Journal of Building Engineering 96 (2024) 110401

Contents lists available at ScienceDirect

Journal of Building Engineering

journal homepage: www.elsevier.com/locate/jobe

Comparative analysis of sustainable building certification processes

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ARTICLE INFO

Keywords:
Building certification system
Portugal
Sustainable construction
Sustainability certification guideline
Systematic literature review

1. Introduction

In the past, the environment was considered an apparently inexhaustible source of natural resources, which led our species to use them in an unsustainable way for several decades. It was only from the 1970s onwards that environmental problems began to become important issues in our daily lives. The development of society in terms of population and quality of life has resulted in an uncontrolled increase in the consumption of resources and materials available in nature, and the concern for natural resources and their use by humans, especially in the construction industry, has growing exponentially over time [1].

The construction sector is one of the main contributors to the environmental impact on the planet, during the construction process, use phase and subsequently, demolition of the building [2,3]. Some of the impacts for which this sector is responsible include energy consumption, emission of greenhouse gases (GHG) into the atmosphere, waste production and use of non-renewable natural resources in an unsustainable way [4].

Regarding the construction panorama, the search for quality and optimization of construction processes in this sector has led to a greater incidence of demand for sustainable methods. This paradigm shift is driven by a growing reflection of companies attempting to mitigate the environmental, social, and economic impact of this sector in order to improve traditional methods that are still used on a large scale [5].

The implementation of sustainability standards in Portugal can be traced back to the 1990s, in response to these growing needs. The ISO 9000 group of standards serves as the reference point for the certification of Quality Management Systems (QMS). ISO 9000 is the vocabulary standard for QMS, ISO 9001 is the standard for the requirements of QMS, and ISO 9004 is the standard for guidelines for improving the performance of QMS [6–8]. The OHSAS 18001 certification for construction companies was extended by an international consortium of standardisation and certification bodies and transposed at national level through standard NP 4397 in 2008 [9].

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https://doi.org/10.1016/j.jobe.2024.110401
Received 25 May 2024; Received in revised form 19 July 2024; Accepted 8 August 2024
Available online 10 August 2024

Since September 2021, the reference standard for the certification of these Occupational Health and Safety Systems has been ISO 45001:2019 [10], which describes the requirements for their implementation. It is a standard that enhances the certification of an Integrated Quality, Safety and Environmental Management System, corresponding to Quality Management certification (NP EN ISO 9001:2015) [7] and Environmental Management certification (NP EN ISO 14001:2015) [11], where one of the dimensions of sustainability converges. Another crucial aspect of sustainability is the CE marking of construction products, which is currently overseen by European Regulation 305/2011 of March 9, 2011 [12]. This regulation requires that construction products meet technical standards, a responsibility that falls upon the manufacturer. These standards and regulations are particularly beneficial for the construction industry, as they help to improve its quality, safety, and efficiency holistically [13]. Furthermore, they are applicable to a range of societal activities, including the certification of sustainable buildings [14].

This type of certification is one of the main initiatives to promote sustainability in civil construction, which consists of evaluating the environmental performance of buildings, through various factors such as energy consumption, use of sustainable materials, energy management, waste management, water efficiency, indoor air quality, among others [15]. Several methodologies for assessing the sustainability of buildings are currently developed or in the development phase, with emphasis on the Building Research Establishment Environmental Assessment Method (BREEAM) [16], Leadership in Energy and Environmental Design (LEED) [17], WELL Building Standard (WELL) [18], and Leading the Environment for sustainable construction (LiderA) [19]. These certification systems are essential for evaluating the environmental performance of buildings by assigning a rating that may vary according to the level of environmental performance achieved.

The geographical scope of this study encompasses Portugal, a state in Southern Europe. Its territory is divided into a continental part situated on the south-western tip of the Iberian Peninsula and two autonomous regions: the archipelagos of Madeira and the Azores, located in the Atlantic Ocean.

In order to implement certification systems successfully, it is essential that an analysis of the territory be carried out. Such an analysis will enable the identification of factors that facilitate the certification of buildings, including.

- Climate – Due to the geographical location of Portugal in a region of the globe that is particularly susceptible to meteorological phenomena, there exists a unique opportunity for the country to capitalise on the potential of renewable energy sources. A total of 61 % of the electrical energy consumed in Portugal is derived from renewable sources, amounting to approximately 31.2 TWh, which represents the highest value recorded in Portuguese territory [20].
- Water efficiency – The climate of mainland Portugal exhibits considerable variability, from north to south. However, the occurrence of high levels of drought in some regions, particularly in the south, necessitates the judicious utilisation of this resource [21].
- Sustainable materials – Although there are several sustainable materials used in the country, cork remains the most relevant, with Portugal being the largest exporter in the world [22]. It is also used for acoustic insulation purposes in buildings [22,23].

In the context of Portugal, a study on the implementation of sustainability certifications in buildings is of particular relevance due to the specific environmental challenges that the country faces. These include water scarcity and the necessity to enhance energy efficiency at the national level [24]. Furthermore, Portugal's national and European commitments to reducing carbon emissions and promoting sustainability make the implementation of these certifications an additional benefit, leading to the creation of new strategies by public policies, subsequently leading to an improvement in well-being of occupants and an increase in the economic value of properties [25,26].

This article aims to: i) identify and succinctly compare the main sustainable certifications in buildings adopted in Portugal; ii) present guidelines designed to help clients select the sustainable building certification system that best suits the objectives of each project.

This analysis is of fundamental importance, as it not only makes the selection simpler and faster, but also helps to solidify the idea of a building that is more stable at an economic, environmental, and social level. It is capable of committing to the imposed environmental objectives and aligning with them through the use of good sustainable construction practices. It is expected that this proposal for guidelines will become an important starting point for greater adherence by companies to the certification of their buildings.

2. Materials and methods

2.1. Systematic literature review

A systematic literature review (SLR) serves as a fundamental approach to identifying, evaluating, and analysing all available research relevant to a specific topic or area of interest [27,28]. These studies, unlike traditional research, present a more rigorous and structured method, leading to some advantages, such as [28,29].

- Synthesize existing information on a specific topic under study;
- Identify gaps in previously carried out investigations and suggest a more elaborate study in these certain areas;
- Provide background for future research projects.

