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SUSTAINABLE IMPACT CONSIDERATION IN COMPARISON GREEN BUILDING RATING TOOLS IN INDONESIA

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Abstract: *Buildings are a significant contributor to environmental degradation. Green building, which incorporates environmentally friendly criteria, is a formal approach to address this issue. Various rating tools have been formally developed to assess comprehensive green criteria. Five GBRTs (green building rating tools) are used in Indonesia: Greenship, Green Mark, LEED, EDGE, and BGH. This study identified the factors and considerations that influence the development of GBRTs in promoting sustainable practices in the built environment. The findings reveal that several factors play a significant role in this process. Firstly, the climate conditions of the country where the GBRT is being developed significantly influence the weighting of criteria, particularly those related to the site category. Secondly, the economic development of a country, as a reflection of the maturity of the built environment infrastructure, influences the formulation of GBRTs. Countries with well-established infrastructure tend to consider economic aspects in the GBRTs criteria. However, in countries like Indonesia, where infrastructure development is still progressing, waste management is considered in GBRT development. Lastly, GBRTs developed by government organizations or institutions recognized by the government often consider social aspects in their criteria.*
Keywords: *Bangunan Gedung Hijau (BGH), green building, Greenship, rating tools, sustainability*

Abstrak: Bangunan merupakan penyumbang signifikan terhadap degradasi lingkungan. Bangunan ramah lingkungan, yang memasukkan kriteria ramah lingkungan, merupakan pendekatan formal untuk mengatasi masalah ini. Berbagai alat pemeringkatan telah dikembangkan secara formal untuk menilai kriteria ramah lingkungan yang komprehensif. Lima GBRT (alat pemeringkat bangunan ramah lingkungan) yang digunakan di Indonesia: Greenship, Green Mark, LEED, EDGE, dan BGH. Studi ini mengidentifikasi faktor-faktor dan pertimbangan yang mempengaruhi pengembangan GBRT dalam mempromosikan praktik berkelanjutan di lingkungan binaan. Temuan mengungkapkan bahwa beberapa faktor memainkan peran penting dalam proses ini. Pertama, kondisi iklim di negara tempat GBRT dikembangkan berpengaruh signifikan terhadap bobot kriteria, khususnya yang berkaitan dengan kategori lokasi. Kedua, perkembangan ekonomi suatu negara, sebagai cerminan kematangan infrastruktur lingkungan binaan, mempengaruhi perumusan GBRT. Negara-negara dengan infrastruktur yang baik cenderung mempertimbangkan aspek ekonomi dalam kriteria GBRTs. Namun, di negara seperti Indonesia yang pembangunan infrastrukturnya masih berjalan, pengelolaan sampah menjadi salah satu pertimbangan dalam pembangunan GBRT. Terakhir, GBRT yang dikembangkan oleh organisasi atau lembaga pemerintah yang diakui pemerintah seringkali mempertimbangkan aspek sosial dalam kriterianya.
Kata Kunci: Bangunan Gedung Hijau (BGH), green building, Greenship, alat pemeringkatan, keberlanjutan

INTRODUCTION

Population and economic growth require building construction, but it degrades the environment. The UN Environment Program identified that by 2020, the global final energy consumption of the building sector was around 35%, and energy-related CO2 emission was 37% (United Nations Environment Program, 2021). To respond to this impact and other environmental issues, designing and constructing green buildings that meet green criteria is an option. Building performance enhancements and eco-friendly and renewable materials increase green buildings' energy and resource efficiency (Nag, 2019).

Rating tools are needed as a comprehensive assessment tool to meet the green criteria. Practitioners are assisted with methodological frameworks and formality rating tools to measure and

monitor building performance. They are encouraged to have integrated thinking from the early stages of design (Ding, 2008). Apart from being an educational tool, rating tools also function as a marketing tool for building owners and practitioners. Through certification ratings, practitioners are incentivized to develop and promote sustainable construction practices (Vierra, 2018).

The world's first green building rating tool (GBRT) is BREEAM (Building Research Establishment's Environmental Assessment Method), which Building Research Establishment (BRE) developed in 1990 in the UK. Then, LEED (The Leadership in Energy and Environmental Design) by US Green Building Council (USGBC) followed in 1998. The use of BREEAM dominates the European market, so it has produced many certified buildings. LEED is considered more transparent and easier to assess, so it is widely adopted in various continents and countries (Doan et al., 2017), including Indonesia. It is noted that 17 new buildings in Indonesia have been certified with LEED NC (USGBC, 2022).

The use of LEED globally has reached more than 79,000 residential projects, educational, health care, commercial and industrial projects. More than 201,000 accredited LEED professionals run these projects across several countries. LEED BD+C New Construction ver. 4.1, released in January 2019, consists of 9 categories comprising three criteria/credits with 128 points (USGBC, 2021). Some LEED criteria are mandatory and do not earn additional scoring points. Other criteria that are met will earn points, and the total points will determine the level of certification obtained (Azhar et al., 2011). USGBC has released several applications to automate the use of LEED, including Autodesk apps for LEED; COMNET Energy Modeling Portal; IES Tap for LEED; Greengrade LEED Management Software; Green Wizard; Tracker Plus LEED; and Trane (Carvalho et al., 2020).

