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Sustainable Transformation of the Construction Industry in Developing Countries

Evidence from Jordan, Malaysia, and Türkiye

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Abstract
This paper looks at the key role Sustainable Building Assessment Tools (SBATs) play in encouraging environmental friendliness in construction, focusing on national situations in Jordan, Türkiye, and Malaysia. As significant ecological damage from construction includes carbon emissions and resource depletion, the paper stresses the value of adjusting SBAT designs locally to fit each country's social and environmental needs. The research analyses how national green building guides address specific local challenges – such as water shortages, energy needs and growth in society and the economy – compared to generic global standards like LEED and BREEAM. This comparison is demonstrated through an Indoor Air Quality analysis in Jordan: one LEED-accredited, and the other certified by Jordan's local tool (JGBG). Using the customised SBAT maturity model, the study looks at each tool through the lens of dimensions such as regulatory embedment, how often it updates, how much it emphasises water efficiency, and the range of building types it addresses. The results classify tools into three levels based on their score (Initiation, Institutionalisation, Optimisation), which indicates that Malaysia's GBI (Green Building Index) tool is more advanced and applies to a broader range of issues (Optimisation). In contrast, Jordan and Turkey's SBATs must make essential improvements to be more compatible with other rules, need also to be updated more often, and cover more buildings (Institutionalisation). As the results imply, using and updating local SBATs is vital to supporting the sustainability transition in developing countries.

Keywords
constructions, LEED, BREEAM, SBAT, sustainability

1 Introduction

Global environmental concerns in fields like climate change, clean water, ocean health, and biodiversity are unprecedented and interdependent. To improve supervision of natural resources, creative ideas should be placed into practice, and support sustainable growth, new corporate initiatives are required (UN Global Compact, online). Back in 1987, the United Nations Brundtland Commission redefined sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). In the context of the post-2015 agenda, Simha et al. (2017) show that the universality of the Sustainable Development Goals SDGs still allows for differentiated national pathways and indicator sets, which underlines the importance of designing context-specific assessment tools for sectors such as buildings in developing countries. In parallel, the idea of creating a tool to assess the sustainability of buildings, specifically their adherence to green building standards and environmental friendliness, is novel and requires significant effort to be thorough and encompass various building types such as LEED, CASBEE, BREEAM, and GBTool. While social and economic concerns should be the primary focus of sustainable development in developing countries, it has also been suggested that the environmental objectives of sustainable development need to be acknowledged and become part of the programmes that focus on major social and economic issues (Gibberd, 2005).

Environmental problems refer to damaging human activities in natural environments, which result in pollution, habitat loss, resource depletion, and reduction of biodiversity. These effects worsen the quality of life and human health. Industries are prominent causes of this

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due to resource extraction, pollution emissions, and waste generation. Above all, the construction industry alone emits 37% of worldwide carbon dioxide emissions from energy consumption (UNEP, 2023). This industry destroys soil and habitats due to the huge consumption of resources, such as sand, gravel, and different metals. The construction industry ranks among the top consumers of natural resources and significantly contributes to CO_2 emissions, thereby intensifying the ecological pressure on countries (UNEP, 2023). The negative environmental impacts of the construction sector can be mitigated through sustainable transitions that involve prioritising the adoption of Sustainable Construction Materials (SCMs) and integrating Environmental, Social, Governance (ESG) principles, which promotes energy efficiency, utilises renewable materials, and supports a circular economy approach through recycling and waste reduction, ultimately contributing to the achievement of the United Nations' Sustainable Development Goals (SDGs) and the creation of healthier and more energy-efficient built environments for future generations (Yap et al., 2024). Reducing the ecological footprint will help the shift to the circular economy (Musa et al., 2024). The new paradigm of environmental and resource economics is based on the premise that the human economy – and construction activities specifically – are inextricably linked to the natural environment; thus, an alteration in one system necessitates a shift in the other (Maris, 2022).

From the Earth Summit in Rio in 1992, Agenda 21 became a global prescription for sustainable development. It applies to every industry, from agriculture and mining to construction, and is a critical industry in the formative and sustaining capability of human settlements (du Plessis, 2002). Economically, most developing countries rely heavily on primary commodities (including agricultural products and raw materials (UNCTAD, 2021). However, with the recent collapse in the value of these commodities in the global markets, the industrialisation process has seen negative changes (Erten and Antonio Ocampo, 2021). The construction industry has the potential to back up industrialisation efforts and support growing infrastructure, thanks to quick urbanisation today. Therefore, with the way the region develops, a sustainable shift in construction is vital for supporting equal progress.

The impact is more severe in developing nations because this industry often operates with weak regulatory frameworks and lacks sustainable approaches. Incorporating STEP analysis, according to Mousa (2015), will provide a customised approach to sustainability practices in those areas. This approach, in turn, will attempt to stimulate local economic development and global competitiveness. With the meaning of "green buildings" extended to cover eco-compatible materials, resource use efficiency, and air quality, sustainable construction has become one of the multi-dimensional remedies directed towards reducing environmental impact, indeed it now commonly characterises the new criterion of environmental care (Kua and Lee, 2002; Reza bin Esa et al., 2011). However, building-code adoption in developing countries is uneven. UNEP (2021) note that 60% of African nations and 35% of those in Latin America still have no codes at all, while much of Southeast Asia has energy-related codes in place. Where codes do exist, progress is slowed by poor data, limited awareness of energy efficiency, and weak enforcement capacity. The studied countries, Türkiye, Jordan, and Malaysia, were selected to provide a diverse comparative framework based on:

1. their representation of three different UN-defined developing regions,
2. their distinct climatic conditions,
3. the varying levels of maturity in their Sustainable Building Assessment Tool (SBAT) adoption.

The research questions of this article are as follows:

1. Which SBAT model better addresses the nation's challenges, global or localised tools?
2. Which of the three studies on developing countries has a more mature SBAT?

