

# Environmental Certification Protocols and Minimum Environmental Criteria in Sustainable Construction: A Comparative Study

Marco Ricchiuti <sup>1</sup>, Marianna Rotilio <sup>2</sup>, Eleonora Laurini <sup>3</sup>

<sup>1 2 3</sup>Department of Civil, Building and Environmental Engineering, University of L'Aquila, 67100 L'Aquila, Italy

## Abstract

This article focuses on a thorough examination of eight internationally prominent environmental certification protocols, including LEED, BREEAM, ITACA, and others, specifically addressing their application and evaluation within the realm of sustainability in construction sites. The analysis delves into the characteristics of each protocol, with a particular focus on the criteria governing practices during the construction process. By normalizing scores and criteria, percentages reflecting the impact of each protocol on the construction site and process were derived. Additionally, a detailed analysis was conducted on practices outlined in the Italian Minimum Environmental Criteria, integrating them with guidelines from international protocols. Common practices were categorized and synthesized into nine management categories, highlighting convergences and divergences among the various standards examined. Using comparative tables, the article clearly illustrates which practices are supported by each protocol and the Italian Minimum Environmental Criteria. This research provides a detailed analysis of sustainability strategies in construction sites, offering a clear and comparative view of sustainable practices supported by international protocols and national criteria.

**Keywords:** Building sustainability, Sustainable construction sites, Environmental certification protocols, Minimum Environmental Criteria (MEC).

## 1. Introduction

The construction industry holds a crucial position in fulfilling essential societal requirements and fueling economic advancement. However, it faces heavy criticism for its environmental impact: approximately 50% of raw materials are used, consuming 71% of electricity, 16% of water, and generating 40% of landfill waste [1]. Coupled with substantial greenhouse gas emissions, these factors significantly contribute to climate change [2]. These data underscore the importance of implementing building sustainability assessments to counter global warming, recognizing the construction industry's significant impact on resources and emissions [3].

Historically, construction sites were often viewed merely as physical spaces for building activities, overlooking their crucial relevance in the building process and environmental context. Recently, there has been growing interest in integrating sustainable practices during the construction phase, with gradual progress in site management [4]. Yet, a knowledge gap persists concerning available solutions, technologies, and procedures for adopting these practices on sites. Additionally,

there's insufficient awareness among companies regarding the tools necessary to monitor and evaluate the actual implementation of sustainable practices during the operational phase [5], [6].

This article aims to meticulously examine eight internationally relevant environmental certification protocols, focusing on their application and evaluation within the sustainability framework of the construction process. Furthermore, it conducts a detailed analysis of practices highlighted by the Minimum Environmental Criteria (MEC) compared with those derived from international protocols. In Italy, the MEC represents a fundamental element in promoting sustainability in construction, differing from international protocols as they are mandatory regulations. Compliance with these minimum environmental standards is mandatory for any public building project [22], [23]. A comparison between mandatory MEC and the voluntary criteria of international protocols is conducted to understand how these criteria are complementary in the construction process. It demonstrates how MEC can support meeting the criteria of international protocols, creating an

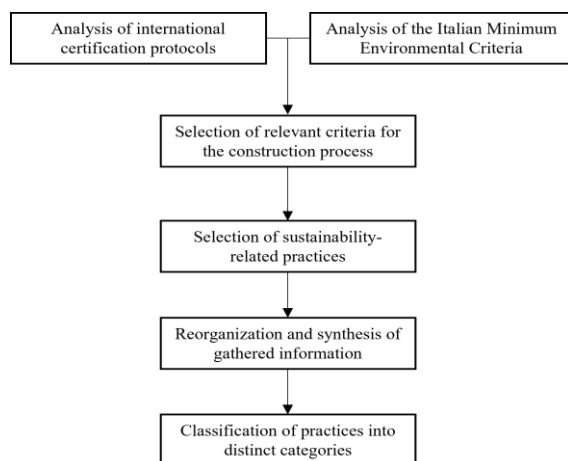
integrated framework of practices to promote sustainability in construction.

## 2. Methodology

Throughout this research, a structured methodology was implemented to conduct an analysis and comparison between internationally recognized sustainable certification protocols and the Minimum Environmental Criteria (MEC) within the construction domain. To ensure transparency in the adopted process, a block diagram was developed to vividly illustrate the key steps of this methodology (Fig.1).

