PROCEEDINGS OF THE 4TH INTERNATIONAL

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CONFERENCE

Volume 2: Architecture

AHMET CAN ALTUNIŞIK
HASAN BASRİ BAŞAĞA
VOLKAN KAHYA
VEDAT TOĞAN



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Ahmet Can Altunışık

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PREFACE

The 4th International Civil Engineering & Architecture Conference (ICEARC'25) aimed to bring together academics, researchers, and practitioners in the fields of civil engineering and architecture from across the globe. Held in Trabzon, Türkiye on May 17–19, 2025, the conference served as a dynamic platform to review recent achievements, share emerging developments, and address both current and future challenges in these disciplines.

ICEARC'25 has once again demonstrated its truly international character, drawing over **500 participants from 33 countries**. The conference hosted **421 research presentations** delivered in **59 parallel sessions**, and provided participants with excellent networking and collaboration opportunities. In addition to the technical sessions, **four dedicated workshops**—focusing on contemporary themes such as sustainable buildings, hybrid structures, and advanced materials—offered attendees practical insights and knowledge exchange in specialized areas.

The **Proceedings of the 4th International Civil Engineering and Architecture Conference** includes all the accepted and presented papers, compiled in two volumes:

- **Volume 1: Civil Engineering**, comprising 303 papers under major categories such as Structural Mechanics, Earthquake Engineering, Hydraulics & Fluid Mechanics, Geotechnics & Soil Mechanics, Transportation, Structural Materials, Hydrology & Water Resources, Construction Management, and Waste Management.
- **Volume 2: Architecture**, featuring 118 papers grouped under topics such as Architectural Philosophy, Design & Practice, Architecture, Conservation & Restoration, Urban Planning & Landscape, Architectural Engineering, and Interior Design.

We are sincerely grateful to all authors for their valuable contributions. The papers included in these volumes were rigorously reviewed by field experts, and only those that were accepted and presented at the conference have been published. We extend our deepest appreciation to the reviewers for their meticulous evaluations, which significantly contributed to the quality of this publication.

We would also like to express our gratitude for the institutional support provided by **Karadeniz Technical University** and **the Chamber of Civil Engineers (Trabzon Branch)** of the **Union of Chambers of Turkish Engineers and Architects**. We sincerely thank our sponsors:

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Our special thanks go to the **Mayor of Trabzon Metropolitan Municipality**, **Mayor of Ortahisar Municipality**, and **Mayor of Yomra Municipality** for their valuable support.

We also acknowledge the outstanding efforts of the organizing committee, the student volunteers, and all the moderators who chaired our sessions with professionalism and dedication. Their contributions were instrumental in the success of ICEARC'25.

Finally, the conference concluded with a memorable **social tour to the iconic Sümela Monastery and Uzun Göl**, offering participants a taste of the region's rich cultural and natural heritage.

We look forward to welcoming you again at **ICEARC'27**.

Editors

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Comparative analysis among cross background green building rating system: LEED, DGNB, SBAT, and Greenship

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Abstract. In the past decades, Green Building Rating Systems (GBRS) have been developed by many countries and organizations around the world to assess, evaluate and certify the performance of green buildings. Some GBRS have been adopted in different sites around the globe, some GBRS have been developed for a specific country. This study aims to compare Green Building Rating System (GBRS) from different backgrounds, to identify the factors of the background in developing similarities, differences, strengths and weaknesses of each GBRS. Namely from globally used GBRS represented by LEED, national GBRS from developed countries represented by Germany's DGNB, national GBRS from developing countries represented by Indonesia's Greenship, and South Africa's SBAT. To achieve these goals, three steps were taken. The first step is the comparison of the general information of each GBRS, followed by the second step with the comparison of the categories and criteria carried out by each GBRS. To deepen the comparison, LEED, DGNB, Greenship, and SBAT were adopted to evaluate Jakarta International Stadium (JIS) and clearly identify the similarities, differences, strengths, and weaknesses of each GBRS. From the analysis, it was revealed that the different background of the GBRS resulted in different emphasis of the certification categories and criteria. This difference was considered important in the process of selecting the GBRS to be adopted in the building, as reference to a particular GBRS can influence different emphases in the design.

Keywords: Green building rating system, LEED, DGNB, Greenship, SBAT for Stadia, Sustainable development, Green Building

1. Introduction

The building sector is currently the major driver to the environmental impact, where in 2022 building sectors as the biggest CO2 emission contributors up to 37% equals one-third of the global emission (UNEP, 2024). Moreover, the building sector currently consumes 40-50% of resources extracted from global materials (Brady & Kamawura, 2021). These conditions are signalling that building sectors are not at the sustainable level, even their uncontrolled development could become a serious threat. As the responsibility to reduce environmental damage for the future, it is crucial for building sectors to transform the development into more sustainable, in the form of sustainable building (Sidig et al., 2024;Zarghami & Fatourehchi, 2020).

The emergence of a green building rating system (GBRS) in sustainable building sectors is one of the efforts to promote sustainability in construction sector. Green building itself is one of the concepts to encourage the construction sector to use an environmentally friendly approach. But environmental issues are not the only concerning issues. Wellbeing and the cost of green building also becomes critical factors (Zhang, 2014). Thus, the meaning of achieving good performance in GBRS or to be called as 'green' building, where a building must satisfy all environmental, economic, and social parameters of sustainability (Illankoon et al., 2017). According to Munasinghe, the social parameters means building should cover empowerment, inclusion, and governance; economic aspects should cover growth, efficiency, and stability; the environmental aspect covers resilience, natural resources and pollution (Munasinghe, 2004).

Leadership in Energy and Environmental Design (LEED) is one of the pioneers of GBRS, established in 1998 by USGBC (US Green Building Council), eight years different from the first GBRS established by UK in 1990, Building Research Establishment Environmental Assessment Methodology (BREEAM). Although it was release after BREEAM, LEED as voluntary standard was used more globally according to the number of countries that adopting LEED as the rating system (Doan et al., 2017). According to the latest report from USGBC, as 2024, LEED was adopted in 186 countries with total project has reached more than 197.000 (USGBC, 2024).