Based on this, three developing countries with diverse social, economic, and environmental contexts were selected for this study: Türkiye, Jordan, and Malaysia. The first research question is examined using Jordan as the illustrative case, given the limited research on a localised SBAT tailored to its construction sector (Alawneh et al., 2024), while the second question is addressed comparatively across all three countries.

This article examines the significance of using customised assessment tools in developing countries like Jordan, Türkiye, and Malaysia to promote a sustainable transition. It focuses on the importance of blending principles for a sustainable world with a nation's own growth. A variety of data, including policy papers, case studies, government reports, and industry reviews, were used to examine the effectiveness of targeted tools at reducing the impact on the environment. Furthermore, the article analyses how policies for SBATs have developed and reviews whether such policies are adaptable for developing countries. Certification systems such as LEED and BREEAM are presented in Appendix A alongside locally used tools from Türkiye, Jordan, and Malaysia in the literature review. Besides, it examines the development of these instruments and highlights areas where they can be improved to resemble global practice. In this paper, SBAT maturity is defined as the degree to which a national green-building rating system is:

1. formally embedded in regulation,
2. up-to-date with global best practices,
3. comprehensive in building-type coverage,
4. focuses on water efficiency.

In the paper, we operationalise these four dimensions.

2 Literature review

2.1 Policy background

The government plays a critical role in imposing sustainable construction policies, overseeing areas from resource management and waste disposal to funding and innovation.

A set of cost-effective incentives in the commercial, industrial, and residential, as well as public sectors, provides policy support to green buildings in most regions. These may be general energy efficiency targets, zero-carbon building initiatives, renewable energy installations, or research and development of energy-efficient technologies, and are financeable through public funds or dedicated resources over defined periods. This support applies to various construction stages, including new green buildings and retrofitting, it will stimulate low-carbon material use and decrease emissions and waste in the construction and operational stages (Azhgaliyeva and Rahut, 2022).

According to the work of Yang et al. (2021) mandatory green building legislation might therefore be a more powerful driver of energy efficiency than a reliance on voluntary measures. Studies have shown that binding green building accreditation can lead to much higher uptakes. Australia's new energy disclosure laws have cut down the energy used by buildings and reduced carbon emissions (Kim and Lim, 2018). Green building policies have been the subject of research in other parts of developing Asia such as China and Malaysia. Researchers in these papers focus on the advantages and problems related to building with greener methods. Energy efficiency is not the only advantage of these policies; they also cut the cost of energy for everyone including governments and households. An effective mix of policy needs to be fit with local resources, capacities, and cultural contexts to foster sustainable construction. However, there is less systematic literature regarding green building policy mixes since studies in energy efficiency outnumber the comprehensive references. The literature also tends not to consider a number of critical aspects, such as the use of core sustainable construction materials and the recycling or reusing of building materials, which calls for an integrated approach to green building policy (Yang et al., 2021).

2.1.1 Developing countries

The building codes in developing countries are quite diverse, with a recent trend toward adopting both mandatory and voluntary standards. However, a report published by UNEP (2021) states that 60% of African countries and 35% of Latin American nations still lack any building codes. Unlike elsewhere, Southeast Asia has a wider use of energy-related building standards, with frameworks already in place in countries such as China, Hong Kong, Indonesia, Japan, South Korea, Malaysia, the Philippines, Singapore, Thailand and Vietnam. Regulating these codes is challenging in developing countries because there are not always reliable databases, enough public knowledge about energy efficiency or effective controls and enforcement. For this reason, many areas need to boost their building codes to include proper climate adaptation. For vulnerability to be reduced, the design of building codes should include crucial factors. They should prioritise responding to anticipated climate variability, particularly shifts in precipitation patterns such as altered rainfall and snowfall. They are responsible for widely sharing information about the new requirements so that builders, architects and suppliers all make proper use of them. Bringing in inspectors to check that these factors have been properly addressed during design and construction is very important for successful code enforcement (UNEP, 2021).

2.2 Customised Sustainable Building Assessment Tool (SBAT)

A construction project is sustainable when all the various factors of sustainability are considered. Most sustainability concerns are embedded within existing approaches, which predominantly emphasise environmental aspects. However, currently, no tailored assessment tools exist that comprehensively address the environmental, economic, social, and technological dimensions of buildings (Banani et al., 2016). Although Leadership in Energy and Environmental Design (LEED) has tried to customise its assessment tool to adapt to several regions and characteristics, it could not satisfy the sustainability assessment criteria's social, economic, and cultural aspects. It was noted that the criteria for building assessment should be designed to accommodate a particular region. As a result, some sustainability criteria and categories were missed by global sustainable building assessment tools such as LEED and Building Research Establishment Environmental Assessment Method (BREEAM) as well. For example, international assessment systems like LEED and BREEAM cannot satisfy Kazakhstan's sustainable construction requirements in their original form due to significant variations in local climate, culture, socio-economic factors, standard technological practices, and the prohibitive costs of foreign certification (Akhanova et al., 2019). Besides, LEED and BREEAM were originally not developed to correspond to Middle Eastern countries (Alhanouti and Farrell, 2023). See Appendix A for additional details.

If we briefly shift our focus to Hungary (where the authors of this paper are based), recent work on an eco-housing project in Budapest shows that housing-related sustainability assessments need frameworks tailored to the specific social and institutional context, because generic tools tend to under-represent aspects such as affordability, social cohesion and resident participation (Babos et al., 2024). This supports the argument that national SBATs in developing countries should not simply copy global schemes, but should instead adapt their criteria and indicators to local socio-economic realities, tenure patterns and housing policies.