Following an in-depth analysis of various protocols and their respective criteria, specifics related to construction phases and the building process were identified. By selecting these criteria, a normalization of credits assigned to each was performed on a scale of one hundred points, determining the percentage focus of each protocol on these themes. This approach facilitated a more precise and standardized assessment of the relative weight of each protocol concerning the construction phase and the involved processes, highlighting the emphasis placed on these aspects within each protocol.

Fig. 1



### Flowchart of the methodology

Concurrently, an extensive analysis of the Minimum Environmental Criteria (MEC) adopted in Italy was undertaken, representing a series of regulatory provisions aimed at promoting sustainability in the construction sector. This phase focused particularly on examining criteria specifically oriented towards the construction process. Through careful evaluation, indications

directly relevant to construction phases and the realization of building works were identified and selected.

While examining environmental certification protocols and guidelines related to MEC for buildings, a wide array of information, approximately around 200 practices and directives, were reviewed and collected. It was noted that many of these practices exhibited similarities and overlaps across different protocols while showcasing significant detailed differences. To render this information more accessible and comprehensible, a synthesis and reorganization process were initiated.

This work phase resulted in a database housing approximately 150 practices, classified into nine distinct categories, thus offering a clearer and structured view of the previously gathered information. The nine categories encompass: Soil Management, Water Management, Construction Material Management, Waste Management, Noise Pollution Management, Air Pollution Management, Pollutant Management, Energy Resource Management, and Site and On-Site Processes Management.

## 3. Results

### 3.1. Preliminary Results

Throughout the world, various building assessment tools focus on different aspects of sustainable development, but only a few enjoy widespread use and establish concrete standards for sustainable progress [7]. This article analyzes eight certification protocols that are most widely used globally [8]: the LEED protocol (United States) [9], the most famous and globally utilized; BREEAM (United Kingdom) [10], the first protocol to be established; ITACA (Italy) [11], the most widespread nationally; HQE (France) [12]; DGNB (Germany) [13]; CASBEE (Japan) [14]; Green Globes (Canada and the United States) [15]; Green Star NZ (New Zealand) [16].

The LEED protocol, *Leadership in Energy and Environmental Design*, established in 1998 in the United States and developed by the U.S. Green Building Council (USGBC), represents an assessment system for designing, constructing, and managing high-performance, sustainable, and environmentally friendly buildings and

neighborhoods [17]. The six main categories include: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, and Innovation in Design. Each category presents mandatory requirements and optional additional credits. Each subcategory can allocate a variable number of credits based on a specific evaluation table. The maximum score is 100, but a building certification requires at least 40 points. All credits carry equal weight, but the number of credits in each category varies based on a defined evaluation table. The evaluation system encompasses four levels: 40-49 points for Certified, 50-59 points for Silver, 60-79 points for Gold, and over 80 points for Platinum. This system provides a comprehensive framework to assess ecological performance and building sustainability, promoting reduced environmental footprint and healthier buildings for communities [9].

The BREEAM protocol, *Building Research Establishment Environmental Assessment Method*, stands out as the first established in 1990 and developed by the BRE Group. BREEAM certification is a crucial tool for measuring building sustainability performance, ensuring projects meet sustainability objectives and maintain their efficiency over time [17]. The BREEAM system consists of ten categories describing sustainability through a total of 71 criteria. Each category is assigned a specific percentage weight, and the 112 available credits are distributed proportionately. Each category focuses on elements such as carbon emission reduction, low-impact design, adaptation to climate change, ecological value, and biodiversity protection. The assessment of each criterion is weighted according to its relevance and reported in a dedicated evaluation sheet. The maximum score assignable is 112 credits, proportionally distributed based on the weight attributed to each category. To obtain certification, a building must achieve a minimum score of at least 30. The evaluation system comprises four assessment levels: Pass ( $\geq 30$ ), Good ( $\geq 45$ ), Very Good ( $\geq 55$ ), Excellent ( $\geq 70$ ), and Outstanding ( $\geq 85$ ). Thus, BREEAM remains a comprehensive and detailed system to assess building sustainability performance, encouraging innovation and adoption of increasingly

sustainable practices in the construction industry [10].