Regarding this study, it follows the guidelines for the SLR proposed by Kitchenham and Charters [30], where it is divided into three phases: "Planning", "Conducting" and "Reporting". This entire process was used methodically through the Parsifal web program, which helps document and perform most of the systematic research [31].

Firstly, in the "Planning" section, it was necessary to define the objectives of the research, that is, define goals and know the direction of the research, establishing a set of topics of interest to be covered. As the research topic deals with Sustainable Building Certification, the main objectives were.

- Identify the main systems considered construction quality assessment tools;
- Describe the selected systems from the perspective of their specificity for different types of buildings;
- Check the strengths, as well as the limitations and weaknesses of each of the systems analysed.

Subsequently, with the assistance of PICOC (Population, Intervention, Comparison, Outcome and Context), the requisite questions for the systematic review were formulated (Table 1). This automated search tool enables the user to filter and search for the information necessary for the investigation, thus facilitating the search process in the most diverse databases. This investigation firstly requires the population under study (analysis of sustainable certification of buildings), a description or motivation and the development of the systematic literature search itself. To address these needs, research questions were created that serve as a starting point for the extraction of data. To form these four questions, a main question was created (Q0): How do the different sustainable building certification systems implemented in Portugal compare in terms of environmental, economic, and social accuracy?

Once all of the questions had been designed, a search string was constructed according to the following procedure: ("Life Cycle") **AND** ("Sustainable Building Certification" **OR** "Building Sustainability" **OR** "Sustainable construction assessment") **AND** ("Certification Analysis" **OR** "Green Building Certification System" **OR** "Sustainability Assessment Methods" **OR** "Improvement Requirements" **OR** "Advantages and disadvantages"). The purpose of this was to create a search system, using a set of previously selected keywords, being used then in the most varied databases [31]. The present study makes use of six databases, namely the American Chemical Society Digital Library (ACM Digital Library), the Institute of Electrical and Electronics Engineers Digital Library (IEEE Digital Library), the Institute for Science Information's Web of Science (ISI Web of Science), ScienceDirect, Scopus and SpringerLink.

In the last section of the first phase corresponding to "Selection Criteria", the discriminants necessary to carry out a more selective search were placed, that is, the definition of inclusion or exclusion criteria. These same criteria may be related to the year of study, the language in which they were published or whether they are related to the present study. The inclusion criteria were as follows.

- Studies published in Portuguese and English;
- Studies published between 2015 and 2023;
- Studies involving certification processes for sustainable buildings;
- Studies that focus on sustainable certification of buildings.

In another similar analysis, the exclusion criteria were as follows.

- Studies published before 2014 (inclusive);
- Studies that do not present Portuguese or English as a language;
- Studies that are not related to the sustainable certification of buildings;
- Studies that do not present environmental certificates for buildings;
- Studies that do not present a clearly defined methodology.

The next step in the process was the "Quality Assessment". This evaluation is crucial in systematic research, as it allows for the identification of any potential discrepancies in quality between studies, which could otherwise influence the outcome [31]. In addition, specific questions were formulated with which to analyse each identified study.

- Is the research question clearly defined and relevant to the area of sustainable building certification?
- Are the selection criteria for the buildings studied clearly described and justified?
- Are data analysis methods clearly described and appropriate for the data collected?
- Is the discussion of the results appropriate and does it provide useful information for the area of sustainable building certification?
- Are the study conclusions based on the results presented and provide a clear answer?
- Are several environmental certification systems for buildings mentioned?

Each question mentioned above was evaluated, in a scoring system, in three possible scenarios: Yes (points = 1), Partially (Points = 0.5) and No (points = 0). Consequently, the score referring to the quality of the study was calculated by adding the score given to scientific articles related to the present study [33]. In the last phase of this section, called "Data Extraction Form", information such as the name of the authors, publication date of the research articles, country of publication and respective DOI was organized. In the

Table 1
Questions for systematic literature search using Parsifal [32].

Research question	Description and motivation
Q1 - **What are the different sustainable building certification systems available and how do they differ in terms of assessment criteria and environmental, economic, and social rigor?**	It is important to study the different environmental standards and certifications and compare them to each other, to create guidelines to be followed.
Q2 - **How do sustainable building certification processes affect the adoption and implementation of sustainable practices in construction?**	It is essential to analyse how the implementation of sustainable certification systems can benefit the construction sector.
Q3 - **What is the impact of sustainable building certification processes on energy efficiency, use of natural resources and carbon emissions of certified buildings?**	To create a more promising future in terms of sustainability, it is important to know the impact that these same buildings have throughout their life cycle.
Q4 - **How can sustainably building certification processes be improved to improve their effectiveness and impact on the environmental, economic, and social sustainability of certified buildings?**	It is important to know the strengths and weaknesses of each standard and certificate, so that their effectiveness can be improved.

second section called "Conducting", with the search string already created, it was used in each previously selected database to obtain the desired information for this article. In short, all the parameters defined in the first section were executed, for data collection, analysis, and respective interpretation of results.

In the first segment of the study, relating to "Imported Studies", the results of the "search string" created previously were found. These outcomes continue to pertain to the initial phase of the research process prior to the reading of each article or book. The number of articles and books found referring to each previously selected six databases demonstrated that the database representing the greatest number of results for the analysis of the topic discussed was SpringerLink, with 175 articles, followed by ScienceDirect, with 74 articles, and Scopus, with 27 articles found. ISI Web Science presented six articles, while both the IEEE Digital Library and the ACM Digital Library presented two articles each.

All articles collected based on the "search string" were individually filtered and analysed within the context of the "Study Selection" phase. This phase involved the responses to the previously presented questions. Following this process, those articles that met the inclusion and exclusion criteria were filtered. Of the total of 286 articles, 53 were accepted and 233 rejected. In the "Quality Assessment" segment, the same questions that were created in the "Planning" section were used, this time with the corresponding rating from 0 to 6. It is intended that the quality of primary studies be evaluated in a more surgical way, as well as, in alignment with Kitchenham and Brereton [34], to provide more detailed inclusion/exclusion criteria, to investigate whether differences in quality may account for any possible disparity in results, and to help with future research. This was followed by the "Data Extraction" segment already mentioned in the planning phase of the systematic search, where information about each article or book found was added. All this information was extracted into an Excel file. Finally, in the last segment called "Data Analysis", information such as the number of articles and books found by each database was obtained.

