	1.7%	Moderate

The new build rating system framework integrates sustainability considerations into three categories: environmental, economic, and socio-functional sustainability. Environmental sustainability covers reducing environmental impact, energy efficiency, water conservation, land use, and biodiversity. Economic sustainability includes life cycle costs and adaptability. Socio-functional sustainability encompasses health, comfort, and accessibility. These categories ensure a comprehensive approach to sustainable development. The evaluation system further includes additional categories like technical, communication, and location aspects to promote sustainable development effectively. Technical considerations involve safety, building quality, and end-of-life issues. Communication considerations apply, providing occupants with information on sustainable practices. Location considerations include local resilience and neighborhood aspects.

With several criteria considered complex for first-time users, a current consideration is to reduce their initial amount and then gradually extend the system. The significance definition describes which criteria have priority in such a scenario, where high significance represents first-draft consideration.

4.2.2. Buildings in Use (BIU)

The CamGCGB BIU system aims to help all stakeholders involved in buildings in use –owners, operators, and building users- develop a sustainable and climate protection-oriented real estate strategy. It explicitly addresses building owners, real-estate/portfolio managers, asset managers, property managers, operators, and facility managers. The new certification system is applicable regardless of the use and type of building, provided that the building has been in operation for at least one year. The certification is valid for five years.

(Table 2) The BIU certification criteria structure consists of nine criteria and 51 indicators to identify sustainable practices, of which three group into a sustainability category. Accordingly, the environmental sustainability criteria assess the impact of buildings on the global and local environment, as well as their resource consumption and waste generation. The economic sustainability criteria evaluate aspects in terms of the building's long-term value and profitability. Socio-functional sustainability criteria support the assessment of building comfort, user satisfaction, well-being, and characteristics of mobility infrastructure. The objective of the individual evaluation criteria includes the following targets.

Regarding assessment, the CamGCGB BIU scheme utilizes the same approach as the NB scheme of summing up the criteria's individual determining performance.

The "continuous improvement process" (PDCA cycle) applies to five of the nine BIU system criteria. The PDCA cycle is an iterative process with four steps: Plan, Do, Check, and Act, which involves defining specific targets, executing and recording data, analyzing and evaluating target achievement, and defining measures to optimize operations to ensure a continuous process. To achieve the desired outcome, proposals for building improvement must be in place across all nine criteria sections. These proposals should not only outline the general idea but also describe the stakeholders involved in the process, define specific goals, establish how these goals can be achieved, monitored, analyzed, and evaluated, and identify measures to optimize the operation further.

Table 2. Overview and Weight Distribution of CamGCGB BIU Scheme

CATEGORY	CODE	CRITERIA	WT
Environmental Sustainability 40%	ENV1.BIU	Energy	30%
	ENV2.BIU	Water	5%
	ENV3.BIU	Materials and Recycling	5%
Economic Sustainability 30%	ECO1.BIU	Operational Cost	5%
	ECO2.BIU	Risk Management and Long-Term Asset Value	15%
	ECO3. BIU	Procurement and Operations	5%
Socio-Functional Sustainability 30%	SOC1.BIU	Indoor Comfort	10%
	SOC2.BIU	User Satisfaction	10%
	SOC3.BIU	Mobility	10%

4.2.3. CamGCGB System Implementation

The CamGCGB system uses performance indices to rate buildings. The overall performance index is calculated as the sum of the evaluation of weighted results of individual criteria. Typically, each criterion describes the assessment requirements in their respective assessment method. The method can consist of several segments of indicator assessment in quantitative or qualitative form, depending on the needs. For each criterion, the indicators usually add up to 100 points; in some cases, when more points are achievable, a maximum of 100 points can be awarded. The Building CamGCGB Silver Certificate awards an overall performance index of 50% or more. A CamGCGB Gold Certificate achieves a performance index of 65% or more. To receive a CamGCGB Platinum certificate, the highest possible recognition, the project must have a completed performance index of at least 80%. Yet, receiving any specific award also requires reaching a minimum performance index in each relevant sustainability category (except "location quality"). For example, a performance index of at least 65% is required for each sustainability category to obtain a platinum certification.

4.2.4. Certification Process

The auditor supports the certification process by providing detailed assessment results and documentation, which he completes and submits to the CamGCGB for confirmation and certification. Each criterion determines the required or permissible forms of documentation. Evidence in other formats is admissible if agreed upon beforehand and achieves the objective of the criterion. Project realization must follow the requirements described. With the project realization and final documentation by the auditor, the certification is verified and awarded by the CamGCGB.

4.3. CamGCGB Implementation and Future Advancement

The development of the CamGCGB system is currently awaiting government action to create a legal framework and implement measures by the relevant ministries. Ongoing exchange among state and non-government institutions and the gradual integration and updating of national building regulations are possible steps to ensure that Cambodia is on the path to sustainable development.