Besides LEED, green buildings in Indonesia have also been certified using GBRTs from other countries, such as Green Mark from Singapore and EDGE (Excellence in Design for Greater Efficiencies). Four new buildings in Indonesia were certified with the Green Mark in 2017 (The Green Building Information Gateway (GBIG), 2022), and 48 new buildings were certified with the EDGE (EDGE Buildings, 2022).

Green Mark (GM) is a rating tool released by the Building and Construction Authority (BCA) Singapore and was first launched in January 2005. This GBRT was formed to achieve the vision of greening 80% of all buildings in Singapore by 2030, considering the limited land and natural resources in Singapore (Hatmoko et al., 2017). Non-Residential Buildings (NRB) Scheme: 2015 has been updated with Green Mark: 2021 from 1 November 2021 and can only be applied in Singapore. Green Mark: 2021 (International) is formulated by BCA (BCA, 2022), so this study uses NRB:2015. This version comprises 140 points, 16 criteria, and five categories (BCA, 2016).

EDGE is a green building certification issued by IFC-WB (International Finance Corporation - World Bank) and was first launched in October 2014. Unlike other GBRTs, EDGE is based on an online application (Kapoor et al., 2019) and is operated independently to reduce certification costs. EDGE was developed to be a cheap, simple, and reliable way to save utility savings regardless of project size. The strategy used is the "20-20-20 strategy", which means a 20% reduction in energy consumption, a 20% reduction in water consumption, and a 20% reduction in embodied energy building materials (Beltrán-Méndez & Nik-Bakht, 2018). Through this strategy, EDGE is also often used as a complementary element of Greenship certification in Indonesia to save resources and energy (Pamungkas et al., 2018). EDGE also collaborates with GBCI for its operations in Indonesia (GBCI, 2022).

Greenship (GS) is the first GBRT developed in Indonesia. Greenship was launched in 2009 and, as of 2016, has been used to certify more than 105 new buildings (Green Building Council Indonesia, 2020). This GBRT was developed by GBCI, part of the World Green Building Council from Canada, so the criteria refer to the rating tools made by World GBC previously (Abduh & Fauzi, 2012). GS minimum requirement of building area to be assessed is 2500m2. Greenship consists of 6 categories and 35 criteria at the design recognition stage and is divided into three types of criteria, namely prerequisite criteria: which must be met, and no points will be awarded if fulfilled; credit criteria: which need to be achieved as much as possible to determine the level of certification; and bonus criteria: criteria that are difficult to meet and will get added points if met (GBCI, 2013).

The other GBRT form Indonesia is BGH (Bangunan Gedung Hijau). The development of the BGH began when the Center for Housing Research and Development (PUSKIM) of KPUPR (Ministry of Public Works and Public Housing prepared the Draft Guidelines for Green Building Ratings in 2013. This draft was synchronized with the Minister of Public Works Regulation No. 2 of 2015 and the existing rating system (Kementerian PUPR, 2020). In 2021, the government, through the Ministry of Public Works and Public Housing (KPUPR), issued a regulation that requires State Buildings (BGN) with a particular area and function to be certified using the Green Building (BGH) rating tools. These criteria include buildings with an area of >5,000 m2 for commercial, warehouse, laboratory, and industrial functions consisting of 4 floors; an area of 10,000 m2 for meeting buildings; an area of 20,000 m2 for health care functions; or an area of 50,000 m2 for mixed residential and office buildings consisting of 4 floors. The assessment uses a point system where each met BGH criteria will be converted into several points, as determined. At the new building planning stage, there are seven categories, 29 criteria, and 69 sub-criteria for the planning stage BGH assessment (Lampiran Permen PUPR No 21 Tahun 2021 Tentang BGH, 2021).

With these five GBRTs, a project's owner and practitioners can choose which GBRTs to implement. This decision depends on the specifics of each project in terms of needs, requirements, and other factors such as cost, usability, appropriate performance levels, and certification level opportunities (Vierra, 2018).

This study compares BGH with Greenship, EDGE, Green Mark, and LEED to identify the factors and considerations that impact the formulation of GBRTs to promote sustainable practices in the built environment. Research focuses on GBRTs in the design phase of new buildings in various comparisons, such as general information/ attributes, categories, and criteria. The results of this research are expected to assist building construction stakeholders in Indonesia in choosing GBRT based on their individual needs and become insights for policymakers, industry professionals, and stakeholders involved in developing GBRT in Indonesia.

METHODS

This desk study's object is five GBRTs used in Indonesia: LEED, Green Mark, EDGE, Greenship, and BGH. This research is conducted by document observation or nonreactive research (Neuman et al., 2002) of three reference approaches: scientific publications, GBRTs official web, and GBRTs manuals.

Scientific publications and the official website approach obtain understanding, research progress, and issues related to the five GBRTs. This approach begins with selecting scientific publications through a Scopus desktop search. Scopus is the most significant scientific database compared to other international databases with a reasonably broad journal scope (Guz & Rushchitsky, 2009). Therefore, to add the most relevant research content of the five GBRT, this research conducts an extended search of academic literature in Google Scholar. Publications used are articles/papers and international or national proceedings in English or Indonesian in the last six years and are open access. To narrow the search, the keywords "LEED", "Green Mark", "EDGE", "Greenship", and "Bangunan Gedung Hijau", along with "rating" or "certification" are used and included in the subject area of Engineering, Environmental Science, and Energy.