The ITACA protocol, established in 2001 by an Italian interregional group at the Institute for Transparency of Contracts and Environmental Compatibility, represents a national system for environmental sustainability certification. This concept stems from the desire to share a common international standard, called the SB method, based on the methodology arising from the International Green Building Challenge research process and managed by the IISBE (International Initiative for Sustainable Built Environment) since 2002 [18], [19], [20]. The five categories in the protocol have different weights based on the number of criteria they encompass: Site Quality (4.0%), Resource Consumption (53.6%), Environmental Loads (17.5%), Indoor Environmental Quality (18.2%), Service Quality (6.7%). The system includes seven evaluation levels for each category and subcategory, from -1 to 5. A score of -1 indicates a performance below current construction standards and practices, while a score of 0 represents a minimum acceptable performance defined by current laws or regulations. A score of 3 represents a desirable performance level with significant improvement compared to current regulations and common practices, whereas a score of 5 indicates an experimental level of significantly advanced performance compared to the best current construction practices. The assessment system comprises four levels: with a score lower than 40, a classification of D is achieved, not allowing the building to be certified; 40- $<$ 55 for level C, 55- $<$ 70 for level B, 70- $<$ 85 for level A, and finally, a score between 85-100 for classification A+ [11].

The HQE protocol, *Haute Qualité Environnementale*, originated in 1994 in France by the Haute Qualité Environnementale association. This certification considers buildings throughout their entire lifecycle, including moments of design, construction, management, and refurbishment [17]. Environmental performance requirements are organized into four main themes divided into 14 categories: Environment (Target 1: Building's relationship with the its immediate environment, Target 2: Quality of components, Target 3: Sustainable worksite, Target 6: Waste

management); Energy and Savings (Target 4: Energy management, Target 5: Water management, Target 7: Maintenance management); Comfort (Target 8: Hygrothermal comfort, Target 9: Acoustic comfort, Target 10: Visual comfort, Target 11: Olfactory comfort); Health and Safety (Target 12: Space quality, Target 13: Air and health quality, Target 14: Water quality and health). Each target receives an assessment of: PR - Prerequisite, P - Achievement, HP - High Performance. For a building to obtain certification, it must achieve an 'HP' score in at least three categories and a 'PR' score in a maximum of seven categories. This assessment system does not attribute different weights to various categories; indeed, all targets are considered equally important. The rating classes include five levels: Pass, Good, Very Good, Excellent, and Exceptional [12].

The DGNB certification protocol, *Deutsche Gesellschaft fuer Nachhaltiges Bauen*, was initiated in 2007 with the intention of promoting building sustainability in Germany and developing a German certificate for sustainable construction [17]. The evaluation is based on 63 criteria divided into six categories reflecting different aspects: Environmental Quality, Economic Quality, Technical Quality, Sociocultural Quality and Functional Quality, Process Quality, and Quality of the Location. Each criterion can score up to ten points, and each category has a specific assigned weight. A building's overall score, derived from the sum of points obtained in each category, defines the type of certification achieved. Evaluation levels comprise four categories: Bronze ( $\geq 35\%$ ), Silver ( $\geq 50\%$ ), Gold ( $\geq 65\%$ ), and Platinum ( $\geq 80\%$ ) [13].

The CASBEE protocol, *Comprehensive Assessment System for Built Environment Efficiency*, was developed in 2001 by the Japan Sustainable Building Consortium (JSBC), a non-governmental organization composed of representatives from the Japanese government, academic institutions, and the industrial sector [17]. The protocol evaluates building projects using the Building Environmental Efficiency (BEE), which represents the ratio of built environmental quality (Q) to built environmental load (LR).  $BEE = Q/LR$ . Both Q and LR range from 0 to 100 and are based on six subcategories. Each category is weighted by a

specific weighting factor: Q1: Indoor Environment, Q2: Quality service, Q3: Outdoor Environment On-Site, LR1: Energy, LR2: Resources and materials, LR3: Off-site Environment [14].

Green Globes is an environmental certification system developed in 2000 by the Green Building Initiative (GBI), both in the United States and Canada. The system is divided into six main categories: Project Management, Site, Energy, Water Efficiency, Materials, Indoor Environment. Each category is assessed by assigning 1 to 1000 points, with a higher score indicating better sustainability and environmental performance. Each criterion holds a specific point value, and the total points earned in all categories determine the Green Globes rating for the project. There are four evaluation levels: 1 Green Globe - This represents the basic level of certification, indicating that a project has met minimum sustainability requirements; 2 Green Globes - A higher level of certification, indicating that the project has implemented more sustainable practices and achieved a higher score; 3 Green Globes - This level represents even higher sustainability performance and often requires significant commitment to sustainable design and operations; 4 Green Globes - The highest level of certification, indicating exceptional sustainability performance and complete commitment to responsible environmental practices [15].