A study by Alawneh et al. (2024), focusing on Jordan, developed an innovative framework for integrating contributions to the Sustainable Development Goals (SDGs) into the assessment and management of sustainable construction projects. The findings demonstrate that such projects can significantly advance progress toward several SDGs. The study identified the assessment indicators with the highest quantified contributions, including energy-efficient management, renewable energy use, energy-saving measures, water conservation, and water recycling (Alawneh et al., 2024).

For instance, they reward energy-efficient design, onsite renewables and carbon reduction (advancing SDGs 7 and 13); require water-saving fixtures, rainwater harvesting and greywater reuse to protect freshwater resources (SDG 6); promote recycled and low-impact materials plus rigorous construction-waste management to support a circular economy (SDG 12); safeguard occupant health through low-VOC finishes, ample ventilation, daylight and thermal comfort (SDG 3); encourage site choices that favour brownfield redevelopment, transit access, open space and ecosystem preservation (SDGs 11 and 15); and foster innovation, knowledge-sharing, green jobs and upskilling in the building sector (SDGs 9, 4 and 8).

2.2.1 Türkiye

Türkiye is one of the rapidly developing countries regarding the energy consumption and imports nearly 70 percent of its energy. As a reaction, the country started to work on creating a national system of Green Building Certification (GBCS) because only international systems were implemented up to the 2010s. In 2008, the initial activities towards the establishment of a national system were initiated with the help of Mimar Sinan Fine Arts University. The result of this effort is the development of SEEB-TR (Sustainable Energy Efficient Buildings) in 2013 as the first national GBCS in Türkiye. The certification system, the National Green Building Certification System of Türkiye, which is also recognized as ÇEDBİK, was also officially introduced in the same year. ÇEDBİK is designed to support healthy communities and comfortable living conditions as well as invest in the national economy. The establishment of a fully recognised system meant that it had to be in line with the Green Certificate Regulation of Settlement and Buildings, which was published by the Ministry of Environment and Urbanisation in 2017. Consequently, Türkiye developed its own variant of a national GBCS, which resulted in the new system of 2019 dubbed as B.E.S.T. (Umaroğulları et al., 2020).

Türkiye is not rich in terms of water resources and the water stress it already experiences is likely to continue to grow as climate change, urbanisation, and growing demand pose more chances of extreme events and water scarcity. Türkiye has a national per-capita freshwater supply of approximately half that of the world, and at least 15 out of 25 river basins are already water-stressed (less than 1,700 m^3/person/year) according to national assessments, including very densely inhabited and industrialised basins such as Marmara (The World Bank, 2021). In line with such pressures at the level of the basin, official forecasts, in accordance with TurkStat population trends, forecast further reductions in per-capita available water to the 1,200 m^3/person/year range by the end of the 2030s, and to the 1,150–1,200 m^3/person/year range by mid-century, bringing Türkiye even closer to the 1,000 m^3/person/year internationally used threshold of water-scarcity (Öztürk and Çolak, 2024; SUEN, 2018).

Another study by Said and Harputlugil (2019) addressed national challenges by comparing the key characteristics of various green building assessment tools with the aim of supporting the wider adoption of green buildings in Türkiye. The authors reviewed six certification systems, and five of them – LEED, BREEAM, CASBEE, HQE, and DGNB – were evaluated based on input from Turkish experts. Although B.E.S.T. is a tool developed by ÇEDBİK for residential certification, it was not included in the comparison matrix because it is not yet widely used and applies only to new residential buildings. According to the research findings, none of the existing international certification systems fully align with Turkey's conditions. Therefore, the country requires the development of its own certification system. Such a system should be specifically tailored to the needs and characteristics of the Turkish context (Said and Harputlugil, 2019). The credit points of B.E.S.T. to new residential (housing) projects under Version 2.0 are allocated under nine major categories (ÇEDBİK, 2019). The weighting is highest to Energy Use 26, then Health and Comfort 14, Material-Resource Use 14, Land Use 13 and Water Use 12. The allocated points are 9 points to Integrated Green Project Management, 14 points to Residential Life, 6 points to Operation and Maintenance and 2 points to Innovation, which in total 110 points (ÇEDBİK, 2019).

2.2.2 Jordan

In 2009, Jordanians' efforts were underway to establish a rating system for buildings that would minimise energy and water consumption and provide an efficient and healthier environment. In 2009, the technical committee to develop the Green Building Rating System in Jordan, now known as the Jordan Green Building Guide (JGBG), was formed with the contributions of experts from both public and private sectors under the guidance of the technical division at the Construction and Sustainable Building Centre (CSBC). In 2013, the JGBG was issued and made free for use by everyone. The Jordanian government incentivised the construction of green buildings due to an incentive scheme implemented by the JGBG rating system, which was approved in 2015 and officially launched on 3rd September 2015, as stated by Zawaydeh (2024).

The JGBG also shares goals common with other codes to bring in an improvement in the areas of building and resource efficiency and, similarly, in enhancing productivity and lessening environmental impact for the occupants. This code was designed by Ministry of Public Works and Housing (MPWH) and encompasses most building types apart from factories, warehouses, hospitals, and health centres. The green prerequisites are segmented into three kinds of credits: obligatory requirements, are essential green practices not in codes, offering points for achieving them, mandatory requirements, are compulsory baseline criteria linked to Jordanian Building Codes, with no points, and optional, attached to rewarded points, to ensure a minimum level of sustainability in buildings and to give equal importance to the design and construction phases. The guidebook is organised according to major categories, which are similar to those of other certification systems and regulations; but each category has a weighted score according to the local priorities. Building Management gets 25 points, Sustainable Site 32 points, Water Efficiency 40 points, Energy Efficiency 98 points, and Materials and Resources 36 points. The accumulated total of points that can be gained for each kind of building determines the amount of sustainability of the building, taken in all, out of 253 total points that are divided into four levels: A, B, C, and D. The points required for the grades are 50–59% points for grade D, 60–69% points for grade C, 70–79% points for grade B, and ≥80% points for grade A (MPWH, 2012).