To boost green building development, buildings with certification may also become entitled to specific government incentives foreseen in the national building code. For instance, projects that achieve green building certification can increase a stated floor area ratio by a percentage.

The synchronization and integration of green building criteria into legal regulations, and vice versa, can help society steer towards a more sustainable future. Yet, while law ordinances and benchmarks must ensure that achieving such mainly on affordable terms, green building certification can strive for future goals to encourage the progression of research and development. Accordingly, legal standards are essential in many building rating systems, with higher targets for improving performance.

5. Discussion

The study outlines the development of the CamGCGB (Cambodian Green Building Certification) system in five steps: desk review, criteria selection, consultation and revision, piloting, and CamGCGB finalization. It involves gathering and analyzing information, adapting criteria, obtaining feedback, integrating improvements, and finalizing the system through training and certification manual preparation.

The approach allows adaptation to local circumstances and facilitates reference and idea-sharing partnerships. The system comprises six sustainability categories: environmental, economic, socio-functional, technological, communication, and site sustainability. The certification criteria for new buildings (NB), subdivided into residential and non-residential building types, and buildings in use (BIU) underwent separate development.

The NB scheme's environmental criteria address strategies to conserve natural resources and minimize environmental impact. Other essential aspects focus on resource efficiency, energy, water, land resources, and initial biodiversity considerations. Collaboration and ongoing research and development in energy and water assessment, material use, and building impacts are essential to strengthening this sustainability group.

The economic focus is on introducing life cycle cost analysis to achieve cost efficiency, long-term savings, and financial viability in green construction projects. In addition, flexibility and adaptability to building changes are promoted. Data collection from actual projects is necessary to make this more effective, and collaboration with industry stakeholders is vital to mainstreaming economic sustainability practices.

The socio-functional part emphasizes creating healthy, safe, and inclusive built environments prioritizing human well-being and community engagement. It focuses on improving indoor air quality and comfort, incorporating accessibility features, and creating spaces that promote social interaction. Stakeholder collaboration and capacity-building programs on indoor air quality improvement and inclusive, universal design can help make these aspects more widely known.

The technology aspect includes building performance and safety advances focusing on fire protection, building envelope considerations, and ease of cleaning. Recovering and recycling building components aims to reduce construction waste and promote circular practices. To manage these aspects, fostering partnerships with technology providers and promoting research and development in green technologies can advance these concerns. The communication aspect focuses on regulatory frameworks and policies integrating sustainability practices and associated communication and management practices into the construction planning process. The location-based portion aims to raise awareness of resilience and district impact and integrate with amenities and transportation.

Concerning the BIU scheme, environmental considerations include improving waste management practices and using environmentally friendly materials during building operations. Risk assessment and long-term value considerations are economically critical, whereas socio-functional aspects have similar aims to the NB scheme.

The project's comprehensive system for green building design and certification aims to support the development of resource-efficient buildings with reduced environmental impact, create more green jobs, and improve the living standards for Cambodians. By integrating green building design into Cambodia's construction sector, the project will help to support the transition to more sustainable lifestyles for Cambodia's urban population and help businesses be more cost-efficient. The presented CamGCGB system has significant implications for promoting sustainable building development in Cambodia. The certification process will help improve buildings' performance and reduce environmental and human health impacts.

Establishing and operating a suitable institution are needed to implement CamGCGB successfully. Such requires the active involvement and cooperation of various stakeholders, such as the government, the construction industry, academia, and civil society. Several recommendations address the challenges of developing the CamGCGB system; this includes establishing a national working group, creating a comprehensive database of building performance data, providing training programs for industry professionals, and conducting public awareness campaigns to promote sustainable buildings and the certification scheme. These measures facilitate the development and implementation of the rating system while fostering a sustainable built environment.

6. Conclusions

This study has provided valuable insights into making the Cambodia Green Building Guidelines and Certifications (CamGCGB). While it is essential to recognize its limitations, such as the restricted scope of the case study analysis and the deficiencies of primary building performance data in Cambodia, future research should address these by conducting more extensive case studies and collecting preliminary building performance data to strengthen the system's effectiveness. Additional research can assess the impact of the national building rating system in promoting sustainable development within the construction industry and in society at large; this can help refine and improve implementation over the long term.

If the CamGCGB implementation is successful, it would be beneficial to develop customized assessment schemes for different building types. Such a realization would optimize the system's ability to address unique sustainability challenges and requirements for various building categories, resulting in a more comprehensive and practical approach to sustainable development.

The CamGCGB system will likely positively impact the promotion of sustainable building development in Cambodia. This system will pave the way for a more sustainable built environment in the country; its positive results can lead to long-term resource efficiency and improved quality of life for Cambodian citizens. The continuous development and improvement of the CamGCGB system will play a crucial role in promoting a greener and more sustainable Cambodia. By working together, policymakers, industry experts, researchers, and the wider community can adopt sustainability principles and create a more resilient and greener built environment.

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