DOI: https://doi.org/10.38027/iccaua2023en0054

Environmental labeling of building sustainability: Focus on international certifications

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Abstract
The environmental labelling of sustainable buildings has become a major concern for the architectural design. Numerous building sustainability assessment methods were developed in various countries, namely the British BREEAM, the American LEED, the German DGNB, the French HQE and the United Arab Emirates ESTIDAMA. The present study aims to find the most appropriate approach that suits the Algerian context. A comparative study is conducted using an analytical procedure. The study focuses on the objectives, the evaluation procedures, the assets, and the qualitative assessment indicators for the environmental performance of the buildings. As a result, HQE of France and ESTIDAMA of the United Arab Emirates appeared to be best suited to the Algerian context.
Keywords: Environmental labels; Building; Sustainability; Assessment; BREEAM; LEED; DGNB; HQE; ESTIDAMA.

1. Introduction

Today, most of national sustainable building councils in both developed and developing countries have established their own frameworks, environmental methods, evaluation systems, certification, and labeling for building sustainability (Amen, 2021, Aziz Amen, 2022, Amen et al., 2023). In countries that have not yet developed a suitable national approach, they have been adopting one or more existing systems. This has led to a significant rise in initiatives implemented by research institutions, expert groups, and non-profit organizations since the early 1990s. Numerous of environmental approaches have been adopted worldwide (Amen & Nia, 2020) to incorporate eco-sustainability into existing and proposed buildings, demonstrating the progress made in this area. There have been several approaches to building sustainability around the world, including BREEAM (Building Research Establishment Environmental Assessment Method) in the UK and LEED (Leadership in Energy and Environmental Design) in the US, CASBEE in Japan, DGNB in Germany, Green Star in Australia and South Africa, HQE (High Environmental Quality) in France, MENERGIE in Switzerland, and recently, ESTIDAMA in the UAE and EDAMA in Jordan. In 2017, Kaoula and Bouchair conducted a study that investigated how life cycle analysis can promote sustainable building practices, with a focus on sustainable hotels. They explored the practical implementation and advantages of life cycle analysis in this context. Meanwhile, Grimes et al. conducted a separate study that year, which looked at the sustainability of expansion areas for coastal tourist sites in Algeria. Biodiversity indicators were specifically studied for assessing the sustainability of these areas. Tebbouche Hocine (2010) has studied the impact of environmental quality in schools on the performance of the education system in Algeria. He uses field surveys, questionnaires addressed to students and teachers, and on-site measurements to assess the environmental quality of high schools in Jijel.

2. Presentation

Various environmental strategies have been adopted globally to promote sustainable building practices, considering each region's unique requirements and circumstances (Tebbouche et al, 2017). These factors include climate, culture, geography, available natural resources, socio-economic development, local regulations, and the specific attributes of existing real estate (Bouchair et al., 2013; Bernardi et al., 2017). National Councils for Sustainable Building (NCSB) and the World Green Building Council (WGBC) support these approaches, but their adoption presents challenges both in research and in practice. Scientific research has been initiated with local case studies in several countries aimed at developing approaches to assess the sustainability of buildings in regional contexts, including Jordan, Malaysia, Sri Lanka, Saudi Arabia, India, Iran, Nigeria, Mexico, Portugal, China, Turkey, and Ghana (Castro et al., 2017; Shao et al., 2018; Said and Harputlugil, 2019; Anzagira et al., 2019).
Countries with established or emerging evaluation methods usually have developed economies and real estate markets that are readily accessible. Sustainable building techniques were mostly developed in Europe, Asia, and the Americas. However, other African nations, including Egypt and South Africa, have also created their own sustainable building technologies. Additionally, certain Arab nations have developed particular strategies to fit their different regions. Examples include "ESTIDAMA" in the United Arab Emirates and "EDAMA" in Jordan. Qatar has the "QSAS" (Qatar Sustainability Assessment System), and Lebanon has the "ARZ Building Rating System."

Figure 1. Logos of some building sustainability assessment approaches (Tebbouche et al, 2017).

Literature research on previous studies has allowed us to note the existence of numerous analytical and comparative studies of different methods for assessing the sustainability of buildings. Research work that has been the subject of several scientific publications, such as those developed by (Florez-Perez, 2019; Kulkarni and Pammar, 2019; Liu et al., 2019; Cao ,2022). These studies have analysed and compared some AEDBs in different ways and from different aspects. Our study is distinctive in that it digs into a full and in-depth examination of these methods with the goal of revealing their distinct traits, methods, weighing and rating schemes, similarities and differences, as well as their strengths, weaknesses, and limitations. This study aims to achieve a particular objective, which is to identify the prevalent categories, criteria, and evaluation indicators utilized in existing sustainable building approaches. The intention is to potentially modify and apply them to the Algerian context for the creation of a new approach.

For this study, we chose five strategies that are regarded as some of the most well-known, significant, and cutting-edge approaches globally. These strategies include:

- The British BREEAM as the Anglo-Saxon reference, the oldest and most widespread in the largest number of countries;
- The American LEED as the North American international reference;
- The German DGNB as one of the most demanding approaches;
- The French HQE as a Mediterranean Francophone example;
- ESTIDAMA in the United Arab Emirates, as a pioneer example in the Arab world and the MENA region. A Muslim Arab country in development presenting several similarities with the Algerian case.

2.1. BREEAM in Great Britain

The Building Research Establishment Environmental Assessment Method (BREEAM) was developed by a group of researchers from the Building Research Establishment Ltd. (BRE) in the UK in 1990. It is the oldest and most widely recognized approach in the world due to its flexibility (Shaawat and Jamil, 2014). Its use at the international level is also significant and influential, particularly in the countries of the European Union.

It is a voluntary approach that allows the level of sustainability of buildings to be evaluated based on the choices made during the design phase. It applies to various types of projects and has served as a reference model for the creation of several other methods in other countries. The BREEAM approach has been specifically adapted for projects in Europe and the Persian Gulf (Mattoni, et al, 2018).

Applied to both new construction and existing buildings, major renovations, interior fit-outs, and neighborhood developments, BRE has gradually launched new BREEAM versions for different building sectors, covering today different types of buildings worldwide. These include offices, housing, healthcare facilities, and courts.