Green Star NZ, founded in New Zealand in 2007 by the New Zealand Green Building Council (NZGBC), aims to promote the design, construction, and management of buildings that minimize their environmental impact, enhance occupants' well-being, and positively contribute to the local and global environment. The evaluation system is divided into eight categories: Management, Indoor Environmental Quality, Energy, Transport, Water, Materials, Land Use and Ecology, Emissions. It employs a points-based scoring system to evaluate and certify building and construction project sustainability performances. The total number of points obtained determines the project's certification level. Subsequently, each category is applied a weighting factor to reflect the overall importance of the environmental aspect addressed by the category. There are six scoring categories divided into two groups: "Rated" (score

of 75 or more - 6 Star World Leadership, score of 60-74 - 5 Star New Zealand Excellence, score of 45-59 - 4 Star Best Practice) and "Not rated" (score of 30-44 - 3 Star Good Practice, score of 0-29 - 2 Star Average Practice, score of 10-19 - 1 Star Minimum Practice) [2], [16].

In the carried-out research, the following were specifically analyzed: LEED v4.1 BD+C Residential [9], BREEAM International New Construction Version 6.0 [10], DGNB Residential [11], HQE Residential [12], ITACA Residential [13], CASBEE for Building (New Construction) 2014 Edition [14], Green Globes New Construction 2021 [15], and Green Star New Zealand V3.2 [16].

The Minimum Environmental Criteria (MEC), adopted in Italy through Ministerial Decree on July 25, 2011. These are a series of provisions, standards, and directives defining minimum levels of environmental performance for the design, construction, and management of buildings. These criteria are designed to encourage the creation of sustainable buildings, reducing environmental impact throughout the entire lifecycle of properties [21], [22].

The MEC analyzed regarding the construction process include: Protection of natural, landscape, and cultural-historical resources; Protection of native tree and shrub species; Increased efficiency in energy use; Noise and vibration reduction; Reduction of polluting gas emissions; Water saving and wastewater management; Reduction of dust and fumes; Protection of soil and subsoil; Protection of surface and underground waters; Visual impact reduction of the construction site; Reuse, recovery, and recycling; Waste separation; Conservation of the surface layer of soil.

### 3.2. Specific Results

In *Table I*, the percentages regarding how each protocol focuses on the construction process and the weight assigned to this aspect are outlined. Additionally, it allows identification of the categories that encompass the selected criteria and their relative percentages. It's interesting to note that most protocols allocate roughly one-fifth of their appropriately weighted criteria to the construction phase.

However, it's important to consider that protocols attributing a lower percentage to the construction process, such as BREEAM or Green Globes, do not necessarily disregard construction site practices. Instead, these differences indicate that these protocols assign a smaller weight in terms of credits to these specific themes. In contrast, CASBEE allocates greater weight in terms of credits, resulting in a significantly higher percentage compared to others in this realm. In *Table II*, practices within the "Soil Management" and "Water Management" categories are listed, further subdivided into two subcategories each. Each practice is denoted by a solid bullet point if mentioned in the certification protocols or the Minimum Environmental Criteria. It's important to highlight that some protocols might be broader and more general in certain aspects compared to others. Therefore, if a protocol mentions the theme of a specific subcategory without specifying related practices, it is marked with an empty bullet point. Additionally, in the final column, fractions represent how many protocols mention a specific practice.

This approach allows the identification of common practices among protocols and others adopted in a limited manner by one or two protocols and/or the MEC. It's interesting to note that the LEED and

**Table I**

	LEED	BREEAM	ITACA	HQE				
Protocollo	78,18%	84,46%	80,00%	81,64%				
Processo costruttivo	21,82%	15,54%	20,00%	18,36%				
Categorie	Siti sostenibili	4,55%	Gestione	4,10%	Qualità ambientale	14,30%	Target 2 Componenti	6,12%
	Efficienza idrica	1,82%	Rifiuti	2,70%	Qualità tecnica	2,86%	Target 3 Sito	8,16%
	Energia e atmosfera	11,82%	Materiali	7,50%	Qualità del processo	2,86%	Target 5 Acqua	2,04%
	Qualità ambientale interna	3,64%	Uso del suolo ed Ecologia	1,40%			Target 13 Qualità dell'aria	2,04%
	DGNB	CASBEE	Green Globes	Green Star NZ				
Protocollo	82,20%	66,06%	86,50%	78,10%				
Processo costruttivo	17,80%	33,94%	13,50%	21,90%				
Categorie	Qualità ambientale	8,30%	Ambiente esterno nel sito	12,75%	1. Gestione del progetto	2,00%	Gestione	3,70%
	Qualità tecnica	2,50%	Risorse e materiali	15,00%	2. Gestione dei rifiuti	3,40%	Materiali	16,80%
	Qualità del processo	7,00%	Ambiente esterno fuori dal si	6,20%	3. Materiali	8,10%	Uso del territorio ed Ecologi	0,70%
						Emissioni	0,70%	

