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Review

The sustainability of the materials under the approach of ISMAS

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HIGHLIGHTS

- An analysis was made of the sustainability index of window materials in Vitória.
- The goal was to define the sustainability index of materials used in windows.
- The method involved the use of a field survey and the ISMAS tool.
- Materials with different properties could have the same sustainability index.
- The issue of sustainability needs to be included in the design process.

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ABSTRACT

The materials used in construction, such as those used in windows, currently require different procedures when making a choice that go beyond the aspect of functionality and take into account the need for efficient use guided the prerogatives of sustainability. Among other requirements, design specification guidelines, in this regard, indicate material selection based on criteria related to the consumption of raw materials, waste generation and its management. The purpose of this research was to define the sustainability index of the materials used or with a potential for use in windows in multifamily residential buildings located in Vitória, Espírito Santo, Brazil, using ISMAS – Instrument for the Selection of More Sustainable Materials – as a tool. The study consisted of two steps, one in the field and the other in analyzing the sustainability index of the materials. Among the 23 types of identified windows, it was found that the most commonly used materials are aluminum, wood, PVC, and glass. The results demonstrate that materials with different compositions and properties can achieve the same sustainability index when assessed using the ISMAS approach, giving the designer different options when making a selection. The research also showed that the functional, aesthetic, and economic criteria traditionally adopted by architects and designers are not sufficient to improve a building's performance when the issue of sustainability is introduced into the process.

Contents

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1. Introduction

A few decades ago, the importance of revamping the training of decision-makers in the construction area was announced and, hence, design practice to strike a balance between natural and constructed environments, also taking into account the need to train human resources in an increasingly demanding market. In various industries, governments have sought to punish and ban practices that cause significant environmental impacts, and legislation is becoming increasingly stringent in an attempt to minimize such impact. In this context, defining what is effectively impactive or sustainable in construction-related activities is fundamentally important.

As the construction industry has developed, so has the demand for materials that meet new profiles for different concepts, such as sustainability. Thus, considering the need for changes in performance relative to the market, designers should include new procedures in the design process, in particular considering immediate environmental impacts and those that take place over time to contribute to improved building performance [1].

Currently, suitability in the choice of building materials is related to the construction technologies' potential to minimize or eliminate the buildings' excessive energy consumption, thereby reducing the need for raw materials, waste production, and a wide range of environmental impacts. In this context, some tools may help in the selection process; however, the importance of having available instruments that present clear technical information and a user-friendly interface is undeniably important as it leads to finding more concise information [2]. Thus, the choice of a practical selection method that would reduce investment in technology without requiring specialized knowledge may be enough to achieve certain goals such as lower cost and a reduction in time [3], even if it does not achieve the level of analysis accuracy of more complex tools used by experts.

Currently, the information found in the environmental assessment tools has become a benchmark for sustainability projects. Each method has specific characteristics, differing in items such as changing environmental agendas, design and construction practices, and changes in economic and cultural issues. The main tools in use are as follows: BREEAM – Building Research Establishment Environmental Assessment Method – England [4]; GREEN STAR, in Australia [5]; CASBEE – Comprehensive Assessment System for Building Environmental Efficiency – Japan [6]; HQE – *Haute Qualité Environnimentale* – France [7]; LEED – *Leadership in Energy and Environmental Design* – United States of America [8]; SBtool – *Sustainable Building Tool* – International Consortium [9]; among others. Furthermore, there are some specifications used in Brazil such as AQUA – Alta Qualidade Ambiental [10], which was developed from HQE, and ASUS – Avaliação de Sustentabilidade [11], developed to address the reality in Espírito Santo.

There are also digital tools used to support decision-making and assist in choosing materials [2]. They consist of systematic procedures used to measure and assess impact and broaden the range of choices. Athena (Canada) assesses and compares the impact of materials in various scenarios [12]. BEES (USA) presents impact categories and provides a way to balance the environmental and economic performance of different materials [13]. SimaPro (The Netherlands) identifies, calculates, and quantifies environmental aspects related to the energy embedded in the materials [14]. In Brazil, MateriaBrasil is an example of an assessment tool focused on materials, a collection of materials available online and free of charge that has associated sustainability indicators [15].

Several other methods have been and are being developed to help designers increase design effectiveness [16,17]. However, to be effectively used, in addition to the need for clarity, information must be easy to use and enable objective responses. Highly complex tools tend to result in expensive products that require hiring experts who know how to use them [3].