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From general use to a nationally designed rating system, the form of the GBRS continues to develop. German is one of the countries in Europe that proposing their rating system. The development started in 2001 by publishing Guidelines in Sustainable Building (GSB) in 2001 by the United Ministry of Transport, Construction and Urban Affairs and evolved into DGNB (D*eutsche Gesellschaft für Nachhaltiges Bauen* or German Green Building Council in 2008. The categories in DGNB incorporate the sustainable development dimension: economic, ecology, and social criteria.

Regrettably, the issue of the gap in the international rating system is becoming increasingly clear, especially in the context of its implementation in developing countries. The approach to building construction in developing countries differs significantly from that observed in developed countries. This is because the primary aim of development in developing countries remains the fulfilment of basic needs (Gibberd, 2002). Meanwhile, the international rating system developed based on the context of their origin, ignoring the issues that exist in developing countries (Zarghami & Fatourehchi, 2020).

South Africa is one of the developing countries that has implemented a national rating system in response to the recognition of a gap in the application of the international rating system at the national level. This system, called SBAT (Sustainable Building Assessment Tool), was developed by the CSIR (Council for Scientific and Industrial Research) of South Africa to address the country's ongoing development. The main question guiding the development of this system was how buildings can contribute to sustainable social and economic development, as well as environmental sustainability. According to Gibberd J. (Gibberd, 2002) as one of the contributors to this rating system, SBAT also helps in defining a new objective of sustainable building for developing countries:" sustainable building and construction aims to maximise beneficial social and economic impact while minimising negative environmental impact".

One of SBAT's achievements that is different from some other rating systems was the establishment of SBAT for Stadia as South Africa's response towards the addition of the Green Goal chapter in FIFA's technical guidelines for football stadium development in 2007, as South Africa prepared themself to become the host of 2010 World Cup. It is recorded that previous stadium construction for the Olympics or World Cup never resulting a new rating system focusing on stadium typology, as the stadium for the London Olympics 2012 used BREEAM to assess their construction towards environmentally friendly development while LEED was used in 2006 Torino Winter Olympics. Indicators in SBAT and FIFA World Cup stadia were reviewed, resulting some adjustment in SBAT criteria. The adaptation can be found in the Social criteria, where *Occupant Comfort* and *Day lighting* in regular SBAT was adopted to become *Spectator Comfort* and *Shading* in SBAT for Stadia (Tn & Jt, n.d.). Despite its emergence brought the new development energy to the county, as finding reference regarding the SBAT rating system, limitations in the number of published research were found.

Just like other countries in the world, Indonesia, as a rapidly developing country also started its movement towards sustainable development in the building and construction sector through the establishment of Greenship certification by GBCI (Green Building Council Indonesia). GBCI as a non-government organization (NGO) is committed to educating the public about green building practices and helping the building industry become more sustainable. Alongside developing the rating system, GBCI also aims to transform the building market and spread green building principles to the public (GBCI, n.d.). Although they are not at the government level, the existence of this NGO as a pioneer towards green development is supported by the government through several collaborations in government projects such as the green certification of several ministries' buildings in Jakarta and collaboration with PT. Wijaya Karya (WIKA) a State-Owned Enterprises (BUMN) in developing a certification program called Greenship Net Zero. There are many research studies on the application of Greenship in building design, but only a few research on reviewing Greenship have been found. While research that will trigger evolution in specific certification systems is expected to support the implementation and improvement (Mardhiyana et al., 2023).

With the emergence of GBRS around the world from various backgrounds, comparative studies among various building rating systems have been carried out by several researchers. Published comparative studies have mostly compared GBRS from developed countries and the pioneers of GBRS: LEED and BREEAM (Suzer, 2015;Doan et al., 2017). On the other hand, there are also comparative studies based on inequality related to the background origins of GBRS, but the number is very limited. For example, the comparison between GBRS in developed and developing countries has previously been studied (Zarghami & Fatourehchi, 2020; Doan et al., 2023; Mardhiyana et al., 2023).

Amidst the many comparisons, the selection of the GBRS used still does not seem to match the context. For example, the use of LEED in Vietnam and Indonesia is found to be based on locally developed certifications (Doan et al., 2023;Mardhiyana et al., 2023). In addition, use GBRS in green building projects globally is still dominated by LEED. Although study shows that there are marketing benefits in increasing the property value of LEED buildings certified (Matisoff et al., 2014) and marketing motivates building owners to build greener buildings, but Fenner and Ryce assume that targets for certain levels can lead to 'point hunting' rather than leading to actual

sustainable development (Fenner & Ryce, 2008). Meanwhile, it is important for sustainable building to recognize impacts of every design process to natural and cultural resources of the local, regional and global environment (Akadiri et al., 2012). Thus, it is necessary to identify to what extent are evaluated by green building rating tools through credit points, so the selection of GBRS is not only limited to the existing market, but as an encouragement to choose the reference according to the issue at hand. Referring to that, this paper aims to identify the similarities and differences as well as strength and weakness in green building certification system practices across distinct cultural and environmental contexts in three dimensions: international rating system, developed and developing country's national rating system; LEED represent international rating system, DGNB represent developed country's national rating system and Greenship and SBAT represent developing country's national rating system The findings of this paper are also expected to present insights for various stakeholders involved in the green building rating tools development, such as industry professionals and policymakers.