Ali and Al Nsairat (2009) developed an approach of green building assessment tool in Jordan. It discussed multiple challenges and factors influencing the assessment tool, starting with economic growth and increasing population, energy demand is expected to increase by at least 50% over the next 20 years. Jordan has a variety of geographic features and may be divided into three physiographic regions: the highlands, including mountainous and hilly areas that extend from north to south through Jordan, the desert region, an extension of the Arabian Desert, comprising around eighty percent of the country, there is a huge variation in the desert's climate during day and night, winter and summer, and The Jordan Rift Valley extends also along the entire length of Jordan, going down to over 400 m below sea level. Jordan is considered one of those countries in the world that has restricted water resources and ranks amongst the lowest per capita. The development of the SABA Green Building Rating System was based upon the AHP method, where three assessment indicators were provided, namely environmental, social, and economic. The final framework of the system includes seven categories. The main categories are site, energy efficiency, water efficiency, material and resources, indoor environmental quality, waste and pollution, and cost and economics (Ali and Al Nsairat, 2009).

2.2.3 Malaysia

Malaysia's green building rating tools were designed as bespoke instruments for the local tropical climate and developmental landscape, while simultaneously addressing specific socio-cultural requirements. This includes the Green Building Index GBI in 2009; Green Performance Assessment System GREEN PASS in 2012; Skim Penilaian Penarafan Hijau JKR – PH JKR in the year 2012, and Green Real Estate which is known as GreenRE, that was introduced in 2013, along with some others that are still focused on the township and highway rating tools. The two most utilised and widely popular are the Green Building Index (GBI) and Green Real Estate (GreenRE) (Usman and Abdullah, 2018).

The Green Building Index GBI was also initiated by the Malaysian Institute of Architects (PAM), the Association of Consulting Engineers, Malaysia (ACEM). It aimed to motivate a sustainable built environment and increase awareness of environmentally related issues among different segments involved in the industry. Since its beginning, GBI has continuously extended the building assessment types that it covers. Currently, it encompasses non-residential new construction, residential new construction, non-residential existing building, industrial existing building, non-residential new construction, non-residential existing building, and townships (Abd Hamid et al., 2014).

The assessment criteria based on GBI for Residential New Construction (RNC) are 23 credit points for Energy Efficiency (EEF), 12 points for Indoor Environmental Quality (IEQ), 33 points for Sustainable Site Planning and Management (SSPM), 12 points for Materials and Resources (MR), 12 points for Water Efficiency (WE), and 8 points for Innovation (I) (Usman and Abdullah, 2018).

In 2013, the Real Estate and Housing Developers' Association (REHDA) launched a Green Real Estate (GreenRE) to drive the real estate sector in Malaysia toward more sustainability and a better place to live. The core focus of this rating instrument is to evaluate a building's performance across several dimensions, including energy efficiency, water efficiency, environmental preservation, indoor environmental quality, and carbon emissions. This assessment spans the entire project lifecycle, beginning with design and conceptualisation, continuing through construction, and extending into post-completion stages. This rating tool applies to both high-rise residential buildings and individual homes. To qualify for certification, a minimum of 30 credits must be achieved in the energy-related category. Additional green requirements include Water Efficiency, Environmental Protection, Indoor Environmental Quality, Other Green Features, and Carbon Emissions of Development. These requirements reward water-efficient features, eco-friendly design practices, innovative green features, and the carbon emissions of the development with credits. The minimum number required to achieve the certification for this category is 20 credits (Abd Hamid et al., 2014). Currently, only GBI has reached a maturity level, as it constantly releases a set of toolkits for specific buildings and usages. Other than this, the rest are not very well-known to the users or the general public; they have just recently been released or are currently in the final editing stages, where they need further modification before being released to the general public (Hung and Ahmad Fuad, 2018).

Although Malaysia is a tropical country with a high precipitation rate, the country experiences rising water insecurity due to seasonal droughts caused by climatic conditions and intense water pollution (Risam and Jamaludin, 2023). This weakness is further compounded by the rapid urbanisation and population explosion that impose overwhelming burdens to the domestic supply of water and overly expose major economic hubs such as the Klang Valley to disruptive shortages (New Straits Times, 2020; Raihan et al., 2023). Add to these environmental and demographic issues are structural technical weaknesses, especially a national rate of non-revenue water (NRW) of 36% based on the old leaking infrastructure and operational inefficiencies (Ikram, 2023). Malaysia can no longer rely solely on expanding its physical water supply to solve these shortages. Instead, as emphasised by the Intergovernmental Panel on Climate Change, mitigating such systemic vulnerabilities requires urgent, long-term demand-side adaptation (IPCC, 2023b).

3 Methodology

3.1 SBATs maturity framework

To answer the research question of which national SBAT is more mature, we applied a maturity model, a structured framework that assesses progressive performance levels across key criteria (Díaz et al., 2025).

The three stage maturity model as used in this research (Initiation, Institutionalisation, Optimisation) expands on capability-maturity models that have been extensively employed to evaluate sustainability integration in construction, higher education and corporate practice, and in general distinguish between progression of initial or ad-hoc practices to successively more institutionalised and optimised forms (Goh and Rowlinson, 2013; Parker et al., 2017; Yücel; 2025).

A category-level comparison between LEED and JGBG is presented in Table 1. Table 2 shows the scoring of each tool in the three countries studied. Here we define a three-stage SBAT maturity model with stages Initiation, Institutionalisation, and Optimisation, evaluated across four critical dimensions: Regulatory Embedment, Update Frequency, Water Efficiency, and Building Type Coverage.