The need for a practical method arises when reviewing the literature, methods that use arrays and complex numerical calculations to choose a material. Examples include multiobjective [18]; multiple criteria [19]; index-based classification [20,21]; and other quantitative methods such as the cost-benefit ratio [22]. However, in light of architectural firms' need for practicality, the existence of methods or instruments to assist in the selection of materials based on sustainability, consistent with the dynamics of design concepts, is still in the initial stages [3].

As recommended by Mateus and Bragança, an instrument's proposed simplification should be related to the presentation of a user-friendly, easy-to-understand language, usability, and practicality [23]. Otherwise, if it proves to be too time-consuming, the architect will rarely use it on a regular basis. Consequently, selecting a suitable approach and applying specific techniques can significantly reduce the simulation runtime [17]. In addition, ease of handling helps users absorb the significance of the concepts at their own pace and expand their knowledge.

The ISMAS instrument proposed by [24] Bissoli-Dalvi exemplifies this context, since it aims to provide simplified criteria to define the sustainability index of the materials in favor of creating an easy-to-use system, as also recommended by Pinter, Hardi and Bartelmu, Ding, and Mateus and Bragança [23,25,26]. In this sense, ISMAS proposes a context for conceptual fragmentation with an emphasis on sustainability analyses that target specific topics such as savings on the use of raw materials and waste generation and management. Some assessment methods are limited in range, as they do not cover all types of impacts, but rather choose those deemed the most important or have a specific business focus [27]. Although there is a tendency to adopt many criteria when it comes to choosing materials, a smaller, properly selected set tends to be more effective [25], also keeping in mind that, currently, there is no universal set of criteria that is equally applicable to all analyses [28].

Particularly with regard to building envelopment, in addition to the materials that comprise closed spans, it is necessary to know the characteristics of the frames and their respective materials to understand the properties that favor the search for the best performance and satisfactory levels of sustainability.

Within this context, this study aimed to define the sustainability index of the materials most commonly used or that could be potentially used in windows of multifamily residential buildings, taking into account the layout of Vitória, Espírito Santo, Brazil, using ISMAS.

2. Construction materials and sustainability

The materials selection stage requires design professionals to know the various aspects traditionally related to visual, tactile, thermal, acoustic, and olfactory perception, along with fitness for use, to the economic, technical, physical, mechanical, and chemical requirements [29].

Technically, there are many factors to be considered, such as cost, reliability, durability, availability, market trends, cultural and aesthetic aspects, social concerns, and user interaction with aspects such as appearance and emotions [30,31,29,32]. Social concerns are related to thermal and acoustic comfort, good indoor air and aesthetic quality, keeping in mind that these aspects are related to human perceptions [33]. The choice of material means weighting different factors [34], which also include ease of operation/maintenance and durability.

Materials manufacturers are increasingly investing in developing products with minimal impact, concomitant with the emergence of a new design method guided by the principles of sustainability [35]. Considered a recent, even unknown, issue, many decision-makers believe that the subject relates only to the basic principles of environmental comfort or consumption of raw materials, with some initiatives relying on "fads" and the benefit provided by real estate marketing, without using criteria that relate to sustainability [36].

When aspects of sustainability in construction are linked to environmental comfort, the performance of the building's envelopment and construction components is of key importance, especially the acoustic characteristics of the specified materials [37]. Nicol and Humphreys regard the indoor environmental quality as an important factor in energy consumption, the occupant's quality of life, and sustainability [38].

As part of the envelopment, windows specifically developed in typology and construction technology, linked to the need to integrate the internal and external environment, establishing thermal, acoustic, and lighting exchange relationships. As the building component is, in many cases, the part of the envelopment that more interferes in internal thermal conditions and, therefore, is a key element in achieving the lowest energy consumption, it is also accountable for much of the environmental heat losses and gains [39].

Choosing materials and components that prioritize lower energy consumption and better performance reflect responsible attitudes, which should culminate in design solutions that encourage the adoption of strategies according to the potential of each region. Faced with such choices, there is not always a single selection criterion and the designer needs to consider and asses the aspect that is deemed to be a priority in the design, particularly when it comes to sustainability, where there is a multitude of variables to be examined.

At the same time, the dissemination and use of tools for assessing a building's sustainability contribute to that knowledge being put into effective in practice since they provide designers with a referential base and encourage better sustainability practices.