Furthermore, as seen in Figure 1, irrelevant publications were excluded by reading the title, abstract, and content. The following approach explains how each GBRT is used through the manual and the official website of GBRT. This research uses the latest version of each manual GBRT and is limited to the design phase of a new building. The LEED, Green Mark, and Greenship new building schemes cover the design to construction stages, while EDGE and BGH only cover the design stage. After the data from the three approaches have been collected, a comparison with the three levels is carried out.

1. Attribute comparison

The collected attribute divides into two groups. First, the general information about the GBRTs consists of the origin country, the form of developer organization, application category, established year, newest version and year, experts, weighting system, certification level, and fee. These attributes are general information that probably impacts the weighting and sustainability balance of GBRT criteria. The second group comprises project phases, rating schemes, minimum area, number of certified buildings, criteria, and maximal score. This group of attributes is to identify and compare the scope and implementation of each GBRT.

2. Category comparison

The second level is the comparison of criteria categories and their weighting or scoring. Criteria that are similar between GBRT are aligned so that it will show which criteria categories are in line and which category Indonesia has or does not have. Furthermore, distribution analysis of the weighting category was carried out to find out and compare what is considered essential to the GBRT. Then elaborate on its relationship with the attribute data that has been collected before.

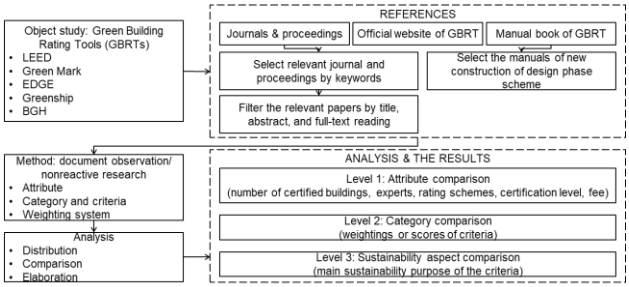

Figure 1. Document observation procedure.

3. Sustainability aspects comparison

The third level is a comparison of the sustainability aspect. This comparison showed maturity in promoting sustainable practices in the built environment and spelled out the relation with its attributes. The assessment of sustainability aspects of the GBRTs criteria is identified through the purpose of the criteria. The guidelines for determining aspects of the criteria adopt the classification by Zimmermann et al. (2019), Wen et al. (2020), and Castro et al. (2014). The most dominant aspect will be selected if the criteria contain more than one aspect. The used sustainability aspect is the environmental aspect (ENV), economic (ECO), and social (SOC), as shown in Table 1 (Castro et al., 2014; Wen et al., 2020; Zimmermann et al., 2019).

RESULTS AND DISCUSSION

The selected search approach identified 131 Scopus-referenced articles from 2017 to 2022. After eliminating irrelevant publications based on their titles and abstracts, there were 29 papers consisting of 16 journal articles and 13 proceedings/ conference papers. This paper is read in its entirety as research data. Papers are then categorized based on the country of origin of the first author. Of 29 papers, 18 countries contribute, and nine are from Asia. Turkey (5) and South Korea (3) are the countries that

participate the most in journal writing. The journals discussed are related to LEED. For the proceedings, Indonesia (4) has contributed much to the Greenship discussion.

Environmental	Economic	Social
• **Environmental Impacts** Carbon reduction, carbon absorption, site water retention, climate adaptability, heat island effect, site selection and impact, LCA, regional priority • **Resources** Lower use of resources (energy, materials, water), avoid using limited resources, renewable resources. • **Biodiversity** Limit the use of new/ undeveloped areas for construction and contribute to increased biodiversity/ site ecology. • **Recycle** Prevent construction waste by good planning, using recycled materials, garbage, sewage treatment, and waste (hazardous and non-hazardous) management. • **Toxicity** Reduce/ avoid the use of toxic materials and construction pollution	• **LCC** Calculating the Life Cycle Cost of building • **Area Use** Optimization of the layout • **Value Stability** Use of materials of high quality & preparation of the building for future changes and scenario • **Commercial Feasibility** Forecasting operating costs on the commercial feasibility	• **Safety and Access** Person safety and safety of the buildings • **Well-being** The well-being of daily users of the building (physical comfort, user experience, clean and hygienic, managing chemical performance, noise, wind effect, glare, and overshadowing) • **Architecture** Quality in architecture, such as aesthetics, space planning, and planning quality • **Transport** Opportunities for healthy transport to the site (public transit, parking, healthy travel) and inside the building (accessibility) • **Social Responsibility** Traceability and responsible purchasing of services and materials for construction, management-related work, social progress, innovation, and peripheral impact • **Convenience and Humanity** Convenient service and humanized facilities

LEED is discussed in 22 papers regarding innovation to meet criteria, its application, and comparison with local GBRTs of a country. Most of the collected papers discuss the comparison of LEED with local GBRTs, such as against Mostadam from Saudi Arabia (Al-Surf et al., 2021), GHIRA from India (Bele & Gogate, 2019), GPRS from Mesir (Daoud et al., 2020), Miljöbyggnad from Swedia (Freitas & Zhang, 2018), GBES from China (Liu et al., 2019), and TREES from Thailand (Lohmeng et al., 2017). They focus on identifying shortcomings, proposing improvements to existing rating systems, and highlighting the significance of specific categories. The GBRT discussed for optimization innovation is only LEED. The research can assist practitioners in assessing and meeting criteria more practically and measurably.