The BREEAM evaluation system is based on several criteria. For each category, points are awarded based on the achieved performance. The building may receive additional bonus points in the "innovation" category to improve its final score. These points are then weighted according to the type of project and added up to obtain a final score that defines the overall performance of the building.

Table 1. Weighting of evaluation categories in the BREEAM method for common projects

Nbr.	Criteria	Number of possible credits	Rate (%)
0l	Integrative Process	01 point	01%
02	Location and Transportation	16 points	16%
03	Sustainable Sites	10 points	10%
04	Water Efficiency	11 points	11 %
05	Energy and Atmosphere	33 points	33 %
06	Materials and Resources	13 points	13 %
07	Indoor Environmental quality	16 points	16%
	Total	100 points	100%
	Innovation and design process	6 points	
	Regional priorities	4 points	
	Total possible points	110 points	

Project total: 100 base points, plus 6 possible additional points for innovation in design and 4 additional points for regional priorities.

Data source: BREEAM, 2018

The overall score obtained allows for the classification of the project on a value scale that comprises 5 levels of performance associated with a number of stars ranging from 'Pass' to 'Outstanding'. It is necessary to obtain a minimum of 30% in order to be eligible for BREEAM certification.

2.2. LEED in the United States

LEED (Leadership in Energy and Environmental Design) is the North American environmental approach for evaluating the sustainability of high-performance buildings. It was developed in 1998 by a group of professionals within the U.S. Green Building Council (USGBC) in collaboration with academic experts in the field of sustainable architecture. LEED® is recognized as the voluntary international reference approach for assessing building sustainability, used in over 165 countries and territories in South America, Europe, and Asia, such as Canada, Brazil, Italy, and India, and represents a significant share of construction activity worldwide (Liu et al., 2019).

LEED encourages an integrated design approach, with an evaluation process based on a rating system that awards credits for building sustainability performance (Asdrubali et al., 2015). The building is assigned points based on its sustainability performance, using a checklist of requirements to be met. The LEED method has seen the most significant increase in terms of credits allocated to different categories, moving from 69 points in version V2 to 110 points in version V4. The new "LEED-V4" version, launched in 2013 and updated in 2014 and 2016, has seen some slight changes compared to the 2009 V-3 version, based on environmental requirements and resource management in the United States. This version integrates a new category (Integrated Process "1 point"). It divides the 26 points allocated to the (Ecological Site Development) category into two new categories (Location and Transportation "16 points" and Sustainable Sites "10 points"). It reduces points for energy and materials categories to 33 and 13, respectively, from 35 and 14, respectively, to increase points for water (from 10 to 11 points) and Indoor Environmental Quality (from 15 to 16 points), respectively (USGBC, 2019).

According to the latest version "LEED®-V4," the rating system of the "LEED-V4" version is based on a maximum total of 110 points distributed across 9 criteria, including 7 main ones and two additional ones. A maximum of 100 points can be achieved for the following main criteria: location and transportation, sustainable sites, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality. An additional maximum of 10 bonus points can be awarded to improve the final score, for compliance with two special categories: innovation in design and regional priority for buildings that address local environmental issues. However, a minimum of 40 points should be obtained to ensure basic evaluation. Table 2 below shows the maximum number of points that can be awarded for each LEED category (Doan et al., 2017; USGBC, 2019).

Table 2. The weighting of evaluation criteria in the LEED Version 4 method

Nbr.	Criteria	Number of possible credits	Rate (%)
0l	Integrative Process	01 point	01%
02	Location and Transportation	16 points	16%
03	Sustainable Sites	10 points	10%
04	Water Efficiency	11 points	11 %
05	Energy and Atmosphere	33 points	33 %
06	Materials and Resources	13 points	13 %
07	Indoor Environmental quality	16 points	16%
	Total	100 points	100%
	Innovation and design process	6 points	
	Regional priorities	4 points	
	Total possible points	110 points	

Project total: 100 base points, plus 6 possible additional points for innovation in design and 4 additional points for regional priorities.

Data source: USGBC, 2019

In the LEED evaluation system, a building must meet prerequisite requirements (mandatory practices) and achieve a minimum of 40 points in the scoring system in order to be registered for LEED certification. Points are awarded for various evaluation criteria. The total sum of points obtained determines the LEED certification level according to a scale of four possible certification levels: LEED Certified requires (40-49 points), LEED Silver requires (50-59 points), LEED Gold requires (60-79 points), and LEED Platinum requires (80-110 points) (USGBC, 2019).

2.3. DGNB in Germany

The Deutsche Gesellschaft für Nachhaltiges Bauen (DGNB), which is the German approach for promoting sustainability in building, was established in 2009 through a collaboration between the German Sustainable Building Council and the Federal Ministry of Transport, Building and Urban Development (Bundesministerium für Verkehr, Bau und Stadtentwicklung). Regarded as one of the most extensive sustainability evaluation frameworks globally, it was published in 2011. It is a voluntary method based on a balanced approach to relevant environmental, economic, socio-cultural, and technical aspects of sustainability (Lee et al., 2015). It is essentially based on German technical standards and guidelines. The DGNB method is intended to be used both as a motivation and planning tool, to enable the construction and management of environmentally friendly and energy-efficient buildings that contribute to preserving natural resources and ensuring a high level of well-being for their users (DNGB, 2019).

Since the publication of the first version in 2008 entitled "New Construction of Office and Administrative Buildings, Version 2008", the DGNB approach has undergone annual updates with the publication of several versions including those of 2009, 2010, 2011, 2013, 2015, 2017, and finally the latest version of 2018. These different versions have enabled the creation of numerous reference frameworks to certify a wide range of building typologies in Germany and internationally, such as office and administrative buildings, commercial buildings, residential buildings, industrial buildings, educational establishments, hospitals, hotels, residential neighborhoods, and urban neighborhoods.

In 2010, an international version of the DGNB was launched to be applied globally with adaptations to the different uses of a building and specific requirements in each country. Thanks to its flexibility, this version has been used in several countries, including Austria, Switzerland, Bulgaria, Slovenia, and China.