2.2. SWOT analysis

A SWOT analysis was used to compare the identified certifications and understand which might be the most advantageous currently in the Portuguese market, with a view to designing strategies. This option was because SWOT analysis is a very versatile tool that provides a holistic view of several topics considered important in a universe of results, from which new ideas or strategies can be developed in order to improve the performance of the initial system [35,36]. It is a tool widely used in business contexts, particularly in business and entrepreneurship [37].

To carry out the SWOT analysis, attention was paid to, among others, the function, competition, and importance in the sector of the four sustainable building certification systems studied.

2.3. Guidelines development

When it comes to implementing sustainable certifications in buildings, it is important to establish guidelines that are clear and comprehensive, so that the client can take them into account when selecting the most correct certification to implement in their project. These same guidelines serve as a guide/manual of good practices, so that the greatest number of sustainable objectives possible can be achieved and, therefore, obtain a higher certification. It is also important to mention that they need to take several factors into consideration, to ensure that the choice of certification system is effective and suitable for the project.

The main criteria for developing these guidelines in this research work were.

- **Client objectives** – discuss with the client what are the main reasons for carrying out certification, for example, if they want to improve energy efficiency, water efficiency, indoor air quality, among others;

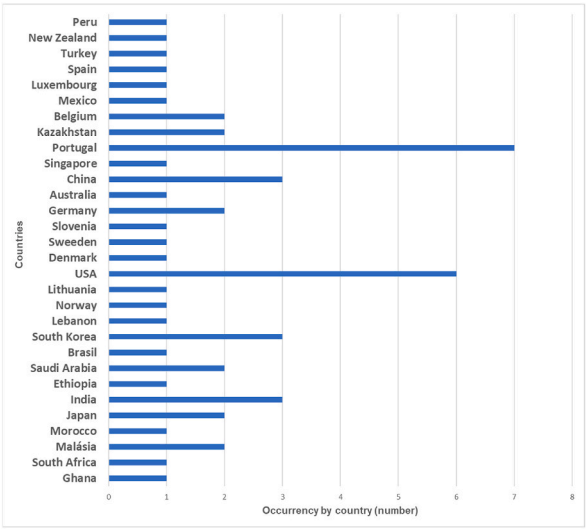

Fig. 1. Geographic distribution of the number of articles and books found and accepted [32].

- **Project type** – know what type of project will be evaluated, that is, whether it is a residential, commercial, office or other building;
- **Geographic analysis** – identify factors such as climate or natural resources, as they influence certain criteria in each certification (more or less credits can be acquired, which influences the final assessment when certifying the building);
- **Costs** – analyse the budget that will be invested in a specific certification to be implemented, as certain systems are more economical compared to their counterparts;
- **Sustainability** – determine which are the most important elements to be achieved with the project;
- **Certification** – select the certificate that best suits the project, considering the information compiled.

These criteria represent an essential phase of the assessment process, helping professionals shape guidelines to select the most appropriate certification system for the client's project. It is important to highlight that the criteria and guidelines can be flexible, that is, they can be added depending on the type of project that the client provides, leading to a greater degree of freedom on the part of technicians in helping them define goals for the project.

3. Results

3.1. Geographical distribution and authorship of articles

It is important to highlight that the SLR aimed to be as diverse as possible, covering as many countries as possible where there were studies focusing on Portugal or sustainable certification of buildings had been implemented more broadly. Fig. 1 illustrates the geographical distribution of the articles consulted, which originate from over 10 different countries. It is noteworthy that, with Portugal serving as the focal point of the study, the scientific articles found are mostly by Portuguese authors with information relating to the national territory. A total of seven articles out of the 53 articles (i.e. 13 %) were written by authors residing in Portugal.

In Table 2, the most relevant articles for this research are listed, in alphabetical order of their respective authors, as well as the journal in which they appear, and the respective number of citations made by the scientific community up to the date of analysis (August 2023).

The SLR contributed to a general and comprehensive overview of the available evidence on the topic under study. Furthermore, it was an added value in obtaining updated and crucial information for this study, particularly for the SWOT analysis.

3.2. Sustainable certification in buildings

3.2.1. BREEAM

The BREEAM certification method (see Fig. 2) was created in 1990, in the United Kingdom, by the company Building Research Establishment (BRE). It is considered the most important, as it is the most used in the world [51,52] with around 610 thousand certified buildings and 2338 thousand registered for evaluation in 102 countries [53]. In 2012, Forum Sintra, a retail establishment situated in a municipality on the mainland of Portugal, became the inaugural Portuguese business to be awarded a BREEAM certification [54]. This certification mainly allows evaluating the environmental, social, and economic sustainability performance of buildings, recognizing

Table 2
Information about the publication, authorship and citations used in the article by the scientific community until august 2023.

Authors (year of publication)	Title of the paper	Name of the journal	Number of citations
Akhanova et al. (2020) [38]	A multi-criteria decision-making framework for building sustainability assessment in Kazakhstan	Sustainable Cities and Society	65
Anshebo et al. (2022) [39]	Developing a Green Building Assessment Tool for Ethiopia	Heliyon	3
Carvalho et al. (2019) [40]	Optimising building sustainability assessment using BIM	Automation in Construction	145
Castro et al. (2015) [41]	A critical analysis of building sustainability assessment methods forhealthcare buildings	Environment, Development and Sustainability	33
Castro et al. (2017) [42]	Development of a healthcare building sustainability assessment method – Proposed structure and system of weights for the Portuguese context	Journal of Cleaner Production	27
Ferreira et al. (2023) [43]	A critical analysis of LEED, BREEAM and DGNB as sustainability assessment methods for retail buildings	Journal of Building Engineering	17
Jamoussi et al. (2022) [44]	Sustainable Building Standards, Codes and Certification Systems: The Status Quo and Future Directions in Saudi Arabia	Sustainability	9
Karaca et al. (2020) [45]	A new stakeholder opinion-based rapid sustainability assessment method (RSAM) for existing residential buildings	Sustainable Cities and Society	23
Lazar and Chithra (2020) [46]	A comprehensive literature review on development of Building Sustainability Assessment Systems	Journal of Building Engineering	63
Park et al. (2015) [47]	A Study on the Sustainable Building Technologies Considering to Performance of Greenhouse Gas Emission Reduction	Procedia Engineering	5
Soussi et al. (2023) [48]	An embedded concept for sustainable building	Materials Today: Proceedings	2
Uğur and Leblebici (2018) [49]	An examination of the LEED green building certification system in terms of construction costs	Renewable and Sustainable Energy Reviews	85
Zimmermann et al. (2019) [50]	Categorizing Building Certification Systems According to the Definition of Sustainable Building	IOP Conference Series: Materials Science and Engineering	30