The SBAT maturity framework evaluates tools across the four internationally validated dimensions mentioned earlier. First, Regulatory Embedment reflects whether a tool is supported or mandated by government policies, an important factor since voluntary tools often lack the influence needed for widespread adoption (Abdou and Mohsen, 2025). Second, Update Frequency indicates the tool's responsiveness to evolving best practices; mature systems like LEED and BREEAM regularly revise their criteria to stay aligned with technological and policy developments (Marchi et al., 2021). Third, Water Efficiency remains a cornerstone of green building assessments, as it represents SDG 6, included as a core maturity dimension because water stress and urban water insecurity are increasing globally, including across developing regions (IPCC, 2023a) and the increasing weight of water-related credits in tools like LEED and BREEAM underscores its essential role in building sustainability (Yıldız, 2024). Lastly, Building Type Coverage signals the tool's comprehensiveness, advanced frameworks assess a wide array of residential, commercial, and institutional buildings, expanding from early prototypes limited to new offices (Sánchez Cordero et al., 2019). Together, these dimensions offer a robust and comparable structure for gauging SBAT maturity across national contexts.

Sections 3.1.1 to 3.1.3 describe clear criteria for each dimension at each maturity stage.

3.1.1 Stage 1: Initiation (0–2 points)

In the Initiation stage, the SBAT is in its emerging phase. Its adoption and scope are limited, and many foundational elements are only partially developed:

- Regulatory Embedment: purely voluntary; driven by early adopters or pilot projects, with no legal mandate (e.g., Nigeria had no national tool) (Atanda and Olukoya, 2019).
- Update Frequency: one-off prototype or first edition; no formal revision cycle, so criteria can sit unchanged for years and quickly date (Garcia Cifre, 2025).
- Water Efficiency (<5% of points on water): the initiation stage reflects only minimal incorporation of water efficiency measures, corresponding to very low credit allocation. Water-saving strategies are basic, focusing on compliance with simple efficiency standards.
- Building Type Coverage: one narrow project type (often new offices, as with early BREEAM) (Sam, 2018).

3.1.2 Stage 2: Institutionalisation (3–5 points)

At the Institutionalisation stage, the SBAT gains wider acceptance and is increasingly integrated into industry practice and policy. The tool is more mature in each dimension, though not yet fully optimised:

- Regulatory Embedment: now referenced in policy; governments use incentives or partial mandates, but not blanket requirements.
- Update Frequency: standing committee and scheduled multi-year revisions. For instance, the LEED is revised and updated by default every three to five years (Nag, 2019).

Table 1 Credit points and percentage of each category for LEED and JGBG

Categories	LEED	Percentage	Categories	JGBG	Percentage
Sustainable Site (SS)	11	10%	Sustainable Site (SS)	32	12.6%
Location and Transportation (LT)	15	13.6%	–	–	–
Water Efficiency (WE)	9	8.2%	Water Efficiency (WE)	40	15.8%
Energy Atmosphere	33	30%	Energy Efficiency	98	38.7%
Materials and Resources (MR)	18	16.4%	Materials and resources (MR)	36	14.2%
Indoor Environmental Quality (IEQ)	13	11.8%	Indoor Environmental Quality (IEQ)	22	8.7%
Integrative Process, Planning and Assessments (IP)	1	0.9%	–	–	–
Project Priorities (PR)	10	9.1%	–	-	–
–	–	–	Building Management	25	10%
Total	110	100%	–	253	100%

Table 2 SBAT maturity vomparison scoring system

Dimension	Indicator and Scoring Criteria (0 = low, 2 = high)	Jordan (JGBG)	Malaysia (GBI/GreenRE)	Türkiye (B.E.S.T.)
Regulatory embedment is the SBAT referenced or integrated in national building regulations?	0: No official recognition or policy support. 1: Voluntary scheme with government incentives or guidelines (not mandated). 2: Mandated or explicitly referenced in national building codes/regulations.	1: The Jordan Green Building Guide (JGBG) was developed by the government and is voluntary but linked to an official incentive programme. It is not a compulsory part of the building code, but the government actively supports it.	1: Malaysia's Green Building Index (GBI) (and similar tools like GreenRE) are industry-developed and voluntary. There are no mandatory green building requirements in Malaysian building codes. However, the government encourages their use through incentives.	1: Türkiye established a national Green Certificate regulation in 2017 to certify sustainable buildings. Participation in the B.E.S.T. certification is voluntary; the scheme is backed by law but not required by building code. This represents partial regulatory integration
Update frequency how recently and frequently is SBAT updated?	0: No significant updates since initial launch (outdated criteria). 1: Infrequent or irregular updates (e.g., one update in >5–7 years). 2: Regular or recent updates (up-to-date within ~5 years; active revision cycle).	0: JGBG was produced in 2013 and introduced in 2015 and there has been no published revision made since then, as of 2025. For ~10+ years, the tool has not changed which shows it has been update rarely or not at all.	2: GBI and related tools undergo periodic updates and expansion. For example, the GBI criteria for Interiors were updated to Version 1.2 in 2019. New tools were introduced, reflecting an iterative evolution of Malaysia's SBATs.	2: Türkiye's SBAT has been revised recently. An initial national framework in 2013 was overhauled to align with the 2017 Green Certificate Regulation, culminating in the updated "B.E.S.T." by 2019. This indicates the criteria were refreshed within the last 5 years.
Water efficiency coverage does the SBAT include robust water efficiency criteria (performance metrics, reuse, conservation)?	0: Little to no focus on water efficiency (few or no credits <5%). 1: Some water efficiency measures included (e.g., low-flow fixtures or basic reuse, but limited scope, 5 – 15%). 2: Comprehensive coverage of water efficiency (>15%).	2: Water efficiency is a key focus area in Jordan's SBAT. JGBG has a dedicated Water Efficiency category (WE) with 15.8%. The tool was developed with an emphasis on Jordan's acute water scarcity, This reflects the high priority of water savings.	1: Malaysia's green building rating tools include water efficiency criteria, such as rainwater harvesting, water recycling, and water-saving fittings, with 12% weight. However, the emphasis on water is moderate. The coverage is solid but not as extensively weighted as in Jordan.	1: Türkiye's B.E.S.T. system addresses water efficiency as one of its nine assessment categories for new residential buildings. It includes measures for water-saving with a weight of 12%. But water is one part of a broader scheme. The coverage is comparable to other general rating systems.
Building type coverage range of building types the SBAT applies to (new vs. existing, residential, commercial, etc.)	0: Very narrow scope (applies to only one type of building or project). 1: Moderately broad (covers multiple building types, but with some notable exclusions or only new buildings). 2: Very broad (applicable to most building types, e.g., new and existing residential, commercial, institutional, possibly even neighbourhoods/ infrastructure).	1: JGBG addresses most types of buildings (such as housing and offices), but does not consider factories, warehouses, hospitals or health centres.	2: Malaysia's green rating systems collectively cover a wide range of building types. GBI has variants for example, new non-residential, residential, existing building, while GreenRE target both private and public developments.	0: The national B.E.S.T. certification is currently limited to new residential buildings. Other building types in Turkey (e.g., commercial offices, existing buildings) still rely on international systems like LEED/BREEAM or await local criteria.
Total points		4	6	4