The evaluation system of the DGNB method in its 2018 version is based on 37 criteria grouped into 6 categories. It is therefore much lighter compared to the versions of LEED (52 criteria) or BREEAM (59 criteria). In addition to the three classic categories of sustainability: ecology, economy, and social aspects, two additional cross-cutting categories concern technical and process aspects. The site is evaluated in an additional category (Bernardi et al., 2017; Green Soluce, 2020).

To ensure the flexibility of the evaluation, sustainability themes are divided into categories (groups of criteria). In each category, there is a set of criteria and their associated indicators that are evaluated qualitatively or quantitatively to obtain points on the checklist. Each criterion has a value of ten points (Møller et al., 2018).

The DGNB evaluation system is based on a weighted list of categories, criteria, and performance indicators, which allow points to be obtained on the checklist. In the DGNB method evaluation system, each criterion can receive a maximum of 10 points, and the categories "Environmental Quality," "Socio-Cultural and Functional Quality," "Economic Quality," and "Technical Quality" have a weighting of 22.5% each. In addition, process quality is taken into account with a total evaluation of 10%. In addition to the qualities mentioned above, construction can receive additional points (2 weights) in the "Location Quality" category to increase the final score. However, this last aspect is more or less taken into account and depends on the type of project, building, or urban neighborhood; it does not influence the rating and determination of the certificate level (Møller et al., 2018).

Table 3. DGNB Category Weights and Credits

Nbr.	Categories	Rate (%)
0l	Environmental Quality	22.5 %
02	Socio-cultural and functional quality	22.5 %
03	Ecological quality	22.5 %
04	Technical Quality	22.5 %
05	Process Quality (Management)	10 %
	Total	100%
	Quality of the location	The evaluation of this criterion has no influence on the performance level of the building.

Data source: DGNB, 2019

The maximum percentage that can be achieved by a project is 100%. The sum of points obtained in all categories determines the final score of the building. The DGNB evaluation system has four levels of certification based on the total performance index achieved. For existing buildings, a minimum performance index of 35% is required for certification. If the total performance index is between 35% and 49.9%, a "DGNB bronze" certificate is awarded. If the total performance index is between 50% and 64.9%, the building will receive a "DGNB silver" certificate. To obtain a "DGNB gold" certificate, the project must achieve a total performance index between 65% and 79.9%. With a performance index of 80% or higher, the building is awarded the highest certificate, "DGNB platinum" (DGNB, 2019).

2.4. HQE in France

The High Environmental Quality (HQE) approach is the French application of sustainable development to the building sector. Launched in 1996 and led by the Association for High Environmental Quality (HQE Association), which brings together all construction professionals, this voluntary approach promotes the consideration of environmental, economic, and societal aspects throughout the building's life cycle (Alliance HQE, 2020). It allows project owners to make the best conceptual choices for sustainable development at all stages of the building's life cycle (manufacturing, construction, use, maintenance, conversion, and end of life). It thus serves a triple purpose: achieving a certain level of environmental quality in the project, promoting the quality of life for users, and ensuring cost-effectiveness through a comprehensive construction project approach.

In order to better meet new environmental requirements and keep up with social and technological development, several HQE™ reference frameworks have been developed and are periodically updated. These frameworks have allowed the HQE approach to be applied to various types of residential, commercial, administrative, or tertiary real estate in all sectors of activity, whether they are under construction, renovation, or already in operation. Such frameworks include "NF-Individual House" (New construction or renovation, 1999), "NF-Habitat & Environment" (2003), "NF-Housing" (2004), "NF-Tertiary Buildings" (2005), "NF-Tertiary Buildings", HQE® Construction (New construction and renovation in 2009 and in operation in 2011), "NF-Sports Facilities," and "NF-Development," HQE™.

The French HQE method evaluation system divides evaluation criteria into two distinct categories: Project Environmental Management System and Building Environmental Performance. It includes 14 categories (referred to as targets) divided into 49 performance indicators (referred to as sub-targets). The 14 targets are divided into four major themes: eco-construction, eco-management, health, and comfort. The latter two criteria specifically reflect this approach's desire to prioritize users' quality of life (Cordero et al., 2020).

The evaluation of the requirements contained in the targets and sub-targets to define the building's environmental quality is of two types: quantitative or qualitative. The certificate shows the level achieved on each target. To

analyse a building's performance, the calculated indicator values are compared with the constraints imposed on the building and compared with reference values (HQEGBC, 2015a).
Three levels of performance can be achieved for each target:
• Base Level (B): level corresponding to the minimum acceptable performance for an HQE® operation. This may correspond to regulations if they are demanding enough regarding the structure's performance.
• Performant Level (P): level corresponding to good practices.
• Very Performant Level (VP): level calibrated with respect to the maximum performances observed in high environmental quality operations.
The "Base" level is awarded when all of a target's minimum requirements are met, while the Performant and Very Performant levels are obtained based on a given percentage of points per target, allowing great flexibility in choosing priorities.
For a building to be awarded the "NF Tertiary Buildings - HQE® Approach" certification, it must have an EHQ profile justifying at least a "Very Performant" level for about 3 environmental targets, a "Performant" level for about 4 environmental targets, and a "Base" level (regulatory level) for the remaining 7 targets. If these requirements are met, the building can be certified as HQE. This scoring system does not weigh each category by a weighting factor, as it is considered that they have the same importance in the overall evaluation framework (Bernardi et al., 2017; Cordero et al., 2020).

Table 4. Weighting of the HQE approach categories.

Nbr.	Categories	Number of targets	Rate (%)
0l	Site	01 of 14 targets (Harmonious relationship between building and neighbourhood)	7 %
02	Management	02 out of 14 targets (Maintenance management and low impact construction)	14 %
03	Energy	01 of 14 targets (Energy management)	7 %
04	Water	02 of 14 targets (Water management and sanitary water quality)	14 %
05	Materials	01 of 14 targets (Choice of construction processes and products)	7 %
06	Indoor Environmental Quality	06 targets out of 14 (hydrothermal comfort, acoustic comfort, visual comfort, olfactory comfort, sanitary conditions of spaces, indoor air quality)	44 %
07	Waste	01 of 14 targets (Activity waste management)	7 %
	Total		100%

Data source: (HQEGBC, 2015b)

For the international HQE version, levels are associated with the four major themes. Building performance is expressed in terms of the number of stars, and each theme is evaluated on a scale of 0 to 4 stars based on the number of points accumulated for each target within the themes. Five levels of classification are possible based on the overall score obtained from the sum of the stars obtained for each of the 4 themes (4 stars per theme, 16 stars maximum).