Meanwhile, research on GBRTs from Indonesia still focuses on the understanding and ability of a building design to meet the criteria. Green Mark (3) and Greenship (4) are discussed more in the proceedings and contain the understanding and application in the origin country. No papers discussed EDGE and BGH (Bangunan Gedung Hijau, English: green building) through the data collection method. Perhaps, it is because the GBRTs are named using common acronyms, and data collection uses keywords in the title and abstract.

The guidebook used in this research is:

1. LEED v4.1 Building Design and Constructions published in October 2021 (USGBC, 2021).
2. Green Mark for Non-Residential Buildings NRB:2015 Revision 3.2 (BCA, 2016).
3. EDGE User Guide Version 3.0.a was updated in October 2021 (IFC, 2020).
4. Greenship for New Buildings Version 1.2 was published in April 2013 (GBCI, 2013).
5. Attachment to the Regulation of the Minister of PUPR Number 21 of 2021 concerning Performance Assessment of Green Buildings (Lampiran Permen PUPR No 21 Tahun 2021 Tentang BGH, 2021).

1. Attributes Comparison

The following ***Table 1*** is GBRT attributes as information that most likely impacts the weighting and sustainability balance of GBRT criteria. As seen in the table below, LEED and GM were from developed countries, EDGE was based on international initiatives, and GS and BGH were from Indonesia, an emerging country. The country's economic development could reflect the maturity of the built environment infrastructure. In most emerging nations, green buildings are still a relatively new type of building, as opposed to the developed countries. It suggests that the risks associated with green building in developing countries are even more significant than in developed countries (Nguyen et al., 2023).

Table 1. The general information of the GBRTs

	LEED	Green Mark (GM)	EDGE	Greenship (GS)	BGH
Origin Country	The US	Singapore	International	Indonesia	Indonesia
Developer	USGBC (NGO under GO recognition)	BCA (GO)	IFC (NGO)	GBCI (NGO)	Kementerian PUPR (GO)
Application category	voluntary	Mandatory	voluntary	voluntary	Mandatory (certain buildings)
Est. Year	1998	2005	2014	2010	2015
Newest version[a]	Ver. 4.1	2021/ NRB:2015	Ver. 3.0	Ver. 1.2 (NB)	2021
Newest update year	2019	2021	2021	2013	2021
Expert	LEED Green Associate; LEED AP with specialty	GM Accredited Professional; GM Advanced Accredited Professional	EDGE expert (partnership with GBCI)	GS Professional (GP)	Expert Professional Team (TPA)
Scoring system	Additive credits	Additive credits	Web-based analysis	Additive credits	Additive credits
Certification level	Certified (32%-39%) Silver (40%-47%) Gold (48%-63%) Platinum (>64%)	Gold (36%-42%) Gold Plus (43%-49%) Platinum (>50%)	EDGE certificate (20% savings); EDGE Advance (40% savings on-site); Zero carbon certificate (100% renewable on-site/ off-site)	Bronze (35%-45%) Silver (46%-56%) Gold (57%-72%) Platinum (>73%)	Pratama (45-65%) Madya (65%-80%) Utama (80%-100%)
Certification price*	Rp 104.381.514 - Rp 564.695.950	Rp 239.909.124 - Rp 574.519.218	Rp 37.700.000 - Rp 77.700.000	Rp 130.000.000 - Rp 267.500.000	Free

In the form of developer organizations, LEED, EDGE, and GS are developed by non-government organizations (NGOs). However, LEED is under US government recognition, while GS did not get the same opportunity because the Indonesian government developed its own GBRT. GBRTs that were developed by government organizations (GO) were GM and BGH. GO has the authority to determine policies, so these two GBRTs are mandated for state buildings.

Nevertheless, the biggest challenge is the expensive cost of designing and constructing green buildings. In the design process, Akcay & Arditi (2017) and (Park et al. (2017) develop design algorithms so that designers can choose an alternative to fulfill the criteria with the lowest cost (Akcay & Arditi, 2017; Park et al., 2017). In the construction process, Amiri et al. (2020) found that filling the LEED criteria of Certified and Silver levels increased the total costs of construction by 3.4% and 5.9%, respectively. Hence, it is crucial to research the cost of BGH, as limited data on costs constrain the widespread implementation of this point-based certification approach in developing countries (Amiri et al., 2020). As seen in ***Table 2***, based on certified buildings, LEED has been used in some countries to certify 1,525 buildings yearly since its established year, Green Mark over 325 buildings yearly, and EDGE 77 buildings per year. Meanwhile, GS has only been used to certify eight buildings yearly, and BGH has only been used to certify two buildings yearly. With this certification rate, GS is Indonesia's most widely used GBRT for green building certification. It indicates that the implementation of green buildings in Indonesia is still low.