2. Method

2.1 The phases of the research

This paper uses qualitative methods in comparing four GBRS that stand for global scope, national scope in developed country, national scope of developing country and characterized scope rating system. The research carried out by three main steps:

(1) *Comparison of General Attributes*. In this step, performed comparative analysis regarding the general information of each GBRS for new construction mainly rooting from the official websites or publication of the related GBRS.
(2) *Comparison of Criteria*. To analyse similarities and differences as well as the strengths and weaknesses of the analysed GBRS, every indicator was grouped according to common categories. To access data regarding the categories and and indicators of each, the following documents were used:
   - LEED v4.1 Building Design and Construction (LEED, 2024)
   - DGNB System New Construction, Buildings, Criteria Set Version 2023 (DGNB, 2023)
   - Sustainable Building Assessment Tool (SBAT-P) V1(Gibberd, 2003)
   - Greenship for New Building version 1.4 (Green Building Council Indonesia, 2013)
(3) *Comparison through cross background context application*. For deeper analysis, selected GBRT was applied to the building assessment. JIS building becomes a comparative tool in this research, where the assessment of JIS with selected GBRS will be compared. The comparation will be limited on the presence or absence of certain point and analysing the relationship between GBRS with the design result. With this, the analysis of similarities, differences, strengths, and weaknesses of GBRS is expected to be clearer.

2.2 Jakarta International Stadium (JIS) as a case study

Jakarta International Stadium (JIS) is an 82,000-capacity football stadium located in Tanjung Priok, North Jakarta. There is an interesting background of JIS, as the building is standing in a district with the largest number of people under the poverty line compared to other districts in Jakarta. Thus, the construction of JIS is one of the efforts to accelerate urban development in the district. The construction of JIS was primarily carried out by local workers and experts (Azzahra, 2022), and it received the highest level of recognition, Platinum, from the Greenship certification. Stadium typology is considered as the case study in this comparative study since stadium construction is counted as a mega-structure that involves major investment, but in contrast shows in many cases become a threat once the event is over. The construction of the stadium as a mega-structure is mentioned to comprise a large amount of carbon footprint and often becomes a financial burden both for the owners and the local community around the stadium after the event due to the lack of utilization and maintenance (Francis et al., 2023;Azzali, 2019). These addressing that sustainable stadium construction is highly directed to all aspects of sustainability, as viewed from the standpoint of the entire rating system.

The study about the comparison between Greenship and LEED within the performance of JIS was previously done by Hanif (Hanif, 2022), one of stakeholders from JIS construction, PT. Jakarta Propertindo. The data obtained in the study regarding JIS and its sustainable tool and performance in achieving Platinum Greenship considered to be valid data that can be used in this paper. Moreover, the result of the comparative analysis towards Greenship and LEED in the study was considered to be useful in extending wider comparative study.

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Greenship certification is carried out in two phases, namely design recognition (DR), where the assessment is carried out to see how the building complies with the green building principle, and the final assessment (FA) phase through on-site evaluation to see the overall performance of the building. The ratio between DR and FA is 77%

and 23%, which means that differences may occur after FA, but are less significant to the total score. Table 1 shows the performance of JIS in each assessment criterion during DR and FA. On the FA, all of the criteria received a score above 50%, where ASD received 59%, energy performances received 85%, water performances received 81%, material received 71%, indoor comfort performance received 70%, and environmental management performance received 77%. The final score obtained has a slight difference with the DR stage, where DR stage of JIS show the results of 81.8% (Hanif, 2022). The difference can occur because there are several indicators in FA that have not reached the maximum in the on-site evaluation.



Fig. 1. Jakarta International Stadium (StadiumDB, n.d.)

Table 1. Greenship Assessment of Jakarta International Stadium

Greenship Assessment Criteria	**Max. Score (DR)**	**JIS's Score (DR)**		**Max. Score (FA)**	**JIS' Score (FA)**	
Appropriate Site Development (ASD)	17	12	70.6%	17	10	59%
Energy Efficiency and Conservation (EEC)	26	24	92.3%	26	22	85%
Water Conservation (WAC)	21	18	85.7%	21	17	81%
Material Resource and Cycle (MRC)	2	2	100.0%	14	10	71%
Indoor Health and Comfort (IHC)	5	4	80.0%	10	7	70%
Building & Environmental Management (BEM)	6	3	50.0%	13	10	77%
Total achieved point	**77**	**63**	**81.8%**	**101**	**76**	**75%**

3. Result and Disussion

3.1 General characterization of GBRT: Overview of LEED, DGNB, SBAT and Greenship

Table 2 presents general information on four major Green Building Rating Systems (GBRS) likely to influence indicator formulation and weighting. LEED, one of the pioneers, is not limited to national use; its global adoption spans over half the countries worldwide. DGNB, though newer than SBAT for Stadia, is implemented in over 30 countries. According to Kouka et al. DGNB aligns most closely with the European Green Deal among European GBRS, suggesting its adaptability beyond national boundaries (Kouka et al., 2024).

SBAT emerged earlier than Greenship (GS) and several GBRS in developed countries (Zarghami & Fatourehchi, 2020a), yet records of its application and updates are scarce. GS, Indonesia's national GBRS, is the most recently established among the four, with a lower number of applications than DGNB. Green building adoption in emerging countries lags behind developed nations due to perceived higher risks in sustainable construction (Nguyen et al., 2023). Nonetheless, GS saw a notable increase in 2024, with 40 new certified buildings (Mardhiyana et al., 2023).

DGNB and SBAT were initiated by government institutions, while LEED and GS were developed by non-governmental Green Building Councils. Despite this, both LEED and GS are officially recognized. LEED is accepted for building tax incentives in the U.S., and GS is similarly recognized by regional governments in Indonesia, with government support seen in public project certifications (GBCI, n.d.).

However, GS and SBAT have experienced significantly slower updates than LEED and DGNB. GS has not been updated for over a decade, and SBAT Regular has remained unchanged for more than 20 years. SBAT for Stadia is its most recent update, prompted by the World Cup. As Fenner & Ryce (2008) note, continual evolution of GBRS is vital to sustain momentum in sustainable development and reach new markets (Fenner & Ryce, 2008).

Table 2 also compares the assessment criteria categories. LEED and GS emphasize key design and construction factors affecting sustainability outcomes. In contrast, DGNB and SBAT are structured around the three pillars of sustainability—economic, social, and environmental. DGNB further includes Technical, Process, and Site Quality categories, which complement its core evaluation areas. This topic is explored in detail in the "Comparison of Categories" section.