2.5. ESTIDAMA in the United Arab Emirates

"ESTIDAMA," an Arabic word for "sustainability," is the first environmental approach designed to assess the sustainability of buildings in an Arab country in the Middle East. As a part of the "Plan Abu Dhabi 2030" project, which encouraged cutting-edge environmental criteria for building, the United Arab Emirates established ESTIDAMA in May 2008. ESTIDAMA was created to solve the difficulties of developing, designing, building, and operating sustainable structures while taking into account the region's challenging climatic circumstances and local cultural traditions and social values. The enhancement of citizens' quality of life is its ultimate objective. ESTIDAMA aims to establish guidelines, regulations, and requirements for assessing the performance of sustainability practices in the construction and urban planning sector in Abu Dhabi (AUPC, 2010).
The ESTIDAMA approach was designed to evolve continuously. Version 1.0 of the ESTIDAMA sustainability assessment system, the "Pearl Rating System (PRS)," which promotes the development of sustainable buildings, was created in April 2010 and updated in December 2016. Several ESTIDAMA benchmarks have been developed to apply to a wide range of building typologies located in the Emirate of Abu Dhabi (AUPC, 2010).
The "Pearl Rating System (PRS)," launched in 2010, comprises a set of performance requirements distributed across eight categories and a total of 86 criteria. These categories include the integrated development process, natural systems, quality of spaces (indoors and outdoors), water, energy, materials and waste, as well as innovative practices (AUPC, 2010).

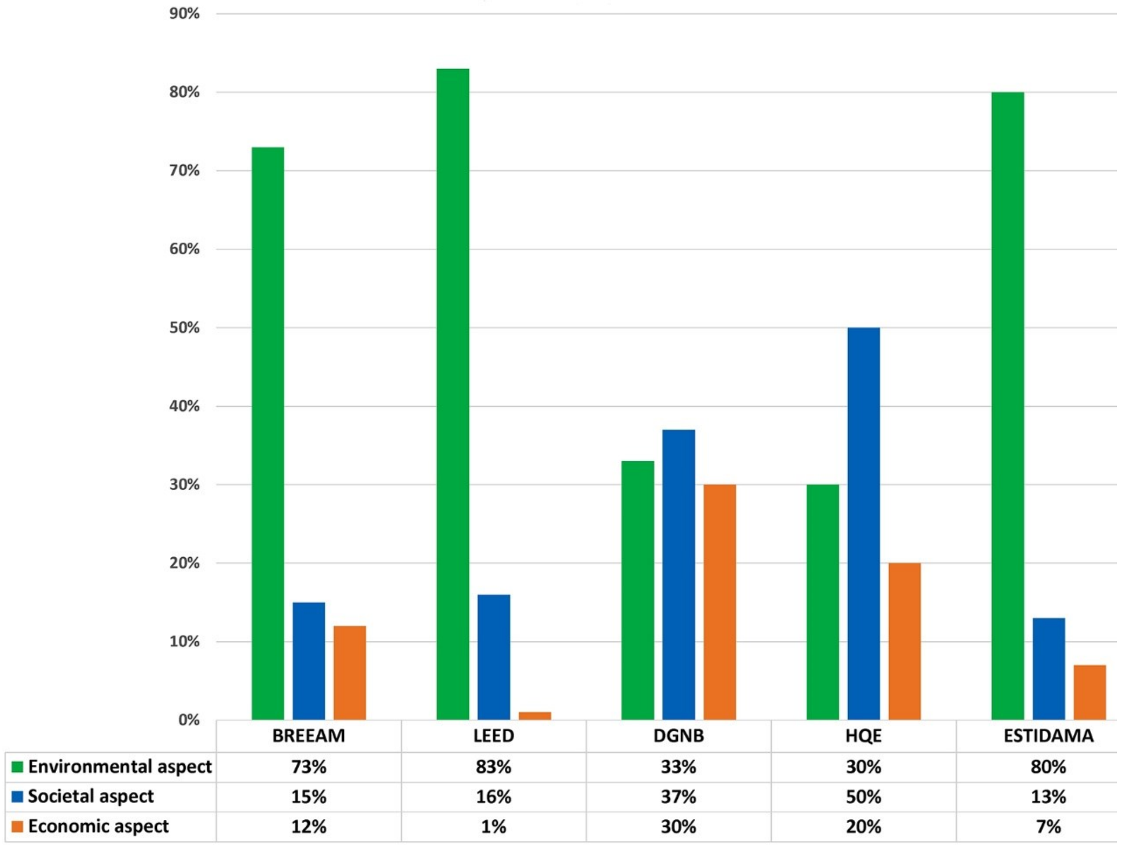
In each category, there are both mandatory and optional credits. Points are awarded for each optional credit obtained. A total of 177 points are available. The "Quality of Habitable Spaces," "Water," and "Energy" categories are the most weighted. A maximum of 3 additional bonus points can be earned for compliance with the special category: "Innovative Practice."

Table 5. Weighting of the categories of the ESTIDAMA approach.

Nbr.	Categories	Number of possible credits	Rate (%)
0l	Integrated development process	13	7 %
02	Natural systems	12	7 %
03	Habitable building : Exterior	14	8 %
04	Habitable building: Interior	23	13 %
05	Precious water	43	24 %
06	Energy resources	44	25 %
07	Materials management	28	16 %
	Total	177	100%
	Innovative practice	03 points awarded as bonus credits	

Data source: AUPC, 2010

Each category is given a weight, and the results for each category are added up to create the total score. The building is then assigned one of five certification levels, signified by pearls and ranging from one to five, based on this score. Any project that meets the requirements for prerequisite credits is awarded a "One Pearl" certification level. To achieve a higher Pearl level, all mandatory conditions must be met and a minimum number of optional



credit points must be reached. Table 5. Pearl Rating System is currently mandatory only for the Emirate of Abu Dhabi, while in the rest of the Emirates, it is applied voluntarily (Khogali, 2016).