Table 2. Implementation of GBRTs in the new building scheme design stage

	LEED	GM	EDGE	GS	BGH
Global certified building	36.602	>3.900	543	105	14
Adoption (country)	>160	12	42	1	1
Certification rate (yearly)*	1.525	325	77	8	2
First used in Indonesia	2011	2010	2015	2010	2015
Certified building in Indonesia*	17	4	48	105	14

Error! Reference source not found. shows that the entire life cycle of the building has been used as the scope of GBRTs. The BGH phases follow the general segmentation of construction projects in Indonesia, where design and construction projects are separate. This scope identifies that GBRT from developed countries have integrated the design and construction project phases so that all certified green building designs are ensured for their implementation during the construction phase. Differences can also be seen in the certification system scheme between GBRT from developed countries and developing countries. LEED and Green Mark have incorporated schemes related to specific building typologies, such as healthcare, school, and retail. Assessing based on typologies can result in more detailed and impactful evaluations. However, the BGH assessment scheme still consists of a basic scheme, and GS already has two additional schemes: Interior Space and Net Zero Healthy.

The other attributes to be compared are the number of criteria, sub-criteria, and maximum possible score of each GBRT. The naming of sub-criteria is different among GBRTs. In this research, sub-criteria means the smallest dimension in GBRT that can earn points independently without depending on other dimensions. As seen i**n** Error! Reference source not found., the number of sub-criteria BGH owns is the lowest but has the second-highest sub-criteria and the highest scores. The high number of scores and the percentage of achieving the certification level is because BGH does not have prerequisite (P) criteria that are not scored.

	LEED	Green Mark	EDGE	Greenship	BGH
Phases	Building design & construction (BD+C) Interior design & construction (ID+C) Operations & Maintenance (O+M)	Design + construction Operation	Design Construction Operation	Design recognition (DR) Final assessment (FA)	Design Construction Operations Demolish
Rating schemes	New Construction; Core and Shell; Data Centre; Healthcare; Hospitality; Retail; Schools; Warehouses and Distribution Centre; Existing Buildings; Commercial Interior; Homes; ND: Plan; ND: Built Project	Super Low Energy Buildings; Non-Residential Buildings (NRB); Residential Buildings (RB.); Non-Residential New Buildings; Residential New buildings; Transit Station; Existing NRB; Existing RB; Landed Houses; Healthier Workplaces; Existing Schools; Infrastructure; District; Restaurants; Supermarket; Existing Data Centres; New Data Centres; Retail; Laboratories	All types of building	New Building (NB.); Existing Building (EB.) Interior Space (IS.) Homes Neighborhood (NH.) Net Zero Healthy (NZH)	New buildings; Existing buildings; Community Green Shelter (H2M); New Green Area; Existing Green Area; Home (just issued, socialized in 2023)
Criteria	53	57	67	35	29
Sub-criteria	60	83	67	67	79
Max. score	128	140	66	77	165

In the form of developer organizations, LEED, EDGE, and GS are developed by non-government organizations (NGOs). However, LEED is under US government recognition, while GS did not get the same opportunity because the Indonesian government developed its own GBRT. GBRTs that were developed by government organizations (GO) were GM and BGH. GO has the authority to determine policies, so these two GBRTs are mandated for state buildings.

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Category Comparison

The GBRT criteria are grouped into several categories based on topic similarity. As seen in **Error! Reference source not found.**, category comparison is made by aligning the categories based on each category's criteria without dividing the category and its original category's name. There are six main categories and one innovative category. The main categories are site, energy, indoor, water, material, and waste.

It should be noted that EDGE does not use a scoring system. So specifically for EDGE, the data shown below is based on the number of criteria, not the weighting. So the level of importance of the criteria on EDGE cannot be known. Whereas in LEED, GM, and GS, prerequisite criteria do not affect the percentage of scores but play an essential role in GBRT. Then it will be explained, per category group, what criteria play a role in each GBRT except EDGE.

Furthermore, ***Figure 2*** shows the distribution diagram per category group and its weighting percentage. The categories are divided based on related criteria for a more accurate comparison.

The site-related categories between Green Mark (21%), Greenship (22%), and BGH (23%) were similar in percentage terms. However, compared to similar categories in LEED: Location and Transportation, Sustainable Sites, and Integrative Process (total score: 34%), site-related criteria on rating tools from Indonesia have less effect on the assessment.