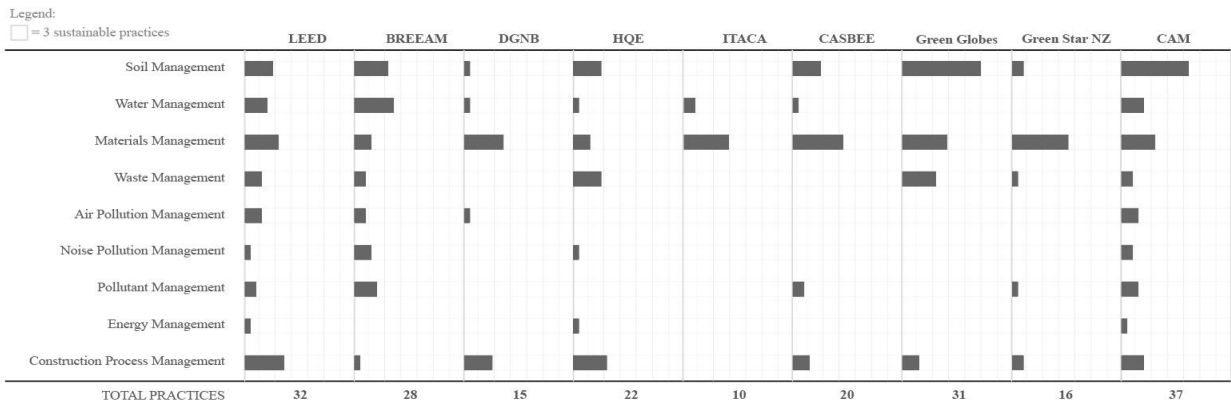
### Incidence percentages of the construction process on the different analyzed protocols.

Table II

SOIL MANAGEMENT	LEED	BREEAM	DGNB	HQE	ITACA	CASBEE	Green Globes	Green Star NZ	CAM	
Soil management	○	○	○	○			○	○	○	
Control soil erosion	●						●		●	3/9
Preserve organic matter and biodiversity in soil layers							●	●	●	3/9
Reuse excavated soil				●					●	2/9
Use of recycled material for backfill with concrete mixes									●	1/9
Minimize soil pollution	●			●			●		●	3/9
Prevent local or diffuse contamination and salinization							●		●	2/9
Decontaminate or treat polluted soil before construction				●						1/9
Contour and minimise length and steepness of slopes		●					●			2/9
Mulch to stabilise exposed areas or line steep channels or slopes		●					●			2/9
Habitat and biodiversity management	○	○	○	○		○	○	○	○	
Preserve greenfield area and existing ecological features	●			●		●	●		●	5/9
Restore disturbed soils for future habitat areas	●					●	●		●	3/9
Preserve the first layer of soil for green works							●	●	●	3/9
Plant native vegetation and avoid invasive species	●	●	●			●	●		●	6/9
Maintain or relocate local biological resources as needed						●	●		●	3/9
Protect native tree and shrub species during construction		●					●		●	3/9
Avoid placing building materials near sensitive vegetation		●		●			●		●	4/9
Encourage development on land that already has limited value to wildlife		●								1/9
Implement screening and landscaping near sensitive residential areas							●		●	2/9
Establish an appropriate biotope plan policy based on the site						●				1/9
WATER MANAGEMENT	LEED	BREEAM	DGNB	HQE	ITACA	CASBEE	Green Globes	Green Star NZ	CAM	
Water quality control	○	○	○	○	○				○	
Minimizing interruption and pollution of natural water flows					●					1/9
Controlling waterway sedimentation from construction activities	●									1/9
Preventing off-site sediment transport through settlement ponds, silt fences, or water treatment		●								1/9
Segregating clean water run-off to prevent mixing with high solids content water		●								1/9
Carrying out activities causing pollution in designated, bunded areas away from watercourses		●								1/9
Protecting groundwater on the construction site			●							1/9
Handling wastewater treatment through sanitization when no connection to public sewerage network is planned				●					●	2/9
Purifying runoff water before conveying to final water supplies									●	1/9
Water management	○	○		○	○	○			○	
Reducing outdoor potable water consumption	●				●					2/9
Preserving no and low-cost potable water resources	●									1/9
Reusing rainwater and aggregate processing water									●	1/9
Retain runoff from rainfall events using green infrastructure.	●	●								2/9
Evaluating utilization of grey water, sewage water, and industrial water						●				1/9
Preparing a drainage plan and identifying risk areas with marked manholes or water entry points									●	1/9
Providing adequate drainage systems to minimize and control infiltration									●	1/9
Provision of a water discharge networks									●	1/9
Schedule works to avoid heavy rainfall periods		●								1/9