Unlike previous methods, ESTIDAMA® only has a local influence, mainly due to the factors analysed in this method, which are determined by weather conditions and resource management in this region of the world."

3. Comparative study

It is quite clear today that the weighting of evaluation criteria in different approaches to building sustainability cannot be generalized on a global scale, as they cannot be suitable for different contexts. However, despite their distinctive characteristics, building sustainability assessment systems could be comparable from one country to another. In this context, several comparative studies between different methods have been the subject of scientific articles published by researchers for some time (Orova and Reith, 2019). These studies have highlighted the complementary aspects, similarities, and differences between the different systems, as well as their strengths and weaknesses. Unlike these previous studies, our present study consists of conducting a thorough comparison between the five approaches already analysed, to highlight the differences in terms of the importance and distribution of credits attributed to different themes, criteria, and evaluation indicators, based on their most recent versions.

3.1. Comparison by pillar

We begin our first part with a comparative study to identify the importance given by each of the five approaches to the three main pillars of sustainability, namely: the environmental, social, and economic aspects.

3.1.1. The Environmental Dimension

Initial findings indicate that all examined approaches attach paramount importance to the environmental dimension, which includes criteria related to site use, transportation, energy and water management, waste, pollution, and material selection. Figure 2 above clearly demonstrates that BREEAM, LEED, and ESTIDAMA approaches are overly focused on environmental sustainability, with each assigning more than 70% weight to the environmental dimension. In contrast, DGNB and HQE allocate a little over 30% weight to environmental aspects.

3.1.2. The Societal Dimension

Although all methods address social sustainability criteria, which primarily integrate requirements for accessibility, indoor environmental quality, user comfort, health and safety, and building safety and security, the societal dimension ranks second in terms of importance. The French HQE approach assigns 50% weight to this dimension, while the German DGNB allocates 37% of credits to social aspects. The other approaches, BREEAM, LEED, and ESTIDAMA, have an average weight of around 15% of the total credits. It is worth noting that cultural aspects are almost neglected in most of the evaluated approaches, with this aspect often integrated into the societal dimension, such as in the DGNB approach, where sociocultural and functional criteria are taken into account under a single category, weighted equally to the other categories.

3.1.3. The Economic Dimension

Except for DGNB, which separately evaluates the economic dimension with a weight of 30% of the total credits, economic issues, including building management, flexibility and adaptability, life cycle cost, and occupant productivity development, are largely underrepresented in the different sustainability evaluation approaches compared to environmental and societal aspects. In HQE, BREEAM, and ESTIDAMA, 20%, 12%, and 7% of credits respectively are reserved for the economic dimension, while the American LEED approach assigns only 1% weight to the economic dimension. It should be noted that there is a direct correlation between the economic aspects of sustainability, which are not explicitly considered in a specific category, and the environmental aspects, where some criteria such as reducing resource consumption (energy, water, and materials) have an implicit impact on the economic dimension and generate significant direct financial benefits during the operational phase. Finally, it should be noted that the BREEAM, LEED, and ESTIDAMA approaches include additional subcategories for innovation, in which bonus points are awarded when the building achieves exceptional or innovative performance. There is also no consideration given to the local legislative, regulatory, and normative context as a sustainability requirement.

It is clear from this analysis that there are numerous categories of evaluation criteria that have the same meaning but are not defined in the same way and are referred to differently in the different approaches, making it difficult to carry out a systematic and precise comparison of the categories due to the inconsistency of evaluation criteria and terminologies used.

3.2. Criterion Comparison:

To facilitate an objective comparative study of the main categories of sustainability evaluation criteria for buildings among the five approaches, the names of certain similar criterion categories with different denominations have been adjusted and grouped into homogeneous categories, and certain credits have been moved from one category to another to make the five methods easily comparable. In total, eight common criterion categories were identified and selected for this comparative study, namely: Site, Energy and Emissions, Water, Indoor Environmental Quality (IEQ), Materials, Waste and Pollution, and Management. Thus, after calculating the weighting of points for each category against the total available points in the same approach, we obtained the following results:

Table 6. Comparison of the importance of assessment criteria categories in BREEAM, LEED, DGNB, HQE and ESTIDAMA

N°	Categories	BREEAM	LEED	DGNB	HQE	ESTIDAMA
0l	Site	18 %	26 %	09 %	07 %	11 %
02	Energy and Emissions	19 %	33 %	12 %	07 %	25 %
03	Water	06 %	11 %	07.5 %	14 %	24 %
04	Indoor Environmental Quality (IEQ)	15 %	16 %	22.5 %	44 %	13 %
05	Materials	12.5 %	13 %	10.5 %	07 %	16 %
06	Waste and Pollution	17.5 %	0 %	06 %	07 %	04 %
07	Management	12 %	01 %	32.5 %	14 %	07 %
	Total	100 %	100 %	100 %	100 %	100%

The importance assigned to the categories of criteria represented in Table 6 above was determined based on the number of credits and the number of evaluation criteria included in each category. A first reading of the results of the comparative study informs us that the importance given by the five environmental approaches to building sustainability (AEDB) analysed to the seven categories of criteria selected for the analysis is highly variable and differs from one approach to another.

3.2.1. The Site

The choice of the location of the building is taken into account in the evaluation of the building's sustainability by all the analysed AEDBs. The evaluation criteria for this category mainly concern the rational use of land, their protection and enhancement, and the promotion of sustainable modes of transportation by offering advantages to pedestrians and cyclists with better access to public transportation. It is clear from Figure 3 below that the American LEED, with a rate of 26%, places the greatest importance on site sustainability, followed by BREEAM with a weighting of 18% of all credits. Meanwhile, this rate is only 11%, 9%, and 7% in the other ESTIDAMA, DGNB, and HQE approaches, respectively. The issue of preserving natural resources, particularly land, in the United States, has led to giving the greatest importance to site selection compared to other AEDB.