Table 3. The comparison of category

Category	LEED		GM		EDGE		GS		BGH	
Site	Integrative process	1	Climatic Responsive Design	30 (3P)	-	-	-	-	-	-
	Location and Transportation	32					Appropriate Site Development	17 (1P)	Site management	38
	Sustainable Sites	12 (1P)								
Energy	Energy and atmosphere	33 (4P)	Building Energy Performance	30 (3P)	Energy Efficiency	37	Energy Efficiency and Conservation	26 (2P)	Energy use efficiency	46
Indoor	Indoor environmental quality	16 (2P)	Smart & Healthy Building	30 (8P)			Indoor Health and Comfort	5 (2P)	Indoor Air Quality	19
Water	Water Efficiency	11 (3P)	Resource Stewardship	30 (1P)	Water Efficiency	18	Water Conservation	21 (1P)	Water use efficiency	22
									Wastewater management	12
Material	Material and resources	13 (1P)			Material Efficiency	11	Material Resources and Cycle	2 (1P)	Eco-friendly material	21
Waste					-	-	Building Environment Management	6 (1P)	Waste management	7
Innovation	Innovation	6	Advanced Green Efforts	20	-	-	-	-	-	-
	Regional priority	4	-	-			-	-		
Total P criteria	11		15		0		8		0	

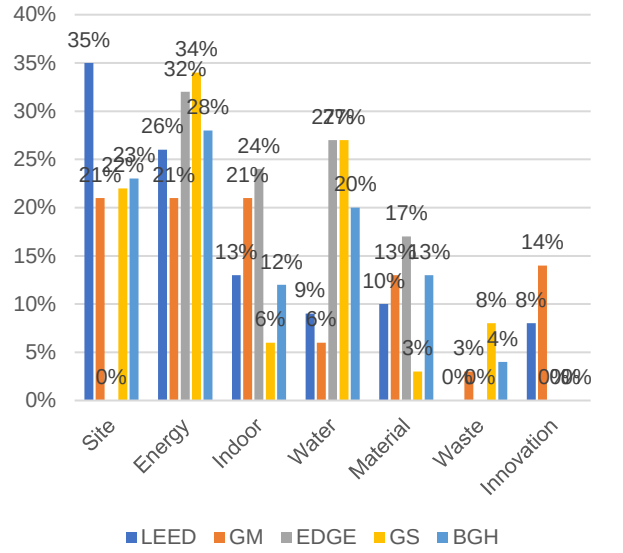

Figure 2. The criteria distribution comparison of assessment scores

Table 4. Critical criteria in the site category

LEED		
• LEED for Neighborhood Development Location	16	13 %
• Construction Activity Pollution Prevention	P	
GM		
• Envelope and Roof Thermal Transfer	P	
• Air Tightness and Leakage	P	
• Bicycle Parking	P	
• Sustainable Urbanism	5	4%
• Integrated Landscape and Waterscape	5	4%
GS		
• Basic Green Area	P	
• Site Landscaping	3	4%
• Micro Climate	3	4%
• Stormwater Management	3	4%
BGH		
• Site management, including accessibility/ circulation	6	4%
• Private green open space plan	6	4%
• Provision of parking space	10	6%

This category is also the highest in LEED itself. The critical criteria in ***Table 4*** show that LEED focuses on building location and management that affect the social aspects of occupants and neighboring communities. Additionally, LEED maximizes passive design to reduce the building's impact on the surrounding environment, such as open spaces, and reduce light pollution and heat island effects.

As a developed country, Singapore has been actively promoting Sustainable Urbanism through criteria in the site category. GM emphasizes green areas and highlights integrating landscape and waterscape to support biodiversity. Singapore's tropical geographical conditions, proximity to the sea, and limited land influence these criteria. In contrast, the GBRT from Indonesia primarily focuses on addressing essential land management in this category due to the challenges posed by the country's less mature infrastructure.

The energy efficiency aspect holds significant importance in EDGE, accounting for a substantial weight of 56%, as illustrated in Figure 4, because interior quality criteria exist (**Error! Reference s ource not found.**). However, separately evaluating these criteria reveals that the energy efficiency category alone accounts for 32% (***Figure 2***).

Table 5. Critical criteria in the energy category

LEED		
• Fundamental Commissioning and Verification	P	
• Minimum Energy Performance	P	
• Building-Level Energy Metering	P	
• Fundamental Refrigerant Management	P	
• Optimize Energy Performance	18	14%
GM		
• Air Conditioning Total System and Component Efficiency	P	
• Lighting Efficiency and Controls	P	
• Vertical Transportation Efficiency	P	
• Building Energy	11	8%
GS		
• Electrical Sub Metering	P	
• OTTV Calculation	P	
• Energy Efficiency Measures	20	26%
BGH		
• Building envelope	9	5%
• Lighting system	12	7%

This category also dominates the assessment of the other GBRTs. Regarding score percentage, the BGH energy efficiency category aligns with LEED and Green Mark, which is around 21-28%. Meanwhile, Greenship has a percentage of 34% because there is a bonus criterion of five points, which is considered challenging to fulfill. However, in LEED, there are four prerequisite criteria; in Green Mark, there are three prerequisite criteria; and in Greenship, there are two (***Table 5***). So, if the non-scoring criteria are considered, the portion of energy efficiency in LEED is more significant than BGH.

BGH and LEED classify indoor quality criteria differently. For instance, LEED incorporates criteria for environmentally friendly materials free from VOCs (volatile organic compounds) within the indoor environmental quality category. However, BGH includes these criteria within the environmentally friendly material category. Between BGH and GM, there is a difference in terms of category score weights.

GM has the highest score percentage (21%) and has the most prerequisite criteria (8) among other rating tools (*Table 6*).