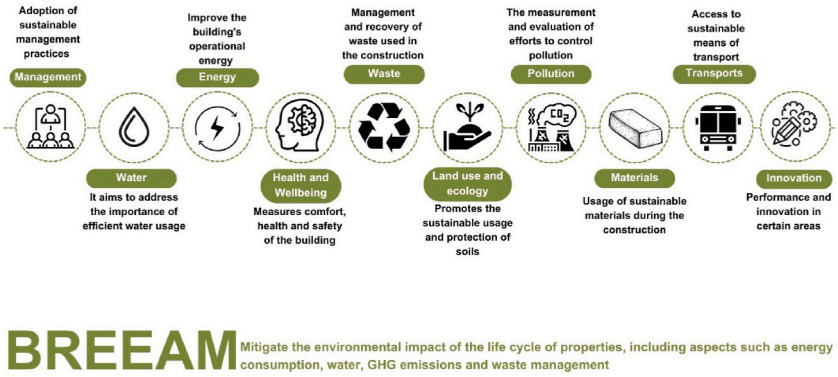

Fig. 2. BREEAM categories.

the value of each property with the highest performance throughout the life cycle of the built environment, from buildings in the construction phase to their use and renovation.

This certification process aims to achieve the following objectives [55].

- Provide the market with recognition of buildings with low environmental impact;
- Ensure that best environmental practices are incorporated into the planning, design, construction and operation phase of buildings;
- Set a robust and cost-effective performance standard that exceeds that required by regulation;
- Challenge the market to provide innovative and economical solutions that minimise the environmental impact of buildings;
- Promote awareness among owners, tenants, designers and developers about the benefits of buildings that have a reduced environmental impact over the life cycle of the property;
- Allow organizations to demonstrate a path towards greater sustainability in a corporate environment.

A BREEAM certified rating reflects the performance achieved by a project and associated parties, which is measured against the ten categories of the same certification. This classification enables comparison between projects and provides guarantees about the performance, quality, and value of the property. Fig. 2 shows all the categories of this certification, as well as their description and importance for the certificate. It is important to note that this certification presents a wide range of topics to be analysed, being an added value to retail buildings, offices, or apartments.

It is noteworthy that across all ten categories, the one with the highest percentage is "Energy", which accounts for approximately 15 % of a total of 110 %. This is followed by the "Materials" category (14 %), "Health and Wellbeing" (13 %), and "Land use and ecology" (12 %), with all the others having percentages less than 10 % [56]. BREEAM ratings range from Acceptable (for In-Use buildings) to Pass, Good, Very Good, Excellent and Outstanding, represented schematically through stars on the certificate itself.

3.2.2. LEED

In 1998, in the USA, the Leadership in Energy and Environmental Design (LEED; Fig. 3) certification system was created by the USGBC (United States Green Building Council), a non-profit non-governmental organization, whose focus was to promote

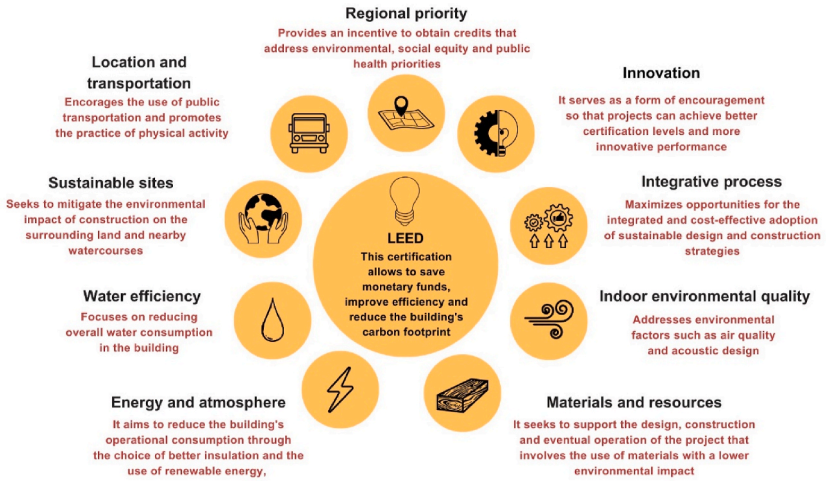

Fig. 3. LEED categories.

sustainability in the industry and construction sector, particularly buildings [57]. Currently, the USGBC [17] aims to transform the way buildings and communities are designed, constructed, and operated, enabling a sustainable, socially responsible, and prosperous environment throughout their life cycle. According to the same source [17], now there are more than 105,000 certified buildings in almost 190 countries. In 2008, the Sonae Maia Business Centre (located in Maia, on the Portuguese mainland) became the first LEED-certified building in Portugal [58].

This certification system is based on the following objectives [59].

- Reduce the impact of properties on climate change;
- Improving human health and well-being;
- Protect and restore water resources;
- Protect and enhance biodiversity and ecosystem services;
- Promote sustainability and regenerative cycles of materials;
- Holistically increase the quality of life of the community.

This certification, whose nine categories are succinctly described in Fig. 3, saves monetary funds, improves efficiency, and reduces the building's carbon footprint, thus creating a healthy place for the users of that property. All these characteristics serve to combat the threat of climate change and achieve the sustainable development goals (SDGs), increase the resilience of communities, and promote a more equitable environment for populations [59].