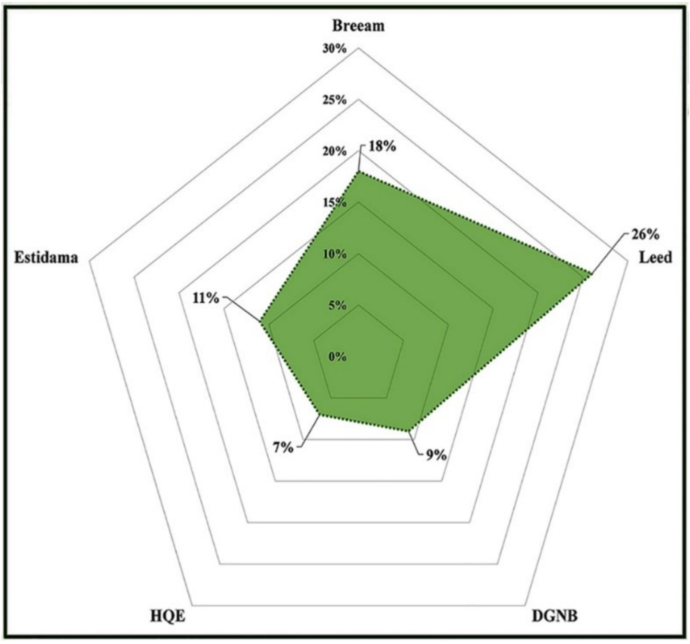


Figure 3. Comparison of site significance
in: BREEAM, LEED, DGNB, HQE and ESTIDAMA (Developed by Authors)

3.2.2 Energy and Emissions

In order to reduce consumption and adopt renewable energy sources, energy performance is a fundamental category in all Sustainable Building Assessment Methods (SBAM). The importance given to this issue, associated with Greenhouse Gas (GHG) emissions, varies but generally represents the highest level of importance in the evaluation of building sustainability due to the high energy demands in the construction sector in most countries and its impact on the environment. Figure 4 below shows that this category occupies the first position in terms of importance with rates of 33%, 25%, and 19% respectively in LEED, ESTIDAMA, and BREEAM. In contrast, it is ranked third in the two other approaches, DGNB and HQE, with respective rates of 12% and 7%.

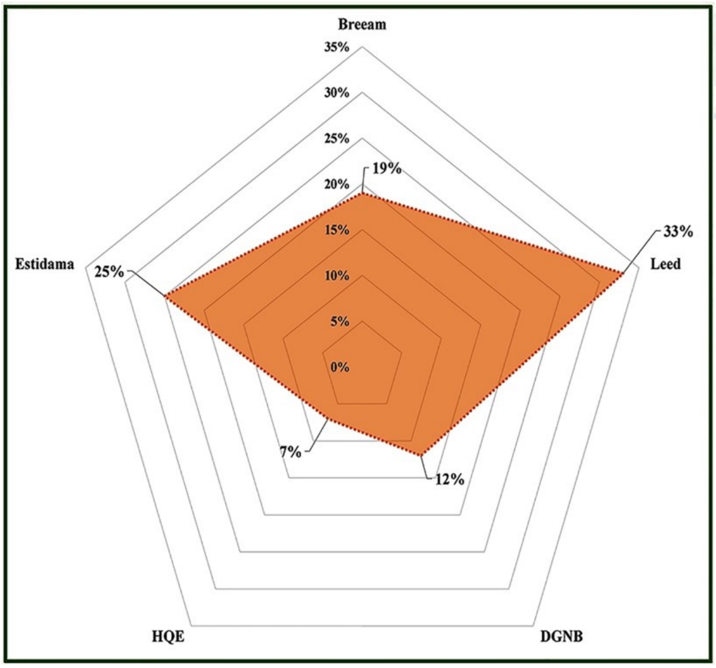


Figure 4. Comparison of the importance of energy in: BREEAM, LEED, DGNB, HQE and ESTIDAMA (Developed by Authors**)**

3.2.3. Water

The sustainable management of water in buildings is integrated into all existing sustainable building assessment approaches. The importance given to the water category varies depending on several factors, including climate conditions and sustainability objectives.

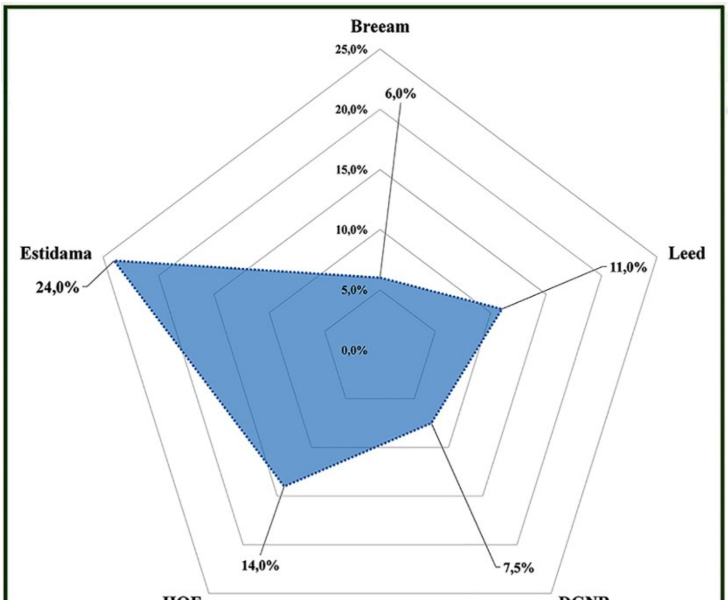


Figure 5. Comparison of the importance of water in: BREEAM, LEED, DGNB, HQE and ESTIDAMA (Developed by Authors)

Among all other approaches, ESTIDAMA provides the highest importance to water with 43 credits out of a total of 177 points, representing a rate of 24%. This is due to infrequent precipitation and scarcity of potable water resources in the United Arab Emirates and the Gulf region in general. According to Figure 5 below, HQE attributes the second most important rate of 14% to water in the overall score. Although water management is also evaluated under other categories, it remains the least considered by the three other approaches, LEED, DGNB, and BREEAM, which assign significantly lower rates of 11%, 7.5%, and 6%, respectively.