Table 6. Critical criteria in the indoor category

LEED		
• Minimum Indoor Air Quality Performance	P	
• Environmental Tobacco Smoke Control	P	
• Low-Emitting Materials	3	2%
• Daylight	3	2%
GM		
• Thermal Comfort	P	
• Minimum Ventilation Rate	P	
• Filtration Media for Times of Pollution	P	
• Low Volatile Organic Compound (VOC) Paints	P	
• Refrigerants	P	
• Sound Level	P	
• Permanent Instrumentation for the Measurement and Verification of Chilled Water Air-Conditioning Systems	P	
• Electrical Sub-Metering & Monitoring	P	
• Lighting	6	4%
GS		
• Outdoor Air Introduction	P	
• Chemical Pollutant	3	4%
BGH		
• CO2 and CO control	9	5%

The significant weight assigned to the indoor space quality score in GM reflects the developer's awareness that achieving ideal thermal and visual comfort in Singapore's climate and humidity requires high energy consumption. Therefore, GM ensures that green building designers consider the achievement of good indoor quality by including numerous prerequisite criteria.

The second largest category in EDGE and Greenship is the category related to water efficiency. There are two prerequisite criteria in Greenship, and the percentage score is 7% greater than BGH. GS and BGH cover this category through water efficiency and water waste management criteria, while LEED and GM emphasize sufficient water efficiency (***Table 7***). LEED has three prerequisite criteria, but the percentage score is much lower than BGH. Considering Singapore's geographical conditions, GM has the lowest score in this category, possibly due to the well-established water and waste management systems.

Table 7. Critical criteria in the water category

LEED		
• Outdoor Water Use Reduction	P	
• Indoor Water Use Reduction	P	
• Building-Level Water Metering	P	
• Indoor Water Use Reduction	6	5%
GM		
• Water Efficient Fittings	P	
• Water Efficient Systems	3	2%
• Alternative Water Sources	3	2%
GS		
• Water Metering	P	
• Water Calculation	P	
• Water Use Reduction	8	10 %
BGH		
• Water source	13	8%
• Provision of solid waste and wastewater management facilities	7	4%

The scoring percentage of the material category in BGH is similar to LEED. However, in LEED, GM, and Greenship, construction stage criteria exist in this category. As seen in ***Table 8***, LEED and GM consider the life cycle of building materials in this category. GS and BGH focus on using environmentally friendly and regional materials. While in EDGE, the material-related category criteria led to the material's efficiency.

Table 8. Critical criteria in the material category

LEED		
• Building Life-Cycle Impact Reduction	5	4%
GM		
• Sustainable Products	8	6%
• Embodied Carbon	2	1%
GS		
• Environmentally Friendly Material	3	4%
• Regional Material	3	4%
BGH		
• Use of environmentally certified materials	15	9%

Furthermore, Indonesia has a particular category regarding waste management in GBRT. It is similar to the GM one criterion in the Resource Stewardship category, Operational Waste Management (***Table 9***). In LEED, there is only one criterion that addresses waste management. It is not about operational waste but focuses on demolition waste management planning. It indicates that the state of a country's management system will influence its GBRT criteria. In developed countries, the government already regulates some environmental issues, while in developing or emerging countries, there is a need for GBRT support to implement environmentally friendly infrastructure.

Table 9. Critical criteria in the waste category

LEED		
• Construction and Demolition Waste Management Planning	2	2%
GM		
• Operational Waste Management	3	2%
GS		
• Basic Waste Management	0	
• Proper Commissioning	3	4%
BGH		
• Implementation of waste management systems	5	3%

The comparative study above shows similar LEED, Green Mark, Greenship, and BGH. Categories In line with research by Illankoon et al. (2017), BGH also possesses the seven critical criteria owned by international green building rating tools, namely (1) site, (2) energy, (3) water, (4) indoor environment quality, (5) material, (6) waste and pollution, and (7) management (Illankoon et al., 2017).

This study also reveals that climate, geographical, and economic development greatly influence the formulation of GBRTs. GBRT developers from Indonesia need to learn from GM how the formulated GBRT criteria respond to climate and geographical conditions. GBRTs from Indonesia also need to continue contributing to implementing environmentally friendly infrastructure by formulating waste management and resource utilization criteria.

Sustainability Comparison

The following ***Figure 3*** is the percentage of sustainability aspects of rating tools criteria to see the direction of GBRT towards sustainable development and the relation with its attributes. The research findings indicate that specific criteria cannot be categorized under the environmental, social, or economic aspects described in Table 1. These criteria were compiled and assigned to a new aspect known as procedural and innovation

The highest aspect percentage of the five GBRTs is the environmental aspect. This aspect even represents all the EDGE criteria. These findings align with Zimmermann et al. (2019) that the environmental aspect also dominates Indonesia's rating tools (Zimmermann et al., 2019). The social aspect needs to be improved, and the economic aspect needs to be included in GS and BGH to balance the percentage of environmental aspect scores. LEED can be an example of a balanced rating tool, and the criteria positively impact the environment and occupant satisfaction (Abbaszadeh et al., 2006; Geng et al., 2019).