Thus, today's professional must be guided by numerous variables, such as the search for healthy, comfortable, affordable space that are responsive to social needs, while respecting natural systems and fostering the selection of materials. Furthermore, professional constantly need updating from with regard to new technologies, concepts, and paradigms [36]. An aspect of great importance to encouraging designs based on the best performance is directly related to public policies, whether in the form of programs or specific legislation.

Agenda 21 [40], for example, calls for authorities to stimulate the intensive use of environmentally sound building materials. Act No. 6938, Article 2 and 170, Brazilian law, indicate a direction regarding environmental maintenance and complement the defense of the environment, control of impacts, preservation of resources, and requirements for the sustainable use of resources.

Given that, in Brazil, the sustainability requirement is also part of Performance Standard NBR 15575 [41], the question of material specification is approached from minimum performance requirements that include durability, low maintenance, and reducing a building's environmental impact. These factors are also assessed in relation to user behavior in how the building and its components are used, which further increases the responsibility of professionals when choosing materials suitable for the type of use, the local culture, and environmental characteristics.

Assuming that the requirement of NBR 15575 is the adoption of such concepts in design practice, the selection of materials used in construction – including materials used in the manufacture of windows – should also be in line with such prerogatives. In Brazil, the quantity, quality, reliability, and degree of information detail is below the minimum required for decision-making, and often the price at the time of purchase is the only objective criterion available [42]. For the effective incorporation of new values in construction, the criteria adopted for the materials selection stage should be extended, covering considerations that go beyond the customary ones [33,35].

Act 8.666 from Brazilian law addresses the selection of materials used in public works in Brazil, which considers choosing the most advantageous bid, i.e., the lowest cost is still determining factor to define materials. However, the lowest price may not be a suitable approach for the best performance over the useful life of the material in relation to its intended use [43], since the purchase price is the only consideration, and aspects related to the maintenance costs and durability are infrequently presented as additional criteria for making a choice.

Also noteworthy is a tendency among building designers to select traditionally used materials, either because their use has been firmly established over time or they are easy for laborers to handle [44]. Given that there is a predisposition to replace underperforming materials in today's society, designers need to consider new criteria such as recyclability and the impact these materials have on the environment.

As society becomes more demanding, a design is likely to need to be developed more quickly, by including computer in the design technique, interfaces, and representation. Thus, considering current design practices, the incorporation of new requirements in the choice of materials should be made expeditiously and without generating additional costs related to the time spent doing so.

The adoption of methods for choosing materials involves new techniques and tools that collaborate with the new commitments to be met. With the global energy crisis that began in the 1970s [45], major problems concerning environmental impact began to emerge, requiring initiatives aimed at making an environmental assessment of buildings, accompanied by the development of indicators and methods for assessing sustainability [46].

3. Method

The methodological procedures were developed in two stages. The first one – **a field survey** – aimed to identify the materials used in the bedroom windows of multifamily residential buildings in Vitória, Espírito Santo, Brazil, considered to be the place where studies have been directed with regard to ISMAS structuring. Bedroom windows were chosen to be part of an environment classified as long-term by the local government building codes [47], whose habitability condition suggests greater stringency when compared to other rooms in the building. The area defined for making a survey of window types considered the following criteria: (I) locations with growth in the construction area; (II) areas with high multifamily housing density; and (III) areas with statistical records of growth and investment in the housing sector.

In light of the established criteria, the parameter of the sample area was defined by the Construction Industry Trade Union in the State of Espírito Santo – SINDUSCON, ES – [48], corresponding to a total of nine districts: Bento Ferreira, Praia do Suá, Santa Lúcia, Praia do Canto, Barro Vermelho, Santa Helena, Enseada do Suá, Jardim da Penha, Jardim Camburi, and Mata da Praia.

The selected regions are also characterized by having open areas and land with single-family buildings that are potentially favorable to new ventures. The districts have a history of about 60 years of occupation and are made up of a mix of recent and old buildings. The types of windows in multifamily buildings in use located in the sample area were recorded and all of them were classified.

At this stage, a systematic observation of facts was applied to get data that require a precise description of phenomena, necessitating the prior preparation of an observation plan [49]. To carry out this that this type of procedure, it was deemed important to define what to observe and how to record and organize information.

A map of the region was used to collect the data and a table was drawn up (Table 1) with a record of the types and characteristics of windows classified as the most sold in Vitória by Nico-Rodrigues [50]. The table was updated during data collection; photographic and descriptive records were also used for the field survey.