3.2.4. Indoor Environmental Quality (IEQ)

The category of criteria "Indoor Environmental Quality (IEQ)," as a fundamental parameter of the societal dimension for the evaluation of building sustainability, is included in all analyzed Sustainable Building Assessment Methods (SBAMs). The objective of this category of criteria is to offer occupants healthy, comfortable, and secure indoor spaces. The highest importance for this category is observed in the French HQE approach, with a weighting of 44%. DGNB ranks second with an estimated consideration of 22.5%. For the remaining three evaluation approaches, LEED, BREEAM, and ESTIDAMA, the importance assigned is almost the same, with percentages of 16%, 15%, and 13% respectively.

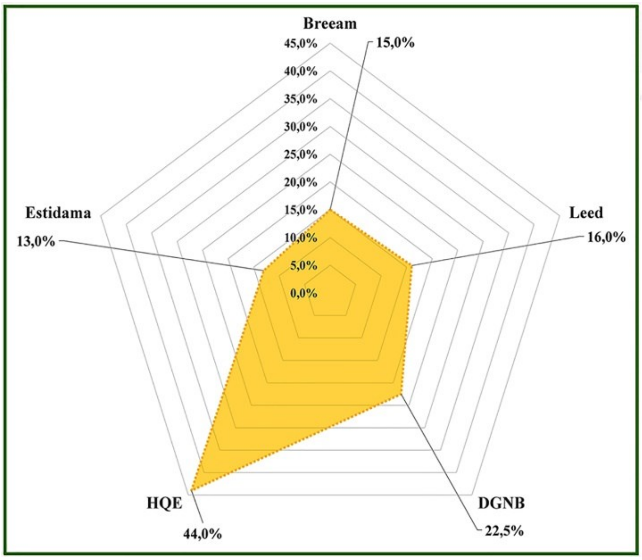


Figure 6. Comparison of the importance of EQI in: BREEAM, LEED, DGNB, HQE and ESTIDAMA (Developed by Authors)

3.2.5. Materials

The "Materials" category is another factor in evaluating the sustainability of buildings that is found in all of the studied AEDBs. The consideration given to this environmental factor remains relatively low compared to the previous categories.

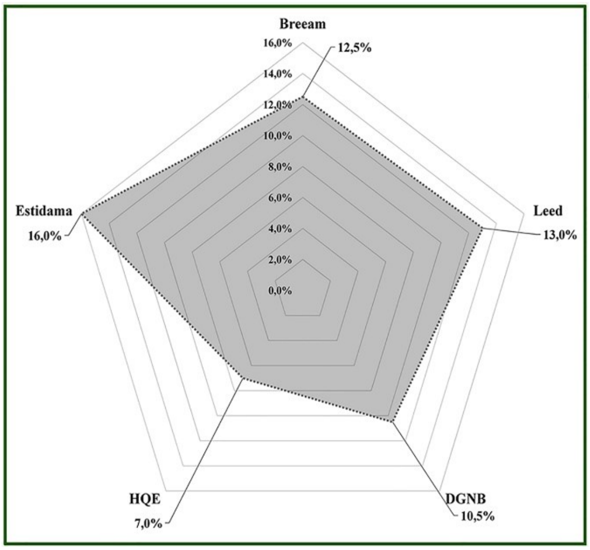


Figure 7. Comparison of the importance of materials in: BREEAM, LEED, DGNB, HQE and ESTIDAMA (Developed by Authors)

Reading the figure below allows us to see that the importance of this category varies from one approach to another, ranging from a minimum of 7% for HQE to a maximum of 16% in ESTIDAMA. While LEED, BREEM, and DGNB all assign almost equal importance to the use of construction materials, with values of 13%, 12.5%, and 10.50%, respectively.

3.2.6. Waste and Pollution

The "waste and pollution" criterion category is not satisfactorily addressed in the majority of the studied AEDBs, despite their dangerous impact on human health and environmental pollution. This criterion category aims to improve the management of construction and operation waste, including their collection, sorting, treatment, reuse, or recycling. Figure 8 below shows that the British BREEAM approach gives it the highest consideration with a percentage of 18%. HQE and DGNB assign very low rates of 7% and 6% respectively. In the ESTIDAMA approach, waste management is included in the "material management" category with a rate of only 4%. Meanwhile, the American LEED approach does not give any credit to this category.

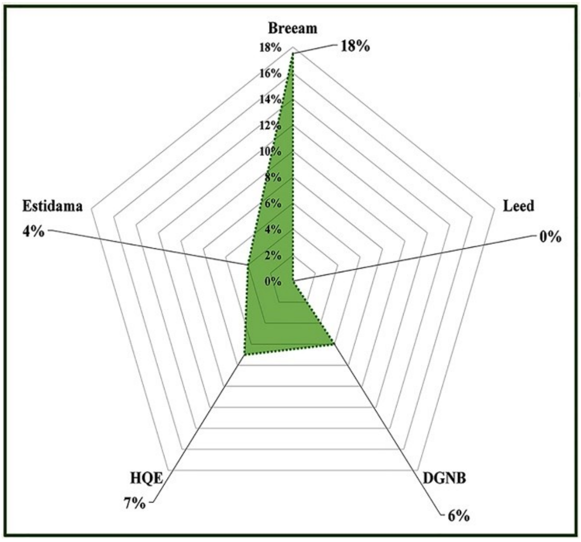


Figure 8. Comparison of the importance of waste and pollution
in: BREEAM, LEED, DGNB, HQE and ESTIDAMA (Developed by Authors)

3.2.7. Management

Also known as "Operations and Maintenance" in some approaches, this category of criteria deals with how buildings should be sustainably operated and maintained throughout their lifecycle, from the conceptual stage of the project to the operation of the building. As a result, it has the greatest impact on the economic performance of the building.