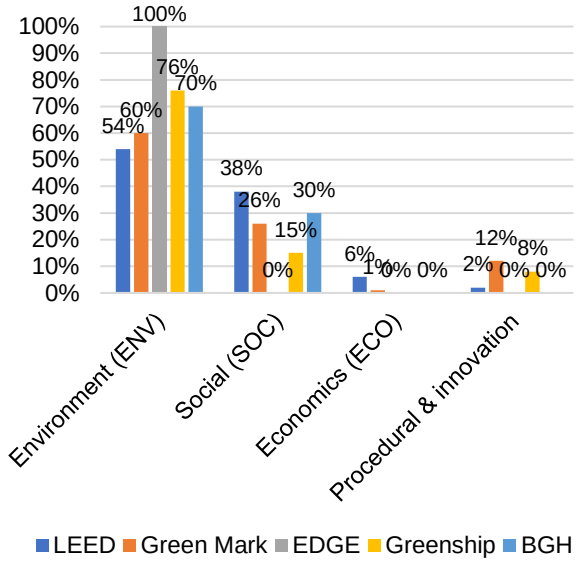

Figure 3. Sustainability-aspects comparison of rating-tools criteria

LEED has the highest social aspect score, followed by BGH and GM. It indicates that GO, or recognized by GO developer, tend to emphasize social aspects more strongly. The social aspect of GBRTs plays a crucial role in shaping the behavior and attitudes of individuals toward green practices. It encompasses safety and accessibility, occupant health and well-being, and equitable resource access.

It is worth noting that EDGE, as a GBRT, does not have a specific social aspect. It is because EDGE focuses primarily on technical solutions and does not have a country-specific context or policy framework. As a result, social considerations may not be explicitly incorporated into the assessment criteria of EDGE.

LEED and GM score percentage gap of environmental and social aspects is less than 20%. Meanwhile, the gap significantly differs in GS and BGH (> 30%). The economic aspect of LEED and GM has a smaller percentage than other aspects. The economic aspect is represented by the value of the building location criteria in LEED and the efficiency and cost control criteria in Green Mark. Nevertheless, this aspect is not found in the BGH and Greenship criteria. It illustrates that green building construction in Indonesia must still be encouraged to move towards sustainable development.

The lack of consideration for the economic aspect of GBRT Indonesia can be seen as a weakness, as there is a tendency to reject it due to a lack of awareness about its benefits. It aligned with research by Yau (2012), which shows that the motivation to incorporate green attributes in housing is predominantly driven by economic incentives (Yau, 2012). Thus, the interest of Indonesian construction stakeholders in green building can be increased by the existence of criteria that raise awareness of the cost advantages of green building construction. In addition, the government, as a BGH developer, can provide incentives in other forms to building owners with BGH certification.

Procedure and innovation criteria are found in LEED, GM, and GS. BGH may not consider procedures and

innovations like other rating tools, but it emphasizes the importance of meeting the requirements by submitting documentation and evidence regarding environmental and social considerations. It is important to note that administrative issues can challenge the certification process. Rather than solely focusing on administration, the green building designer's time should be allocated to improving building performance. Ensuring certified buildings' performance significantly differs from non-green buildings is imperative. Addressing these administrative challenges and ensuring certified buildings function as intended is essential to implement green buildings effectively.

CONCLUSION

Indonesia's high commitment to green building development has been demonstrated by the obligation for state buildings to meet the BGH criteria. However, the yearly certification rate for GS and BGH and research on these two GBRTs are still low. Therefore, research must be continuously encouraged to assist stakeholders in implementing and innovating GBRTs from Indonesia. BGH requires a strategy for its implementation to ensure smooth progress and avoid hindering development. Developers must increase awareness and provide comprehensive information about green buildings and BGH rating tools to educate and motivate project stakeholders to certify green buildings. Collaboration with other stakeholders is also essential for developers in Indonesia to improve design capabilities in achieving green building performance. Additional assessment schemes for specific typologies should be planned to ensure maximum green performance.

GBRT criteria can be grouped into six key categories: site, energy, indoor, water, material, and waste. In the site category, GBRT criteria from developed countries such as LEED and GM maximize passive design and consider social and economic values. Category comparison also found that rating tools from Indonesia pay exceptional attention to water waste and waste management, which is not found in other rating tools. Indonesia's economic development also influences it as an emerging country with infrastructure that is not yet well-established. Meanwhile, in LEED and GM, this aspect is represented by only one criterion placed in the material category. In addition to economic development, GBRT criteria are also influenced by climate and geographical conditions. GM has the most prerequisite criteria in the indoor category to ensure that all green buildings are adaptable to Singapore's climate conditions. Developers from Indonesia need to learn from GM how the formulated GBRT criteria respond to climate and geographical conditions.

Based on the sustainability comparison, it is evident that developer organizations influence the sustainability aspect of criteria formulation. Government organizations tend to consider the social aspect of GBRTs more than non-government organizations. The findings also indicate that green building development in Indonesia still has room for improvement in achieving sustainable development goals, particularly economically. The findings suggest that a balance between environmental, social, and economic aspects should be carefully considered in the subsequent renewal of BGH. By doing so, it has the potential to enhance the overall impact of green building construction and generate greater interest among project stakeholders in adopting BGH.

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