LEED certification is a system that focuses on the energy aspects of a building [60], although it also encompasses other important categories, such as indoor air quality and the use of sustainable materials. It should be noted that the category with the highest score is "Energy and atmosphere", with approximately 35 points. This is followed by "Sustainable sites" (26 points), "Indoor environmental quality" (15 points), "Materials and resources" (14 points), and "Water efficiency" (10 points). The remaining categories, "Innovation" and "Regional priority", have 6 and 4 points, respectively [61]. Similar to BREEAM certification, this is applicable to a diverse range of building types, including retail, office, and residential structures such as apartments.

To obtain LEED certification, the project will have to acquire points by committing to achieving the prerequisites and credits in the categories mentioned above. Each property goes through a project registration process, preparation of the application and respective review by the responsible entities (GBCI), receiving points and reaching one of the following levels.

- Certified (40–49 points acquired);
- Silver (50–59 points acquired);
- Gold (60–79 points acquired);
- Platinum (+80 points acquired).

3.2.3. *WELL*

The WELL certification system (Fig. 4) was developed by the International WELL Building Institute (IWBI) in 2014, after six years of research and development [62]. In the same year, the first version (WELL v1) was launched, followed by WELL v2 in 2020 after several requirements were adapted with the evolution of the state of the art in studies on human health and building design [63]. Since it was launched, around 72 million m^2 of residential and commercial areas have been certified across the world [64]. On June 15, 2023, Nestlé's headquarters became the first WELL-certified building in Portugal [65].

This certification system aims to [66].

- Prioritize the health and well-being of building occupants;

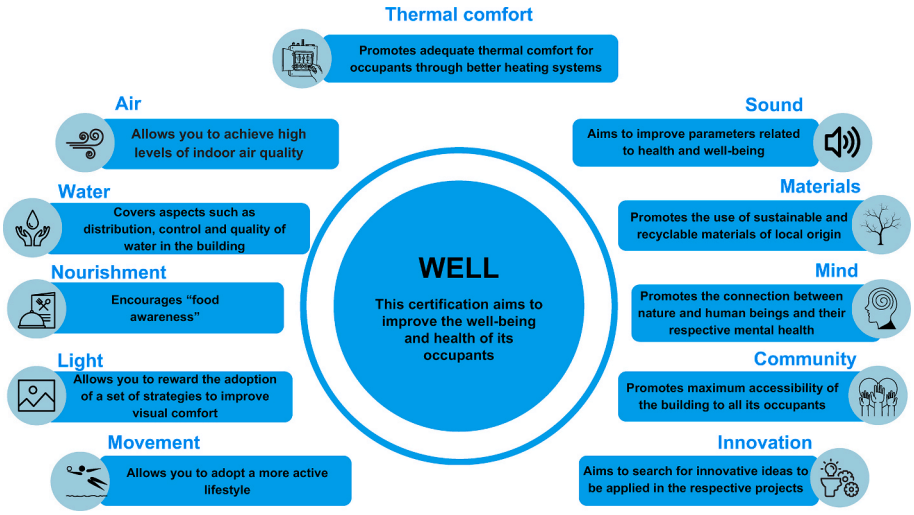

Fig. 4. WELL categories.

- Align real estate, operational practices, human resources and administrative staff to share a common vision on the importance of health at work;
- Try to give greater value to the building;
- Validate health and well-being commitments through third-party assessments.

Fig. 4 shows the eleven categories relating to this certificate and a summary of each of them. It is worth noting that this certification, as previously mentioned, has a greater focus on the health and well-being of the occupant, and is mainly used in office buildings.

In contrast to the aforementioned certification systems, the WELL certification is not measured by percentage, but by score. Each credit is worth between 0.5 and 10, with the customer free to choose which points they will follow. The most valuable categories of this certification are "Community", with a maximum of 43 points that can be achieved, followed by "Innovation" with 28 points and "Movement" with 21 points [63].

To achieve WELL certification, the building is covered by four levels.

- Bronze (40–59 points)
- Silver (50–59 points)
- Gold (60–79 points)
- Platinum (80 points minimum).

3.2.4. LiderA

LiderA is a voluntary building sustainability system that can support the development of sustainable guidelines (see Fig. 5). This certification was created by Manuel Duarte Pinheiro, in 2000, in the Department of Civil Engineering and Architecture of the Instituto Superior Técnico (IST), with the aim of developing a system of support, evaluation and contribution to the development of sustainability, implementing it at the level of buildings or outdoor spaces [67]. The inaugural edifice to receive LiderA certification was the Hotel Jardim Atlântico in Calheta (a municipality in the Autonomous Region of Madeira, a group of islands in Portugal, located in the Atlantic Ocean) in 2007 [68].

The objectives of this certification are: i) to be a distinctive brand in terms of environmental performance and sustainability in Portugal and Portuguese-speaking countries; ii) promote good environmental practices in terms of building design and construction [69]. Fig. 5 shows the main categories of this certification system, also covering criteria such as energy, use of sustainable materials and waste management. In contrast to other certificates, LiderA has a greater focus on services to the population, socioeconomic factors and habitat protection.

By contrast with the aforementioned certifications, the LiderA certification system covers a greater variety of topics. The "Resources" category, which includes the subcategories relating to "Energy", "Water", "Materials" and "Food production", is presented as the section with the highest weight, at approximately 30 %. This is followed by the "Socioeconomic experiences" and "Local integration" categories, which account for 22 % and 12 %, respectively [69,70].

Like other certifications, this has a classification from G to A+++, like energy certification, with E representing the usual or reference practice. The degree of sustainability by area is measurable in good performance classes, from reference level E and classes C (higher than 25 % of practice), B (37.5 %) and A (50 % or factor 2). In the best performance class, in addition to class A, there is class A+ associated with an improvement factor of 4 and class A++ associated with an improvement factor of 10, with A+++ being an already regenerative class [71].