Table 2. Comparison of General characterization of LEED, DGNB, SBAT and Greenship (table edited).

	LEED	**DGNB**	**SBAT**	**GS**
Year	1998	2007	2001	2010
Origin	USA	Germany	South Africa	Indonesia
Organization	USGBC	DGNB	CSIR	GBCI
Adaptation in other country	186	30	1	1
First version	1998	2007	2001	2010
Latest version	2019 (V4.1)	2023	2003	2013 (V1.2)
Rating level	Certified >= 40 Silver >= 50 Gold >= 60 Platinum >= 80	Bronze >=35%* Silver >=50% Gold >=65% Platinum >=80%		Bronze >=35%* Silver >=46% Gold >=57% Platinum >=73%
Number of certified buildings	>190.000	>10.000	-	146
Average project (yearly)	7.307	588	-	40

3.2 Comparison of categories

The GBRS categories were compared by grouping into several categories by the similarities. Category comparison is made by identifying and aligning the indicators and grouping based on the common topics. It should by highlighted that comparison is not limited only to the same category name, but to the context of the indicators. This was done since there are different approaches of GBRS's category (LEED and GS, DGNB and SBAT), resulting different title but covering the same context. After that, we also analysing what topics are emphasized in each GBRS by marking indicator with the high score. The result of the comparison is shown in

Fig. *2*.

The Common Categories; As a final, the indicator of LEED, DGNB, SBAT, and GS was grouped into eleven topics: Site, Energy, Water, Material and Resources (MR), Indoor Environment Quality (IEQ), Waste, Management, Innovation, Social, Economy, and Technical Quality. In the grouping process, even though according to literature occupants' health and comfort is included as social aspects, but it is found that several GBRS only assess social aspect only up to health and comfort. Since this paper aims to have deeper analysis in GBRSs' differences and strengths, social aspect that also cover empowerment, inclusion and governance was excluded on the separated group. All GBRS share four common topics categories in Site, Energy, Water, MR and IEQ. According to Nevado-Pena et al., three out of four common topics such as site (land use), Energy, Water, and MR referring to environmental dimensions of sustainability (Nevado-Peña et al., 2015). Meanwhile only IEQ refers to social aspects of sustainability (Illankoon et al., 2017). From that, even though with the same goal towards sustainability development, it shows that each GBRS have the common concern in environmental aspect but different extension in the social and economic aspects.

Prominent Strength of LEED; Among six categories in LEED, a high score category owned by Energy, Location and Transportation included in Site, and Indoor Environmental Quality. This is in line with LEED's aims, as according to the official website of LEED (USGBC, n.d.), 60% of LEED indicator is related to the environment (climate change, water source, and biodiversity), 20% to human health, and the rest is green economy and community. Zimmermann et al. (Zimmermann et al., 2019) address this case by describing LEED and 'Green Building' certification rather than 'Sustainable Building' certification, even though LEED has correlated their indicator with the UN's Sustainable Development Goals. Originating from the developed country become a factor in the environmental aspect's suppression in LEED. Developed countries such as US, can be identified as a country that has reached the economic stability by the GDP value as well as the assurance in the social aspect. These results formulated GBRS has addressed the environmental aspect as a priority instead of social and economic aspect, as it is pointed out by Zarghami and Fatourehci (Zarghami & Fatourehchi, 2020). With the high existences of LEED as the global GBRS, it can be taken to note that LEED is suitable for the project that focus to minimize the environmental impact rather than to reach out as sustainable development approach.

Greenship's Notable Strength; Unlike international GBRS, national-based GBRS shows different criteria formulations. Sharing the same parent organization as LEED, GS highlights similar categories but prioritizes Water over Indoor Environment Quality and even Site development. This emphasis stems from Indonesia's serious water issues, despite its high rainfall and coastal geography. Problems like water supply-demand imbalance, erosion from palm oil plantations, poor sanitation, mining contamination, groundwater over-extraction, and increased flooding (USAID, 2021) led to GS focusing on Water Conservation (WAC) as a prerequisite, stressing water metering, usage calculation, and Water Use Reduction. Even in the Appropriate Site Development (ASD) category, GS emphasizes Storm Water Management to encourage rainwater reuse instead of burdening city drainage systems.

Moreover, while GS indicators appear similar to LEED, there are notable adjustments to prerequisites and the addition of new indicators, influenced by technological differences and local culture. For instance, "Environmental Tobacco Smoke Control" is mandatory in LEED but a high-value (non-mandatory) indicator in GS, reflecting Indonesia's strong smoking culture (Nua, 2024; Salsabila et al., 2022). Similarly, "Renewable Energy" is treated as a bonus in GS due to challenges like expensive solar power investments in developing countries (Pristiandaru, 2023) and Indonesia's reliance on imported solar panels due to limited local production (Thomas, 2019).

Stand-Out Aspects in DGNB; Despite DGNB originated from a developed country, they emphasize all the pillars as equally by providing equal weight to each pillar namely Environmental Quality which includes indicator in Site, Energy, and Water, Socio-Cultural and Functional Quality which includes Indoor Environment Quality, and Economic Quality. The perspective used by DGNB creates this rating system is not just a 'Green Building' rating system, but a 'Sustainable Building' rating system. Initiated from Guidelines for Sustainable Building (GSB) by The Ministry of Transport, Construction and Urban Affairs Germany, lead the GBRS developed by Germany to stick with the sustainable principle. According to

Fig. *2*, the indicators in DGNB are only missing in two categories: Waste and Innovation. However, this does not mean that they are not considered. The discussion of this finding takes place later in Waste and Innovation categories discussion.

DGNB also shows another unique side through the category 'Technical Qualities' which is only found in DGNB. This category specifically encourages building envelope quality, in-building technology, reuse of site potential, and mobility infrastructure. This category is mentioned to "strongly influence the other sustainability qualities in the early planning phase" and "determines the degree to which the planned quality is implemented during execution' (Federal Ministry for the Environment, 2016). Technical categories also can cover the reliability, durability, flexibility, and adaptability of the system (Illankoon et al., 2017).