- Water Efficiency (5–15% of points): 5–15 %; metering, recycling, and indoor/outdoor reduction are standard. LEED v4 ≈ 11 pts (~10 %) and BREEAM ≈ 6 % (Nag, 2019).
- Building Type Coverage: expands to most residential, commercial, and institutional buildings, new and existing, though highly specialised types remain outside the core schemes (Sam, 2018).

3.1.3 Stage 3: Optimisation (6–8 points)

In the Optimisation stage, the SBAT is fully matured and embodies best practices across all dimensions. It is an established part of the regulatory and market landscape, continuously refined and broadly applicable:

- Regulatory Embedment: embedded in building codes; minimum ratings compulsory for certain project classes and aligned with code baselines.
- Update Frequency: rigorous, frequent cycle (e.g., major releases every 3–5 years plus annual minor updates) to capture new science and stakeholder feedback, similar to LEED, which was mentioned in Appendix A. This ensures the rating tool maintains credibility and continuously raises the bar for sustainability performance.
- Water Efficiency (>15% of points on water): ambitious performance-based targets integrating conservation, reuse, and broader catchment impacts, especially in water-scarce regions.
- Building Type Coverage: full life cycle and sector reach, residential, commercial, industrial, public, plus neighbourhood or infrastructure versions (e.g., BREEAM Homes, Communities) (Sam, 2018).

4 Results

Despite being classified as developing nations (United Nations, 2023), Malaysia, Türkiye, and Jordan were picked for this study because they have unique environmental, social, and economic traits. For example, Malaysia's Asian culture includes many traditions, a range of Asian heritage, weather that changes by season, and economic progress that supports its urban and building projects (CIA, 2024b). Moreover, it has an ecological deficit of −98%, which means their demand for their natural resources is higher than the ability of nature to replenish them (World Population Review, 2024). In contrast, large parts of Türkiye, enjoy seasonal weather patterns (warm summers, mild winters) closely resemble those found in European countries, in addition to a mixed population of Turks and Kurds, leading to political challenges, and more housing and construction projects needed (CIA, 2024c). And similar to Malaysia, Türkiye has an ecological deficit of −120% (World Population Review, 2024). In addition, the Middle Eastern country of Jordan has a Mediterranean climate. For several years, the country has experienced multiple refugee issues from nearby countries which has increased the number of people. This has put pressure on the country's urban and infrastructure development, especially considering the scarcity of water and lack of energy, and natural resources (CIA, 2024a). Notably, Jordan has a much higher ecological deficit than the other mentioned nations, at −600% (World Population Review, 2024). A common thread among these countries is the adverse environmental impact caused by the construction industry and the high ecological footprint, particularly in some developing countries lacking regulations, such as Jordan. This has drawn international attention and led to the emergence of research and Innovation in Building and Construction CIB Agenda 21 as part of the Action Plan for the implementation of the CIB (du Plessis, 2002).

As can be seen in Fig. 1, Jordan was also a proactive early adopter in developing its local tailored sustainable building assessment tool, starting with SABA that was developed in 2009. It was not yet at that point an official instrument, but it paved the way for serious consideration to formalise Jordan Green Council guidelines (later known as "Jordan Green Building Guidelines (JGBG)"). This transition allowed the JGBG to serve as a regulatory basis for granting incentives to high-scoring green projects.

4.1 Comparison between LEED and JGBG

To address the second research question based on the literature, a comparison between LEED and JGBG will now be made to understand how developing a tailored green

Fig. 1 Timeline of issuing SBAT in Türkiye, Jordan, and Malaysia

assessment tool can prioritise the unique characteristics of each country (see Table 1).

As shown in Table 1, JGBG allocates a notably higher percentage of its credit scoring to energy efficiency (38.7%) and water efficiency (15.8%) compared to LEED, which assigns 30% and 10% to these categories, respectively. This prioritisation is particularly relevant in Jordan, where persistent challenges such as limited energy resources and chronic water scarcity necessitate a stronger emphasis on resource-efficient building practices. These locally responsive priorities do not only distinguish JGBG in terms of energy and water performance; they also extend to other dimensions of building sustainability. Table 1 demonstrates how the same high-level categories can be retained while national tools adjust weighting to local priorities; the IAQ example below is included as an illustration of how such differences may manifest in practice. Indoor Air Quality (IAQ), a key component of the broader Indoor Environmental Quality (IEQ) category, offers an illustrative example in this specific pair of buildings provided by Elnaklah and Natarajan (2019) which they compared absenteeism and indoor CO2 concentrations over a five-week period in two certified buildings in Amman, one accredited by JGBG (Izzat Marji Group Headquarters) and the other by LEED (Middle East Insurance Company). Their findings revealed a significant disparity in average CO_2 levels during working hours, with the LEED-certified building exhibiting higher concentrations than the JGBG-certified one. Although both buildings remained within the acceptable limits of their respective guidelines, employees in buildings with higher absenteeism tended to experience elevated CO_2 levels toward the end of the workday. These results suggest the possibility that a locally tailored green building assessment tool, such as JGBG, may better support not only improved environmental performance but also enhanced occupant well-being within the Jordanian context but broader conclusions require more cases.