3.3. SWOT analysis

The SWOT analysis regarding certification systems aims to address the positive and negative points of a project, through an internal analysis of strengths and weaknesses and external analysis that is reflected in opportunities and threats. By analysing the strengths, it is possible to describe which options are seen as advantages. Regarding weaknesses, weaknesses or points that could be improved are

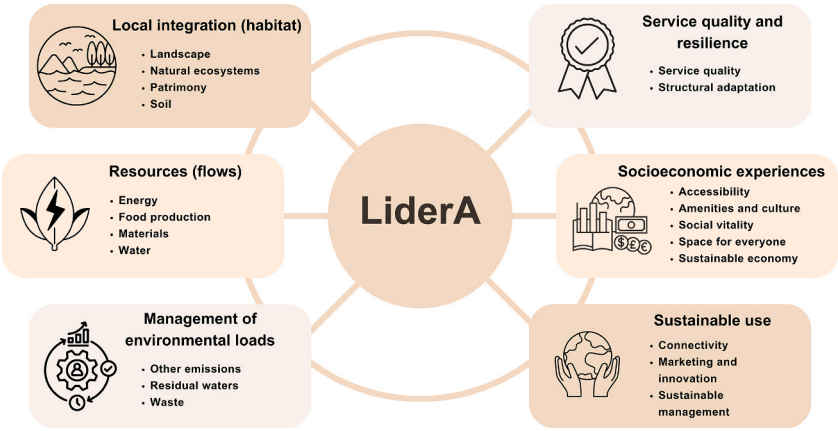

Fig. 5. The six categories of LiderA.

identified. Regarding external factors, these refer to external elements that can be used as favourable or unfavourable. Table 3 presents the results of this study, focusing on the four main sustainable certifications in buildings adopted in Portugal.

The SWOT analysis relating to each system studied, BREEAM, LEED, WELL and LiderA, showed that this type of certification systems presents multiple strengths and opportunities, which are sometimes common in their use, in the construction sector in Portugal.

This analysis is fundamental to identifying the strengths, weaknesses, opportunities and threats of the various sustainable certification systems in Portugal, also highlighting competitive advantages and improvement factors. This analysis reveals that the adoption of this type of certification has several advantages. A holistic approach to various environmental factors (water, energy, use of sustainable materials, etc.) is prioritised, as is the health and well-being of occupants. The ultimate objective is to reduce CO_2e emissions into the atmosphere. These factors are also driven by financial incentives from external organizations, leading to a certain financial return and therefore greater implementation of these certifications at an international and regional level.

3.4. Guide to preliminary certification selection

Based on the description of the four certifications used in Portugal (Chapter 3.2) and the SWOT analysis that compares the same ones (Chapter 3.3), a guide was created to make the preliminary process of selecting the certification that best suits the objectives of the project to be built and used in this country.

This guide consists of two Microsoft Excel sheets. The first sheet introduces the guide and provides brief information regarding the certificates that can be implemented in Portugal (origin, description, objectives and investment). The second sheet, in addition to providing instructions on how to fill in the table presented in it, also functions as a spreadsheet. It allows the client to quickly and easily obtain numerical results to support the decision on the certification system best suited to the project in question analysis. This spreadsheet is pre-programmed in such a way that, once completed, the user will have an understanding of the most appropriate certificate for their project.

Table 4 contains the 18 general questions about sustainability in buildings included on the second sheet of the guide. Each question has one or more answers, each of which corresponds to one or more certificates, considering their relevance to them. To illustrate, in the first question, if the property intends to emphasize sustainable waste management during the construction and operation of the building, the certificate that most covers this topic is BREEAM. Consequently, the cell corresponding to the question will be marked with an "X". Should the response encompass one or more certificates, one or more options will be similarly marked in the Excel table. For instance, if the construction of the building utilises local sustainable materials (question 3), the BREEAM and LEED certificates will be marked with an "X" simultaneously. The column corresponding to the certificate that shows “X” in the largest quantity (Total) will be the most suitable for the property under study. The result will be displayed in a yellow cell, with the name of the certificate to be applied. It is important to note that the number of questions posed to all certification systems is consistent. This guarantees a balanced

Table 3
Comparative SWOT analysis of the main sustainable certifications in buildings adopted in Portugal [17,43,68,72,73].

	BREEAM	LEED	WELL	LiderA
Strengths	•National and international recognition •Since implementation in Portugal and until May 2024, 194 buildings have been certified in this country •Issuance of pre-certificates •Lots of information available to the public •Possibility of assistance from a BREEAM AP (accredited professional) in the certification process •Reduction of CO_2e emissions into the atmosphere	•Recognition at national and international level •By May 2024, 46 projects had been certified in Portuguese territory •Comprehensive approach, with many criteria and information, particularly in categories such as energy and materials •Reduction of CO_2e emissions into the atmosphere	•Recognition at national and international level •In May 2024, there were 5 certificates in Portugal •Emphasis on occupant health and well-being •More holistic approach compared to other certifications, also covering categories such as sustainable materials, water efficiency and occupant well-being •Reduction of CO_2e emissions into the atmosphere	•Recognition at national level, with 59 certified buildings •Adapts to any project •Assistance from a LiderA advisor during the certification process •Certificate issuance in the design phase •Verification by a third party •Reduction of CO_2e emissions into the atmosphere
Weaknesses	•System complexity •Very expensive for smaller scale projects	•As it is an American system, the certificate standards and criteria have difficulty adapting to other countries outside the USA	•High initial costs •Despite taking a holistic approach, this certification focuses on health and well-being, leaving aspects of other categories with a lesser approach.	•Certification only used in Portuguese and Portuguese-speaking African countries
Opportunities	•Attracting demand from customers, as it is an international system •Financial incentives •Growing market	•As it is an internationally recognised system, it will attract more demand for this certification •Financial incentives	•Internationally recognized system, leading to more customers from various countries •Financial incentives •Growing awareness of occupant mental health and wellbeing	•Growing in the real estate market, increasing demand for property certification •Accreditation of the system becomes an added value, as it increases its credibility •Financial incentives
Threats	•Growing competition	•Growing competition	•Growing competition	•Growing competition

Table 4
Above: questions for the calculation used in the guide to building sustainability; Below: answers to the proposed questions.