SBAT Noticeable Strength; SBAT has general points for assessing green buildings with the main categories using triple bottom line of sustainability. The formulation of SBAT indicators projects the conditions of its home country in the consideration of indicators. By using a sustainable approach in the formulation of indicators such as that used by the DGNB, it provides an explanation that may not be available in other GBRS. In the Location category, which reflects the issue of food security in South Africa, "Food garden" is a separate indicator.

The Different Extension towards Economic and Social Sustainability; In the Economy category, promoting local contractors, materials, components, and furniture is explicitly mentioned, along with considerations like Efficiency, On-going Cost, and Capital Cost—elements absent in GS and LEED. These align with Munasinghe's (2004) elements of economic sustainability: growth, efficiency, and stability, showing that SBAT and DGNB address both environmental and economic "Green" performance.

For the social aspect, LEED and GS do not assess design inclusivity, unlike DGNB and SBAT for Stadia. DGNB emphasizes "Barrier-free design" to promote inclusivity, while SBAT adds categories like "Social-Participation Control" and "Social-Education, Health, and Safety," reflecting South Africa's high social inequality (World Bank, 2022). This shows the relevance of social considerations, especially in large community buildings

like stadiums. Education-related health issues, like HIV/AIDS control, are only found in SBAT for Stadia, highlighting the link between local health conditions and building certification—an approach other GBRS could adopt.

The lack of social and economic assessments in LEED and GS undermines a full sustainability approach, as sustainable buildings should balance the triple bottom line (Illankoon et al., 2017). Studies also show LEED's weakness in this area (Doan et al., 2017; Zarghami & Fatourehchi, 2020; Ferreira et al., 2023). Meanwhile, government-developed GBRS like DGNB and SBAT address sustainability more comprehensively (Mardhiyana et al., 2023), suggesting that LEED and GS could improve to better suit developing countries' needs.

The Differences in Waste Category Assessment; It is noticeably found that in the Waste category, only SBAT gives separate space for waste assessment. GS assess waste from the BEM category, the 'Basic Waste Management' indicator as it promotes domestic waste management for building operations becomes a prerequisite. Both show differences with other GBRS from developed countries. LEED assess waste in MR category, with the aim to managing waste related to the construction activity. Meanwhile, DGNB did not put 'waste' in any title of the indicator. Instead, DGNB discussed it in the 'PRO2.1 – Construction site/construction process' instead. Where in the mentioned indicator, waste is discussed together with noise, dust, and negative impacts to soil and groundwater during the construction process.

It is interesting since international and developed country's GBRS such as LEED and DGNB assess waste in the indicator to the construction process only, while GBRS from developing countries such as SBAT for Stadia and Greenship assess waste up to the operation phases. Even in GS, indicators for waste during construction are not mandatory, and the priority is taken by waste management during the sage of the building. Positively, LEED, DGNB, SBAT for Stadia and GS promotes adaptive reuse of old structure as one of the ways to fulfil the indicator, which is one of the efforts to run the circular economy (Potting et al., 2016).

The differences in Waste assessment can be triggered by differences in waste management conditions in the country of origin. It is reported that South Africa has been working in the waste and recycling landscape by funding and technical expertise, but the progress has remained slow in the non-packaging waste stream including in construction and demolition waste and organic waste (Godfrey & Oelofse, 2017). In Indonesia's case, it is reported that waste management is still not optimal and sustainable condition (Kusumaningrum et al., n.d.). Different from the condition in the US, where the US already implemented the Environmental Protection Agency (EPA) and 3R (reduce, reuse, recycle) and implemented the recycling program with a goal of utilizing solid waste up to 50% (Kerenhapukh et al., 2021). A Similar condition within Germany, where a waste management policy has been adopted for more than 20 years successfully increasing people's awareness to separate waste and implement disposal technology, leading to 14% of raw materials used by the German industry are from recovered waste (Nelles et al., 2016). The contrasting conditions between the countries of origin of the GBRS may give some insight into the indicators listed. Where the indicators are a directive towards the improvement of the conditions that are still lacking in the country.

Spaces for Innovation Activity in GBRS; Regarding the opportunity to innovate in design, despite the condition of the country, LEED and SBAT for Stadia encourage innovation in assessing green buildings as we can see in

Fig. *2*, Innovation technology. But while DGNB does not have a specific category for innovation, it integrates innovation as a bonus option in the overall certification, mentioned as the "Innovation Area" segment in the guidelines (Fig. 3). As for GS, the term 'innovation' is not mentioned directly in the handbook. What is included is an encouragement to 'use innovative technologies' to achieve targets on water efficiency only. The innovation activity promoted by GBRS in line with a statement by OECD (Organisation for Economic Co-operation and Development) where innovation in the form of creation of new products, processes and technologies, as well as the diffusion and application in green development is helpful to achieve green growth (OECD, 2011). Therefore, the addition of separated indicators for innovation is recommended for GS to catch up with the current condition.