4.2 SBAT maturity results

The comparative evaluation of the three Sustainable Building Assessment Tools (SBATs) in the four evaluation dimensions, namely, regulatory embedment, frequency of update, the scope of water efficiency, and the applicability of the tool to a building type, demonstrates the unique differences in the degree of maturity, summarised in Table 2. Although Jordan, Malaysia and Türkiye have all achieved some significant gains in the development of national SBATs, their scores reflect some variation in the level of institutional development. In all three nations, the findings in Table 2 indicate that in all three nations, the tools are not required in any of the national building codes, but they are all positively influenced by government support or incentive schemes. This puts the SBATs in the middle stage of regulation integration, where it has policy recognition but not yet complete regulation or mainstreaming by imposing on a mandatory basis.

The greater distinction between the countries is observed in the dimension of the update frequency. According to Table 2, Malaysia and Türkiye do the best in this category because of their comparatively new and organised revision cycles, with both GBI/GreenRE and B.E.S.T. systems being updated in the last five years. JGBG in Jordan, in its turn, has the lowest score due to the lack of updates since its release in 2013 and operationalisation in 2015. This stagnation acts as a constraint to the tool to maintain the pace with the changing sustainability technologies and international best practices, therefore, restricting the overall level of maturity.

The water efficiency coverage shows a different trend. Jordan is doing well on this dimension, as indicated by Table 2, as the country scores the highest in the dimension because of the high weighting of the JGBG on water conservation owing to the extreme water shortage in the nation. Malaysia and Türkiye are moderate in the score, and water is given lesser proportion of total credits in the instruments. The strengths of context-specific SBAT development and the correspondence of criteria to national environmental priorities are the main points of the performance of Jordan.

The most significant disparities of the three tools are in building type coverage. The highest rating is achieved in Malaysia since the country offers a wide and diversified range of rating tools that can be used in both new and existing buildings, residential buildings, commercial buildings, industrial buildings, interiors and even township-level development as demonstrated in Table 2. The coverage of Jordan is narrower, covering major building types, but not industrial and healthcare facilities and has little to say about retrofits. Türkiye is the lowest ranked on this dimension, with only new residential buildings being subject to the B.E.S.T. system, other industries continue to depend on international certification. This limited scale greatly decreases the national influence and maturity of the SBAT in Türkiye.

It can be observed that each of Malaysia and Türkiye has developed a higher number of SBATs over the years, where they are using cumulative learning based on the challenges that might arise throughout the journey of sustainable development. This methodology is similar to LEED, where revisions and updates to the versions occur every 3 to 5 years, as previously indicated in Appendix A, and this can give these countries an advantage as more mature tools compared to Jordan's tools. Therefore, the JGBG should be revised and modified according to the challenges and situations facing Jordan, while B.E.S.T. in Türkiye, along with Malaysia's and Jordan's tools, should be developed to encompass all building types and serve as a reference.

As per shown in Table 2, it can be observed Malaysia's GBI/GreenRE scores 6 which let it fall in the Optimisation stage based on the maturity framework that been indicated in Section 3, it is updated regularly, works for nearly every type of project, both old and new and is promoted by the government, ensuring it has a strong presence in the market, despite all certifications being voluntary. In Jordan and Türkiye, each of the two standards scores 4, they are officially recognised by the government and set real criteria for performance, but their reach is limited, and in Jordan, they have not changed since 2015, although they focus specifically on new homes in Türkiye. While these localised tools provide a superior alternative to generic frameworks, significant progress is still required: Jordan must initiate a comprehensive programme update, Türkiye needs to codify its guidelines into law, and Malaysia should consider integrating GBI standards into national legislation and public procurement policies.

5 Conclusion

The paper discussed the role of locally specific Sustainable Building Assessment Tools (SBATs) in facilitating the sustainable change of the construction industry in the developing world, specifically in Jordan and in relation to the experience in Malaysia and Türkiye. Using a tailored SBAT maturity framework based on four dimensions, including: regulatory embedment, frequency of updating, water efficiency coverage and building type coverage, the analysis found that all three countries have made significant strides in the establishment of national tools, but it is important to observe that they are at various stages of institutional maturity. JGBG of Jordan and B.E.S.T. of Türkiye are currently in the Institutionalisation phase, whereas GBI/GreenRE combination of Malaysia has already reached the Optimisation phase as it covers a wider range of building types and is updated more frequently, although it is still voluntary. Meanwhile, the comparation of LEED and JGBG with the data of indoor air quality and absenteeism in certified buildings helps highlight the importance of context-relevant requirements that do reflect the local environmental priorities like severe water shortage and energy limitations in Jordan.

Nonetheless, this study has a number of limitations. Most importantly, Jordan fails to provide a complete and up-to-date publicly available registry of JGBG-certified buildings, as well as release post-occupancy performance information in a systematic manner. This non-disclosure limits the potential of carrying out high scale empirical confirmations, such as statistically fortified comparisons of energy utilisation, water utilisation, or inside environmental quality amid certified and non-certified building inventories. Rather, the study is based on case studies, secondary sources, and the formal design of the rating tools themselves. Also, the maturity framework is strategically designed around four fundamental dimensions; this enables comparability, but not a direct measurement of other dimensions including life-cycle carbon accounting, socio-economic equity, or the transaction costs incurred by project developers.