QUESTIONS	BREEAM	LEED	WELL	LiderA
1. Does the project emphasize sustainable waste management during construction and operation?				
2. Are the health and well-being of employees, including aspects such as natural lighting and acoustics, priorities?				
3. Is choosing local materials with low environmental impact a priority for the project?				
4. Does the project seek international recognition and alignment with global sustainability standards?				
5. Are efficient water use and strategies to minimise waste considered critical to the project?				
6. Is active involvement of the local community in the design and operation phases a priority?				
7. Does the project seek to incorporate innovative technologies to achieve sustainable goals?				
8. Are accessibility and inclusion for people with limitations important factors for the project?				
9. Is life cycle assessment of building systems and components a critical design consideration?				
10. Does the project aim to achieve high standards of energy efficiency and sustainability in general?				
11. Does the project emphasize the promotion of social equality in the local community?				
12. Is the integration of green technologies, such as renewable energy systems, a priority for the project?				
13. Is budgetary consideration a critical consideration for the client in the sustainable certification project?				
14. Does the client have a preference for sustainable certification with specific recognition in the region/nationally?				
15. Does the project emphasize the use of innovative water reuse systems to reduce demand on potable water supplies?				
16. Does the project include dedicated spaces and programmes to promote physical activity and overall fitness of building occupants?				
17. Is there a focus on providing access to natural light and views to improve occupant wellbeing and productivity?				
18. Does the project include strategies to reduce light pollution and minimise disruption to the local ecosystem?				
TOTAL	**0**	**0**	**0**	**0**
Certificate to consider for the project				

Answers: **1.** BREEAM **2.** WELL **3.** BREEAM/LEED **4.** BREEAM/LEED/WELL **5.** LEED/BREEAM **6.** LiderA **7.** BREEAM/LEED/WELL/LiderA **8.** WELL/LiderA **9.** LEED/BREEAM **10.** LEED/LiderA/BREEAM **11.** WELL/LiderA **12.** BREEAM/LEED/LiderA **13.** LiderA **14.** LiderA **15.** WELL **16.** WELL **17.** WELL **18.** LEED.

selection process for clients, as the same number of questions are posed to each system, thus ensuring that the evaluation is conducted in a more objective and equitable manner.

Answers:

1. BREEAM	**5.** LEED/BREEAM	**9.** LEED/BREEAM	**13.** LiderA	**17.** WELL
2. WELL	**6.** LiderA	**10.** LEED/LiderA/BREEAM	**14.** LiderA	**18.** LEED
3. BREEAM/LEED	**7.** BREEAM/LEED/WELL/LiderA	**11.** WELL/LiderA	**15.** WELL	
4. BREEAM/LEED/WELL	**8.** WELL/LiderA	**12.** BREEAM/LEED/LiderA	**16.** WELL	

While this guide is invaluable in the preliminary stages, the information it provides is too general. It would be beneficial to develop a more robust tool, also for initial use, which would provide more detailed information.

4. Discussion and proposal of guidelines

As mentioned in Chapter 1, research into environmental practices in the construction sector has increased over the years, so that the sustainable certification of buildings has become a fundamental tool for reducing the energy consumption of these buildings and the respective environmental impact [33]. The results of this study highlight two systems as very strong in the market: BREEAM and LEED. As previously noted in other research (e.g., see Olanrewaju et al. [74]), these two certifications share the same objective of promoting sustainability. Their multifaceted approaches allow for a global analysis of the various criteria included in each certification, although LEED has a particular focus on energy and materials efficiency. The first is a pioneering certification system in the sustainability of buildings, making it a greater source of wealth in terms of knowledge and greater maturity. LEED also has several years of experience in the national and international market (particularly in the United States), although better adaptation of the system outside the United States of America is still necessary. WELL, in turn, has its focus on the health and well-being of the occupant, although it has some categories in common with the BREEAM and WELL certification systems, such as water efficiency and materials.

Regarding LiderA, it has a more geographical approach, as it focuses mainly on Portuguese territory and Portuguese-speaking African countries. Compared to the previously mentioned certifications, despite having some presence in Portugal (with 59 buildings certified to date) [68], the certification of buildings in BREEAM and LEED together has a greater presence in the national territory. The popularity of these two certification systems in Portugal reflects their international recognition and credibility. They not only attract investors seeking to meet high sustainability standards, but also comply with EU sustainability directives, which further encourage their use [75]. Although this fact may change in the future with the increasing demand for building certifications in the real estate sector, as LiderA has a wide range of categories that allow it to be quite comprehensive in the social and environmental sectors.

To make a better choice when selecting which certificate is most suitable for a given building, some guidelines were created, helping to understand the needs of each project and the respective certification to be applied. These same guidelines are essential for a practical and succinct approach, which also allows technicians to provide the best information to customers, so that all project objectives are met. It is important to highlight that the guidelines presented below may be adjusted depending on the project under study or new guidelines may be included.

4.1. Determination of objectives by the client

A clear definition of objectives is one of the most important principles for determining the best sustainable building certification system to choose, so that the client can understand, according to their needs, in which categories of each certificate to invest mainly. Below, the main objectives of each certificate are briefly analysed to understand which will be the best to be applied according to the client's priorities.

- **BREEAM** – This certification is based on a holistic approach across several categories, essentially highlighting categories relating to well-being and health, energy, and indoor air quality. Therefore, if the client wants greater energy savings for their project, better indoor air quality or investing in the health and well-being of users, this will be one of the best options, although in general both the present certified like its LEED counterpart, are quite comprehensive. It is worth noting that BREEAM continues to grow both nationally and internationally, and the project with this certification will have a greater scope in terms of attracting new customers and stakeholders.
- **LEED** – Regarding this certification system, it has a greater focus on matters relating to energy, transport, and materials. Compared to its counterpart BREEAM, it has a greater number of degrees of freedom in relation to the British system, which is more rigorous in the organization of criteria.
- **WELL** – Compared to other types of certifications, this one stands out mainly in the category of health and well-being of building occupants, being mostly used for offices or properties where several people work. Presents rigorous standards in relation to categories such as indoor air quality, lighting, and mental health of all employees.
- **LiderA** – As this certification was created in Portugal, it will have the advantage of being adapted to national legislation and construction standards, being one of the main advantages of this system in relation to its counterparts of international origin. It also seeks to relate various aspects of sustainability, such as energy, water use and sustainable materials. In addition to this fact, it also takes a very solid approach to connecting these themes with the surrounding communities, particularly in the socioeconomic aspect.