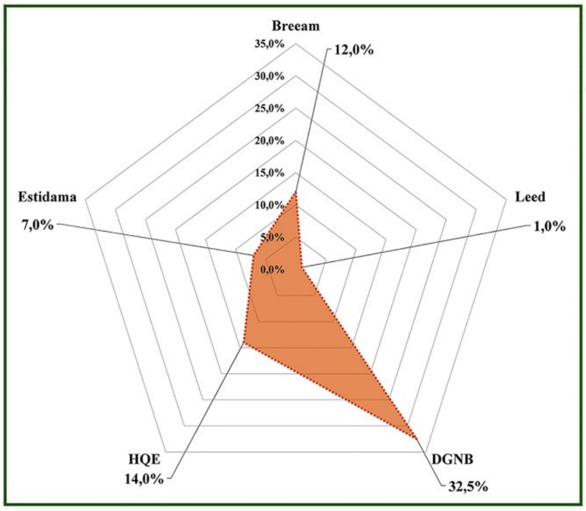


Figure 9. Comparison of the importance of Management
in: BREEAM, LEED, DGNB, HQE and ESTIDAMA (Developed by Authors)

It is clear from the figure below that DGNB gives the greatest consideration to this category of criteria, with a percentage of 32.5%. HQE, BREEAM, and ESTIDAMA assign relatively low rates of 14%, 12%, and 7%, respectively. Once again, the American approach LEED assigns the lowest weight to this category of criteria, with an almost negligible rate of only 1%.

Finally, it is important to note that in the latest versions of some of the assessed Building Environmental Assessment Methods (BEAMs), such as BREEAM, LEED, and ESTIDAMA, there is an additional category of criteria related to innovative practices concerning the use of advanced technologies and innovation in design. Although this category of criteria effectively contributes to improving the sustainability performance of the project, it is optionally integrated into the evaluation system, where few credits are allocated to it as a bonus and it is not supported in the building's classification.

4. Analytical Study

The in-depth and cross-referenced analytical study we conducted on the five approaches presented in this chapter allowed us to identify numerous similarities and differences between them. Among the most important converging points, we can cite the following common characteristics:

- **Contextual:** Contextualization is the main common characteristic of these approaches. They are developed based on the local context in which they are applied. A sustainable building for one region may not be sustainable for another.
- **Multidimensional and systemic:** These are second-generation global building sustainability assessment methods that simultaneously cover all attributes related to the three fundamental dimensions of sustainable development: environmental, economic, cultural, and societal in a holistic manner.
- **Multicriteria:** They use various evaluation criteria, the main ones being management, site, energy, water, indoor environmental quality, materials, waste, pollution, and innovative practices.
- **Flexible:** Despite their contextual nature, the majority of the approaches studied are characterized by flexibility that allows them to be applied to different types of buildings, both existing and future. They are developed in a flexible manner to adapt to different contexts in different places and to expand internationally.
- **Evolving:** All the approaches studied evolve and continuously improve with updates to their evaluation systems. This evolution is mainly due to the existence of several reference frameworks with updated versions to better adapt to economic, social, and technological development, as well as regulatory and normative changes.
- **Voluntary and non-mandatory:** Although the majority of the sustainable building evaluation approaches studied are voluntary and optional, they continue to be recognized and their adoption is increasingly becoming more widespread thanks to economic incentives.
- **Evaluation system based on rating:** Another similarity that characterizes these environmental approaches is the use of rating evaluation methods (numerical values) in the form of "credits". Points are awarded based on performance achieved in terms of environmental, socio-cultural, and economic requirements. The total sum of accumulated credits allows for the classification of the building's performance level on an appropriate scale.
- **They propose a whole range of reference frameworks, certificates, and labels** that differ from each other depending on the sector of activity concerned or the targeted performance parameter.
- Regarding the differences between the five approaches studied, we have identified several points of divergence, the most important of which are:
    - The structure of their evaluation systems and the certification process;
    - The number of performance criteria and indicators taken into account in the evaluation;
    - The weighting given to the different evaluation criteria;
    - Evaluations according to different ranking scales;
    - The number of required prerequisite credits for the minimum performance level.

5. Discussion of the Results

The concept of sustainability in the construction industry has gained momentum over the past two decades and has now become a global trend that offers alternative solutions to reduce the negative impacts of buildings on the environment, economy, comfort, and well-being of occupants. This awareness of the need to build and operate buildings sustainably is demonstrated by the rapid development of multiple environmental approaches for assessing the level of building sustainability that have emerged worldwide and are constantly evolving. Approaches that depend on geographic and climatic context, sociocultural specificities, regulatory and normative requirements, as well as local economic and strategic priorities in each country, demonstrate a general willingness to incorporate the construction industry into a sustainable development logic.

This study clearly shows that the different approaches studied have many similarities in terms of objectives and evaluation processes based on categories of criteria and performance indicators that resemble each other and interact with each other. The main categories common to all approaches are: "Site, Energy, Water, Indoor Environmental Quality and Materials, Waste and Pollution, and Management".

The points of divergence between the different environmental approaches for building sustainability mainly concern the nature and number of criteria considered by their evaluation systems, as well as the degree of relevance they give to certain indicators compared to others. The study showed that the highest priority differs between the five approaches studied. LEED, ESTIDAMA, and BREEAM are much more focused on energy performance by giving the highest consideration to the "Energy" category with respective rates of 33%, 25%, and 19%. For DGNB, the highest importance is attributed to the "Management" category with a rate of 32.5%, while Indoor Environmental Quality is the primary concern for the French HQE approach where almost half of the 14 targets aim at the comfort and health of occupants, representing a percentage of 44%.

6. Conclusion

The comparative study conducted on the five environmental approaches for building sustainability - BREEAM, LEED, DGNB, HQE, and ESTIDAMA – reveals that they are highly diverse and follow different directions based on their genesis and the environmental, economic, regulatory, and sociocultural specificities of the place where they are applied. Therefore, each country has been forced to develop its own approach to sustainability in construction based on its environmental priorities, economic capabilities and technological development, physical characteristics of its territory, available resources, and sociocultural practices of its population. As clearly emerges from the discussions, a rating system that has been developed for a specific region may not be effective for another region, and it may provide inaccurate results.

In Algeria, the absence of an official environmental assessment approach for building sustainability necessitates the establishment of an evaluation system aligned with the country's environmental, economic, and sociocultural context. The diverse Algerian territory and its unique characteristics make the adoption of existing international approaches unsuitable as they often overlook national and regional specificities. Nevertheless, in the current period, the HQE certification from France and ESTIDAMA from the United Arab Emirates could be regarded as partially fitting choices for the Algerian context. Nonetheless, it remains crucial to develop a customized approach that specifically caters to Algeria's needs.

Acknowledgements

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of Interests

The authors declare no conflict of interest.

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