These constraints point towards a number of future research directions. Initially, when comprehensive data is available again, empirical research must be conducted to assess the actual performance of the Jordanian buildings having the JGBG-certificate in energy, water, and indoor environmental quality, and compare it with the performance of the non-certified buildings and those accredited according to the international programmes like LEED and BREEAM. Second, comparative studies ought to be further developed, aiming to explore the effectiveness of B.E.S.T. in Türkiye and GBI/GreenRE in Malaysia, in terms of realised environmental performance, user satisfaction, and cost-efficiency, but not only regarding credit structures. Finally, cross-country studies featuring other developing countries may further contribute to the optimisation of the maturity framework and an analysis of them may highlight local trends in the development of localised SBATs.

On the evidence provided, a number of actionable strategies are identified for the policymakers and decision makers. In the case of Jordan, the priority actions would be:

1. to revise JGBG to reflect the current best practices in energy efficiency, water resilience and circular construction;
2. to make it applicable to industrial, healthcare, and existing buildings;
3. to establish a publicly available database of certified buildings, in terms of basic performance indicators and post-occupancy assessments.

It should be further enhanced by a gradual inclusion of minimum JGBG performance levels into building codes, beginning with the public buildings, large-scale commercial projects and social infrastructure, and making it a regulatory mechanism, as opposed to a voluntary choice.

In the case of Türkiye, the policy should be directed into expanding B.E.S.T. to cover commercial, public, and existing stock in addition to new residential buildings and gradually bring the Green Certificate Regulation to these new standards. Incentive plans and state procurement may be employed to make B.E.S.T. or other national tools higher in priority than using the international certifications exclusively, thus supporting the local relevance and capacity building process. The key issue in Malaysia is to shift the largely voluntary, market-driven framework to a higher degree of regulatory entrenchment; meanwhile, incorporation of GBI/GreenRE thresholds into national and local building codes, and the mandate of minimum certification levels of government-funded projects, would tie together their already high level of maturity. In all three countries, a shared policy agenda must be based on:

1. aligning SBAT requirements with the SDGs and the decarbonisation of the existing national policies;
2. enhancing water security and climate adaptation indicators in water-stressed areas;
3. encourage the utilisation of low-carbon, locally applicable construction materials;
4. regional cooperation and sharing of information in the design of SBATs, governance approaches, and digitalisation.

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Appendix A

Certificates represent the use of various analytical systems and tools worldwide to evaluate the environmental performance of buildings. Interestingly, most of these tools originate from Europe, the USA, and Canada. The variety of tools, such as BREEAM, LEED, and many others, is wide, and their development and maturity are of great interest.

Growing consumer and building developer, designer, and operator attention to green building in different parts of the world has spurred several building assessment tools and methodologies that range from initiatives by voluntary agencies or stakeholder groups to those mandated by governmental regulation. Indeed, these various assessment systems have gone through development cycles of design iteration, revision, and updates to reach levels where some have gained acceptance in multiple countries or offer certifications in multiple building categories. Among these, some of the green building rating schemes are playing a significant role in the building accreditation: BREEAM, LEED, Green Star, SBTool, CASBEE, and DGNB. The first major milestone in the full environmental assessment of buildings was the introduction of BREEAM (Building Research Establishment Environmental Assessment Method) in the UK in 1990. This system, developed and credited by Crawley and Aho (1999), is the most widely used environmental assessment system for buildings in the world. Following BREEAM, the second important international system was LEED (Leadership in Energy and Environmental Design), which came into existence in 1998 as a product of the US Green Building Council. This is a consensus-based building rating system. These pioneering efforts have been followed by several standards, rating systems, and tools that aim at fostering interest in this area of green building among government regulators, building professionals, property appraisers, and consumers. Due to the large number of accreditations used throughout the world, only the most popular systems will be discussed in terms of how the analysis and assessment methodologies are carried out (Crawley and Aho, 1999).

BREEAM was designed to reduce the environmental impact of buildings throughout their lifecycle, praise those buildings that help the environment, and create a well-known environmental label that gives sustainable buildings, products, and supply chains greater value.

BREEAM covers office, eco homes, industrial and retail units, schools, courts, prisons, hospitals, and tailored buildings. It also includes a BREEAM International version, adapting existing schemes to assess buildings worldwide, including the Netherlands and Canada. Main categories of assessment include the following: management, health and wellbeing, energy, transport, water, materials, land use, ecology, pollution, and innovation. The environmental rating methodology adopts an awarding scheme of credit for meeting the criteria under various categories. Environmental categories are weighted by their perceived importance; the cumulative score determines the BREEAM rating: Pass-25%, Good-40%, Very Good-55%, Excellent-70% or Outstanding-85% (BREEAM, 2025).

Presently, LEED is not only the most used environmentally qualified building rating system in the United States, but it is also adopted in different nations, such as LEED Canada, LEED India, LEED México, LEED Brazil, or LEED Emirates – the United Arab Emirates. The LEED, by default, is revised and updated every three to five years (Nag, 2019). In addition, there could be minor changes every year. Relevant evidence of the quantifiable sustainable design measures required for certification and third-party verification is submitted to the U.S. Green Building Council USGBC. Some of the variations of this LEED system include whether the building is new construction, extensive renovations, Core and Shell, Schools, Retail, Data Centers, Warehouses and Distribution Centers, Hotels, and Health care, among others. This technical review was based on a 2025 update on the LEED Version 5 (USGBC, 2025). A holistic approach to building environmental performance deals with specific environmental building-related impacts. Prerequisites and credits are spread over key categories for new buildings constructions. LEED is a widely adopted international green building rating system developed by USGBC (2025). It organises credits across core sustainability categories (e.g., sites, water, energy, materials, indoor environmental quality) and is periodically revised. The key category mappings relevant to the analysis are summarised in Table 1 and discussed in Section 4.1.