4.2. Certification costs

When selecting certification, analysis of the costs of implementing sustainable building certification systems plays a crucial role as it is a factor with weight in the client's decision-making. This factor influences its total budget, making it essential to carry out an a priori analysis of its viability and future return on the amount invested in having the certificate. Considering this fact, it is vital to analyse, in the long term, the expenses incurred, particularly in terms of energy efficiency, operational costs and future appreciation of the building in the real estate market. Below are values that can be expected when acquiring each of the certifications already mentioned [57,67].

- **BREEAM** – The total fee for this certification depends on your objective (final assessment), the country and the gross area of the project. For BREEAM New Construction, that is, new projects still in their initial construction phase, the price varies between around 1100€ and 4500€, depending on the gross area. The minimum size allowed for the certificate to be applied is 500 m^2, with a maximum of 10,000 m^2, presenting two intermediate payment levels, making four in total. The total amount is the result of the registration fee plus the certification fee. If the documentation is not written in English, translation costs are approximately 1725€.
- **LEED** – The fee is calculated based on the variation in gross area and certification scheme, ranging from 425€ to 27,200€. For those who are not members, the price range is between 2800€ and 26,700€.
- **WELL** – Compared to its counterpart certifications, this one has a higher price. The project registration fee for this certification varies between 1200€ and 8000€, intended to be a commitment to achieving full certification. The price for a full certification, including registration, starts at 11,100€ for small buildings, increasing in value for larger buildings and considering their location. It is pertinent to mention that WELL has developed an online price calculator, which enables the user to simulate various types of projects. This helps the client to gain a solid understanding of the costs involved, thus facilitating informed decision-making.
- **LiderA** – In this certificate, costs depend mainly on the type and size of the building, and values can vary from:
- 1500€ + 0.15€/m^2 + VAT and 150€ + 1€/m^2 + VAT (where VAT = 23 %)

4.3. Prerequisite analysis

At this stage, after knowing what the various certificates already mentioned consist of, the client's determination of objectives and respective project budgets, it is important to know the importance of the prerequisites of each sustainable building certification system. These establish minimum task standards, where each of them must be fulfilled, otherwise the project will not obtain certification.

4.4. Tax incentives and educational programmes

External entities, such as the Portuguese "Fundo Ambiental [Environmental Fund]", can provide grants intended to support sustainable construction practices, thereby assisting to offset the initial costs associated with the aforementioned certifications [76]. Furthermore, the creation of tax credits and deductions for owners who obtain this type of certification could reduce the financial burden and, in turn, encourage a greater number of investments and initiatives in the field of sustainable construction. Simultaneously, educational programmes are essential to increase stakeholder awareness, highlighting the environmental and financial advantages of this type of investment.

5. Conclusions

The Portuguese market for sustainable buildings has experienced a period of rapid growth in recent decades, with an estimated 290 certified buildings expected to exist by 2024. As this is an ongoing commitment, it is imperative to analyse all the guidelines of each certificate together with specialised professionals in order to move towards an increasingly sustainable future.

Certificates such as BREEAM and LEED continue to be the most frequently selected, as they have a strong international presence and generally present the most complete and comprehensive measures, focusing on different types of categories. However, it is noteworthy that LiderA certification is gaining prominence throughout the Portuguese territory to the extent that it is already supplanting LEED certification. International recognition is afforded to certifications such as BREEAM and LEED, which are more focused on energy efficiency. This is evidenced by the fact that 15 % of the total score is allocated to this area, representing 110 % of the total, while 35 points are attributed to this category, representing 35 % of the total. In contrast, WELL certification has a more specific focus on occupant health and well-being, with the categories of "Community", "Innovation" and "Movement" being of particular relevance. Each of these comprises 43, 28 and 21 points, respectively. The LiderA certification system is the most comprehensive in environmental terms and is the most suitable for the Portuguese context. The "Resources" category, which encompasses the subcategories "Energy", "Water" and "Food production", is of particular relevance, accounting for approximately 30 % of the total score, which is out of a total of 100 %. The categories "Socioeconomic experiences" and "Local integration" follow with 22 and 12 % of the total score, respectively.

A SWOT analysis was carried out for each certification system, with a view to highlighting the importance of considering the specific context of each project. This approach reveals the strengths, weaknesses, opportunities and threats that may have an impact on the choice of certification, thus providing extra help to interested parties at any time during the project.

Furthermore, the investigation demonstrated that the implementation of these certification systems not only enhances energy efficiency and natural resource management practices, but also fosters a healthier environment for building occupants by integrating sustainable methodologies that have notably reduced the carbon emissions and long-term operating costs of the respective properties.

Another crucial point identified is the necessity for the implementation of public policies that facilitate the adoption of sustainable certifications. Such policies should include tax incentives and educational programmes designed to enhance awareness and adherence to sustainable construction practices.

To assist professionals in selecting the most appropriate certification system for their clients' projects, regardless of the stage they are in (in plan, construction phase or in-use), a guide was developed. In order to achieve this, several decisive factors were subjected to analysis, including the determination of objectives and construction costs for obtaining the certification. This comprehensive guide offers insights into four certification systems that were the subject of this study, outlining their respective criteria and the benefits they provide. As previously stated by experts in the field, although this guide is still in its preliminary phase and contains very general information about the aforementioned certifications, it serves as an invaluable starting point for the creation of a more comprehensive and updated version. This updated version will provide clients with a more detailed understanding of the various certification options available, enabling them to make informed decisions regarding the certification best suited to their building. This consequently permits professionals to make well-informed decisions that are aligned with both the project goals and the sustainability standards.

CRediT authorship contribution statement

David Feijão: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Cristina Reis:** Writing – review & editing, Validation, Supervision. **Margarida Correia Marques:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Investigation, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgments

This work was financially supported by the National Funds through the FCT – Portuguese Foundation for Science and Technology (Fundação para a Ciência e Tecnologia, I.P.), under the projects UIDB/04033/2020 (CITAB – Centre for the Research and Technology of Agro-Environmental and Biological Sciences) and UIDB/04708/2020 (CONSTRUCT – Institute of R&D in Structures and Construction). We would like to express our gratitude to the company Greenlab for the information provided.

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