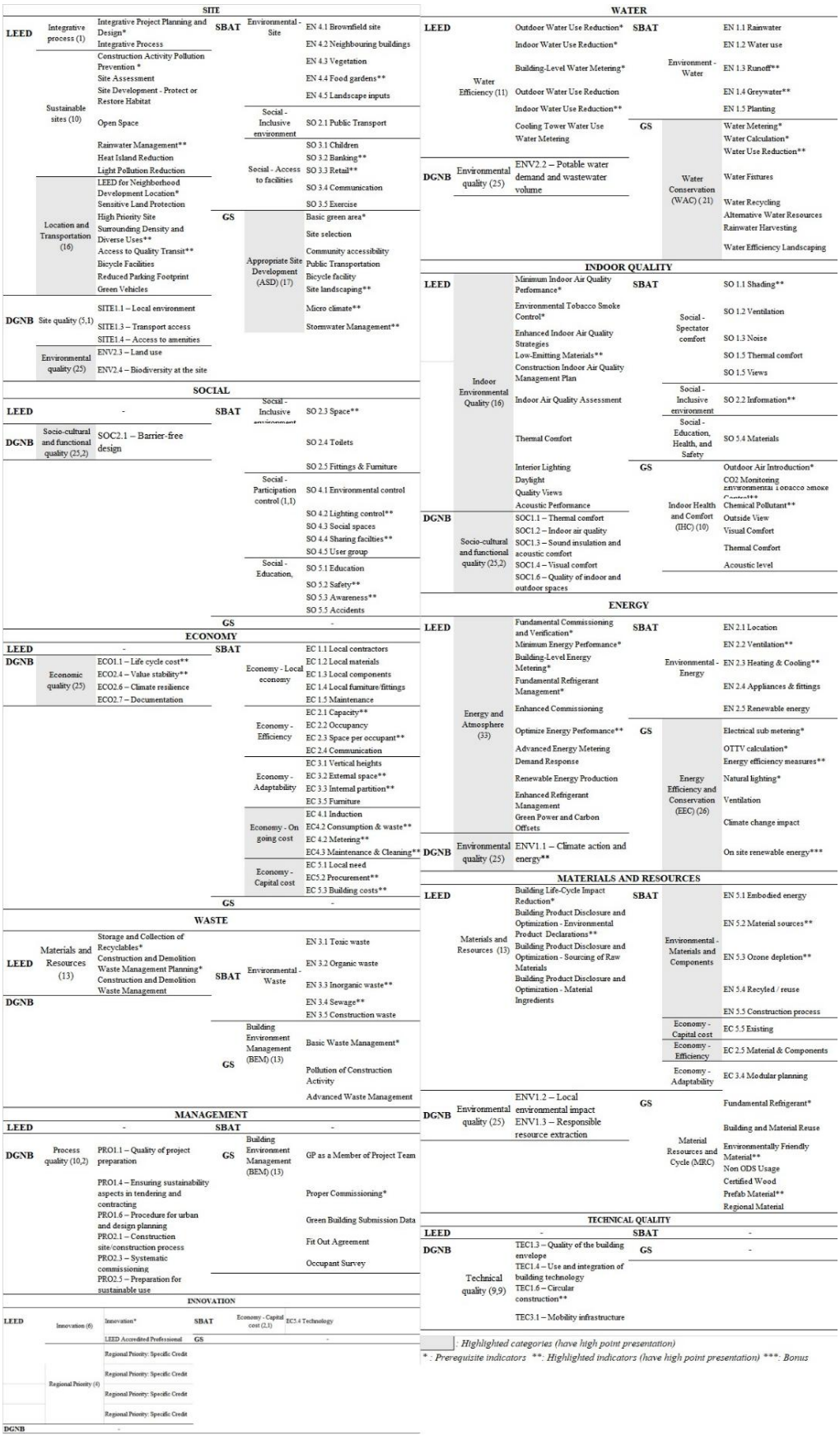


Fig. 2. LEED, DGNB, SBAT, and Greenship (GS) indicators comparation

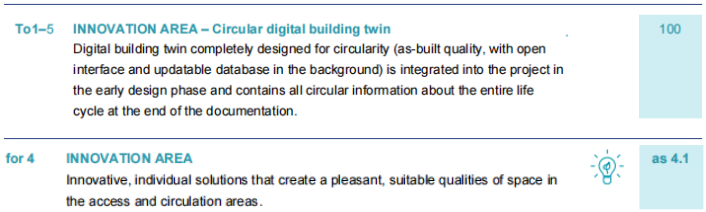


Fig. 3. Innovation Area in DGNB Guidelines (DGNB, 2023)

3.3 Comparison through cross background context application

This section compares GBRS—GS, LEED, DGNB, and SBAT—based on JIS performance. In case of SBAT, the analysis adjusted to the SBAT for Stadia version, tailored for stadium projects. Notably, the 'Occupants Comfort' indicator becomes 'Spectators Comfort', where daylighting is replaced with shading; other indicators remain unchanged.

Based on the LEED assessment, JIS falls short in MR, Energy, and IHC categories. Similarly, DGNB and SBAT for Stadia highlight gaps in economic and social aspects, particularly in inclusive design. However, JIS satisfies the Water and Site categories across the systems.The MR shortfall in JIS is linked to lifecycle assessment, which GS does not explicitly include. DGNB does incorporate this, particularly regarding demolition waste—an aspect absent in GS and SBAT. Despite national waste management differences, post-occupancy scenarios, as noted by Fregonara et al. (2018), are critical for long-term sustainability, especially for large-scale facilities (Fregonara et al., 2018).

Stadium-specific assessments in GS and SBAT for Stadia shows differ in focus. JIS meets GS's 'Thermal Comfort' criteria through energy-saving envelope design, aligned with LEED and DGNB. Conversely, SBAT for Stadia prioritizes passive cooling via roof shading. The unique 'Spectators Comfort' indicator in SBAT for Stadia, replacing 'Daylighting', reflects the needs of semi-open stadiums, where excess sunlight can impact occupant comfort and health. Research supports roof shading as more effective than natural ventilation (Guo & Sun, 2024; Conradie, 2018), highlighting SBAT's critical evaluation of social sustainability aspects.

Further, JIS shows deficiencies in meeting the economic and social indicators emphasized by DGNB and SBAT. These systems assess not only environmental but also community and long-term economic impacts. In JIS's context—built in a dense urban area requiring relocation—DGNB's 'Quality of Indoor and Outdoor Spaces' and SBAT's 'Participation and Control' indicators stress community integration. Similarly, economic indicators examine building longevity, cost-effectiveness, and societal value—essential for projects with high public investment and social implications.

Nonetheless, GS performs well in Water and Site Development, consistent with its high standards in these areas. Meanwhile, the unique SBAT category of 'Spectators Comfort'—focused on lighting—has limited impact on overall assessment.