Elist of practices related to the categories 'Soil Management' and 'Water Management.'

Table III



A matrix illustrating how many practices each protocol entails for each specific category.

BREEAM protocols, along with the CAM, feature at least some practices in each subcategory, although not in high numbers. Conversely, the Green Globes protocol offers numerous practices for the "Soil Management" category but none for the "Water Management" category. Furthermore, it's evident that despite Green Globes focusing only 13.50% of its entire protocol on the construction process (as indicated in Table I), it does provide a considerable number of

practices for the "Soil Management" category. This is possible because many sustainable practices derive from the same criterion, resulting in lesser weight when weighted. Table III depicts a matrix organizing categories and protocols. Each protocol is represented by bars placed in a grid, indicating the number of practices associated with each category. Additionally, the total practices for each protocol are highlighted.

It's noticeable that the LEED protocol boasts the highest number of practices compared to others, covering all categories. Similarly, the BREEAM protocol is represented in almost all categories. Conversely, although Green Globes presents a high total number of practices, it focuses only on certain categories. The matrix also reveals how protocols emphasize specific categories at the expense of others; for instance, the "Materials Management" category is addressed by all protocols, whereas "Energy Management" is covered only by LEED and the MEC. Additionally, it's interesting to note that the Italian Minimum Environmental Criteria cover all categories and offer the highest number of sustainable practices to implement on construction sites.

#### **4. Discussion**

The detailed analysis conducted on eight internationally relevant environmental certification protocols has provided a comprehensive overview of sustainability within construction sites. Evaluating the criteria and practices executable during the construction process revealed a wide range of sustainable approaches supported by these protocols. It unveiled a complex landscape characterized by points of convergence and differences among the examined protocols. While some protocols emphasize greater attention on certain categories, others present a more balanced distribution of sustainable practices.

This comparison highlighted the importance of considering not only international protocols but also the Italian Minimum Environmental Criteria to attain a complete picture of sustainable practices in the construction sector. While international protocols are voluntary and offer comprehensive guidelines for sustainable building implementation, the Minimum Environmental Criteria are mandatory. Following these CAM criteria can indeed lead to the automatic compliance with a significant portion of the criteria outlined in certification protocols. This is because, as emerged from the analyses in this research, the stringent requirements of the CAM often align with some of the criteria outlined in the protocols. The primary goal of this study is to develop a comprehensive and detailed construction protocol

that integrates information from both international protocols and the Minimum Environmental Criteria. This tool aims to provide a complete landscape of guidelines and practices to be implemented within the construction process, not only ensuring compliance with minimum requirements but also simplifying and facilitating the path toward environmental certification.

#### **5. conclusion**

This research represents a significant stride in delving into the complexity of sustainable practices within the construction sector, providing a detailed and comparative analysis of international protocols and national criteria governing sustainability in construction sites.

The comparative tables have clearly outlined the practices supported by each protocol, highlighting their inclusion or exclusion within the Italian Minimum Environmental Criteria. This has allowed for the delineation of a detailed framework of sustainability strategies in construction sites adopted by various sustainable certification protocols and the CAM, offering a comprehensive view of sustainable practices supported both internationally and nationally.

Future activities will involve a thorough analysis of systems and procedures supporting Industry 5.0, aiming to understand how these can facilitate the application of identified practices to achieve the highest levels of sustainability and minimize environmental, social, and economic impacts. The goal of the research is to deliver a high-tech sustainable protocol specifically related to the construction process.

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