Ultimately, JIS meets over half the criteria in LEED, DGNB, and SBAT. However, its shortcomings reflect the differing priorities among GBRS, shaped by their regional origins. While all aim for sustainability, each system applies distinct strategies based on local contexts.

4. Conclusions

Green Building Rating Systems (GBRS) have been developed by many countries and organizations around the world to assess, evaluate and certify the performance of green buildings. Some GBRS have been adopted in different sites around the globe, some GBRS have been developed for a specific country, and some of them are specially made for special occasions. This study address to compare GBRS from different backgrounds, to identify the similarities, differences, strengths and weaknesses of each GBRS.

As the result of the comparison, it shows that all GBRSs are similar in their focus on environmental aspects, addressing categories such as site, energy, water, MR, and social aspects through IEQ. However, differences in their backgrounds lead to variations in the indicators they evaluate, presenting both strengths and opportunities for improvement. From this research, it can be suggested for stakeholders in the construction field to choose locally developed GBRS as a green building reference to access regionally specific sustainability issues. In addition, it is expected that the wide use of regional GBRS can lead to the development of GBRS periodically, especially in improvement areas found at several points. That way, the goal of future sustainability can be achieved.

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References

Akadiri, P. O., Chinyio, E. A., & Olomolaiye, P. O. (2012). Design of A Sustainable Building: A Conceptual Framework for Implementing Sustainability in the Building Sector. *Buildings*, *2*(2), 126–152. https://doi.org/10.3390/buildings2020126

Azzahra, T. A. (2022). *Grand Launching JIS, Anies: 100% Dibangun dari Keringat Orang Indonesia Baca artikel detiknews, "Grand Launching JIS, Anies: 100% Dibangun dari Keringat Orang Indonesia*. https://news.detik.com/berita/d-6196469/grand-launching-jis-anies-100-dibangun-dari-keringat-orang-indonesia

Azzali, S. (2019). Mega sporting events and their impact on the built environment: Lessons learned from the past. *A/Z ITU Journal of the Faculty of Architecture*, *16*(2), 25–37. https://doi.org/10.5505/itujfa.2019.12499

Brady, C., & Kamawura, S. (2021). *An integrated approach to a sustainable built environment: the co-benefits of resources & circularity*. WGBC.

Conradie, D. (2018). *THE QUANTIFICATION OF SHADING FOR THE BUILT ENVIRONMENT IN SOUTH AFRICA*.

DGNB. (2023). *DGNB SYSTEM NEW CONSTRUCTION, BUILDINGS, CRITERIA SET Version 2023*.

Doan, D. T., Ghaffarianhoseini, A., Naismith, N., Zhang, T., Ghaffarianhoseini, A., & Tookey, J. (2017). A critical comparison of green building rating systems. In *Building and Environment* (Vol. 123, pp. 243–260). Elsevier Ltd. https://doi.org/10.1016/j.buildenv.2017.07.007

Doan, D. T., Tran, H. Van, Aigwi, I. E., Naismith, N., Ghaffarianhoseini, A., & Ghaffarianhoseini, A. (2023). Green building rating systems: A critical comparison between LOTUS, LEED, and Green Mark. *Environmental Research Communications*, *5*(7). https://doi.org/10.1088/2515-7620/ace613

Federal Ministry for the Environment, N. C. B. and N. S. (2016). *Guideline for Sustainable Building Future-proof Design, Construction and Operation of Buildings*.

Fenner, R. A., & Ryce, T. (2008). A comparative analysis of two building rating systems Part 1: Evaluation. *Proceedings of the Institution of Civil Engineers - Engineering Sustainability*, *161*(1), 55–63. https://doi.org/10.1680/ensu.2008.161.1.55

Francis, A. E., Webb, M., Desha, C., Rundle-Thiele, S., & Caldera, S. (2023). Environmental Sustainability in Stadium Design and Construction: A Systematic Literature Review. In *Sustainability (Switzerland)* (Vol. 15, Issue 8). MDPI. https://doi.org/10.3390/su15086896

Fregonara, E., Ferrando, D. G., & Pattono, S. (2018). Economic–Environmental Sustainability in Building Projects: Introducing Risk and Uncertainty in LCCE and LCCA. *Sustainability*, *10*(6), 1901. https://doi.org/10.3390/su10061901

GBCI. (n.d.). *Green Building Council Indonesia*. Retrieved November 24, 2024, from https://www.gbcindonesia.org/web

Gibberd, J. (2002). *BEPC 2002 : sustainable development : Built Environment Professions Convention, Sandton Convention Centre, 1-3 May 2002*.

Gibberd, J. (2003). *Sustainable Building Assessment Tool (SBAT-P) V1*.

Godfrey, L., & Oelofse, S. (2017). Historical review of waste management and recycling in South Africa. *Resources*, *6*(4). https://doi.org/10.3390/resources6040057

Green Building Council Indonesia. (2013). *GREENSHIP untuk Bangungan Baru versi 1.2*.

Guo, X., & Sun, Y. (2024). A thermal comfort assessment on semi-outdoor sports stadiums located in 3 different climate zones in China. *Building and Environment*, *261*, 111660. https://doi.org/10.1016/j.buildenv.2024.111660

Hanif, H. (2022). Towards achieving Platinum standards for Green Building certification: A case study using Jakarta International Stadium (JIS) design. *IOP Conference Series: Earth and Environmental Science*, *997*(1). https://doi.org/10.1088/1755-1315/997/1/012006

Illankoon, I. M. C. S., Tam, V. W. Y., & Le, K. N. (2017). Environmental, Economic, and Social Parameters in International Green Building Rating Tools. *Journal of Professional Issues in Engineering Education and Practice*, *143*(2). https://doi.org/10.1061/(ASCE)EI.1943-5541.0000313

Kerenhapukh, Y., Fadhila, A., Puteri, H. N., Fadilah, P., & Halim, A. (2021). Effectiveness of Waste Management in the United States of America. *Frequency of International Relations (FETRIAN)*, *3*(1), 33–55. https://doi.org/10.25077/fetrian.3.1.33-55.2021

Kouka, D., Russo, M., & Barreca, F. (2024). Building sustainability assessment: A comparison between ITACA, DGNB, HQE and SBTool alignment with the European Green Deal. *Heliyon*, *10*(14). https://doi.org/10.1016/j.heliyon.2024.e34478

Kusumaningrum, L., Dewi, R., Diva Ulya, F., Anggi, J., Sitepu, P., Salsabila Izdihar, R., & Pramitasari, T. A. (n.d.). P a g e | 13 Journal of Global Environmental Dynamics (JGED) Comparison of Waste Management between Indonesia and South Korea. In *Journal of Global Environmental Science* (Vol. 1, Issue 1). https://jurnal.uns.ac.id/jged/index

LEED. (2024). *LEED v4.1 Building Design and Construction*.
Mardhiyana, G., Larasati, D., Nadia, S., & Triadi, F. (2023). SUSTAINABLE IMPACT CONSIDERATION IN COMPARISON GREEN BUILDING RATING TOOLS IN INDONESIA. In *Jurnal Arsitektur ARCADE* (Vol. 510, Issue 3).
Matisoff, D. C., Noonan, D. S., & Mazzolini, A. M. (2014). Performance or Marketing Benefits? The Case of LEED Certification. *Environmental Science & Technology*, *48*(3), 2001–2007. https://doi.org/10.1021/es4042447
Munasinghe, M. (2004). Sustainomics: A Trans-disciplinary Framework for Making Development More Sustainable . *International Society for Ecological Economics*.
Nelles, M., Grünes, J., & Morscheck, G. (2016). Waste Management in Germany – Development to a Sustainable Circular Economy? *Procedia Environmental Sciences*, *35*, 6–14. https://doi.org/10.1016/j.proenv.2016.07.001
Nevado-Peña, D., López-Ruiz, V.-R., & Alfaro-Navarro, J.-L. (2015). The Effects of Environmental and Social Dimensions of Sustainability in Response to the Economic Crisis of European Cities. *Sustainability*, *7*(7), 8255–8269. https://doi.org/10.3390/su7078255
Nguyen, H. D., Do, Q. N. H., & Macchion, L. (2023). Influence of practitioners' characteristics on risk assessment in Green Building projects in emerging economies: a case of Vietnam. *Engineering, Construction and Architectural Management*, *30*(2), 833–852. https://doi.org/10.1108/ECAM-05-2021-0436
Nua, F. (2024, September 19). Capai Rp213 Triliun, Sumbangan Industri Rokok Lebih Besar dari BUMN. *Metro TV*.
OECD. (2011). *Fostering Innovation for Green Growth*. OECD. https://doi.org/10.1787/9789264119925-en
Potting, J., Hekkert, M., Worrell, E., & Hanemaaijer, A. (2016). *CIRCULAR ECONOMY: MEASURING INNOVATION IN THE PRODUCT CHAIN*.
Salsabila, N. N., Indraswari, N., & Sujatmiko, B. (2022). GAMBARAN KEBIASAAN MEROKOK DI INDONESIA BERDASARKAN INDONESIA FAMILY LIFE SURVEY 5 (IFLS 5). *Jurnal Ekonomi Kesehatan Indonesia*, *7*(1), 13. https://doi.org/10.7454/eki.v7i1.5394
Sidig, D. S., Ratri, C. W., & Wibowo, A. (2024). What is the value of green building features? An empirical analysis of green building development in Jakarta, Indonesia. *Journal of Property Investment and Finance*. https://doi.org/10.1108/JPIF-10-2023-0089
StadiumDB. (n.d.). *Design: Jakarta International Stadium*.
Suzer, O. (2015). A comparative review of environmental concern prioritization: LEED vs other major certification systems. *Journal of Environmental Management*, *154*, 266–283. https://doi.org/10.1016/j.jenvman.2015.02.029
Thomas, V. F. (2019, February 27). Peneliti Ungkap Penyebab Panel Surya Lokal Lebih Mahal dari Impor. *Tirto.Id*. https://tirto.id/peneliti-ungkap-penyebab-panel-surya-lokal-lebih-mahal-dari-impor-dhUB#google_vignette
Tn, S., & Jt, G. (n.d.). *ASSESSING THE SUSTAINABILITY PERFORMANCE OF THE 2010 FIFA WORLD CUP STADIA USING THE SUSTAINABLE BUILDING ASSESSMENT TOOL (SBAT) FOR STADIA*.
UNEP. (2024). *Global Status Report for Buildings and Construction: Beyond foundations: Mainstreaming sustainable solutions to cut emissions from the buildings sector*. https://wedocs.unep.org/20.500.11822/45095
USAID. (2021). *Indonesia Water Resources Profile Overview*. https://www.globalwaters.org/resources/assets/indonesia-water-resources-profile
USGBC. (n.d.). *Leadership in Energy and Environmental Design*. LEED. Retrieved November 22, 2024, from https://www.usgbc.org/articles/leed-hits-100000-certified-projects
USGBC. (2024). *USGBC Impact Report Accelerating Green Buildings to Improve Lives and Livelihoods*.
Zarghami, E., & Fatourehchi, D. (2020). Comparative analysis of rating systems in developing and developed countries: A systematic review and a future agenda towards a region-based sustainability assessment. In *Journal of Cleaner Production* (Vol. 254). Elsevier Ltd. https://doi.org/10.1016/j.jclepro.2020.120024
Zhang, J. W. (2014). Cost, Efficiency and Hygiene - Three Reflections on Green Building. *Applied Mechanics and Materials*, *587–589*, 203–207. https://doi.org/10.4028/www.scientific.net/AMM.587-589.203
Zimmermann, R. K., Skjelmose, O., Jensen, K. G., Jensen, K. K., & Birgisdottir, H. (2019). Categorizing Building Certification Systems According to the Definition of Sustainable Building. *IOP Conference Series: Materials Science and Engineering*, *471*(9). https://doi.org/10.1088/1757-899X/471/9/092060

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