It is noteworthy that the window element to consider for analysis consists of a window trim, panes, and sealing elements, with the window frame being composed of beams and crossbeams; the panes being either the fixed or movable parts of the window to which the sealing elements are attached, and the sealing elements are usually made of glass, louvers, venetian blinds, and others [51]. The material in its natural composition, without added components such as pigments that alter the aesthetics, were considered when defining the sustainability indexes.

Although not identified in the field survey as one of the usual materials on the windows, an analysis was conducted of synthetic

Table 1
Model spreadsheet of the photographic, descriptive, and quantitative record of window types [50].

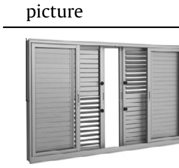
Region – district:			
Window type – picture	Template	Characteristics	Quantity
	A1	Natural aluminum/colorless glass	
	A2	White aluminum/colorless glass	
	A3	White aluminum/green glass	
	A4	Black aluminum/smoked glass	
	A5	Bronze aluminum/smoked glass	

Table 2
Adopted parameters and respective points with an analysis example of a criterion [24].

Criterion	Coverage of the criterion to drive sustainability			Complexity to assess the criterion			Impact of the criterion on the environment			Points assigned
	6 Comprehensive coverage	3 Average coverage	0.5 Little coverage	2 High	1 Average	0 Low	2 High	1 Average	0 Low	
It is possible to be reused, in whole or in part		3				0		1		**4**

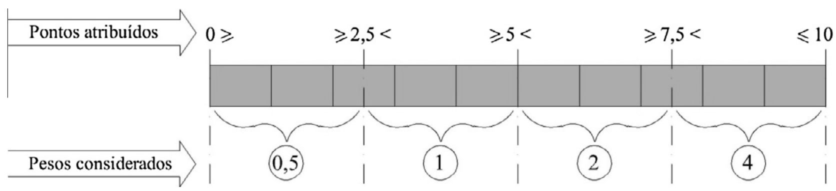


Fig. 1. Adjusted scale of points assigned to weights.

wood (WPC – Wood-Plastic Composites), also known as plastic wood or ecological wood. This decision was motivated by the results obtained by Dias et al. [52], which identify the great potential of using this material, especially for the specific environmental conditions found in coastal areas. WPC emerged in Europe in the 1970s and began to be used in the United States in the early 1990s, when the market began to accept technologies that used recycled plastics for molds, thus replacing natural wood in decks and fences [53].

The second stage of the survey aimed to **define the sustainability index of the identified materials**. It is observed that various methods, grounded in a solid scientific foundation, have been and are being developed to contribute to this process [16,17]. In Brazil in particular, some difficulties are encountered due to the lack of databases on the environmental impacts of the materials or the high cost of the processes [54]. Moreover, the lack of basic information to feed the simulations and assess the impact throughout the materials' life cycle is seen as a barrier [55]. Often it is necessary to simplify the methods and make adaptations and approximations regarding the available data [56].

Simplifying and reducing means selecting essential information to improve the performance of a given situation or is related to a dimension of sustainability [57]. Some assessment methods have limited range, since they do not cover all types of impacts, but select a few that are deemed important or necessary to meet specific requests [27]. For instance, the Agenda calls attention to the fact that the construction industry needs to propose measures to assist in selecting materials that promote the economy of raw materials and encourage the utilization of waste [40].

In this context, ISMAS was chosen as an assessment tool [24]. It aims to help the designer select materials with an emphasis on sustainability. ISMAS is a web format tool system whose structure is organized from seven criteria with positive affirmations. Considering that the criteria have differentiated values, ISMAS adopts references marks for each criterion, and suggested values are assigned with the aid of a numerical grading scale, adopting the scales used in tools like SBTool [9], which is a Green Tool [58], and ASUS [11] as examples. The score for each criterion indicates three possible response levels, in which each level presents a strategy and is tied to a particular numerical value.

To achieve standard practice (level 0), the material proposes a given situation, considered as a benchmark or best practices. As one reaches better performance levels, the objectives to be achieved are driven higher and receive a note of +1, which is considered a positive practice. Conversely, when the aims of the criterion are not met, it is regarded as a negative practice and receives a score of −1.

How each criterion influences sustainability is neither consensual nor immutable over time, highlighting the difficulty in expressing sustainability in absolute terms [59]. Macías and Navarro state the assessment of sustainability requires a score that contributes to the definition of the weighting elements [58]. Selecting what would be the "best" material requires the professional to use various, at times contradictory, criteria, which lead to weighing them individually for the purpose to which they were intended. This optimization usually results in a better design solution [17].

Therefore, a weighting system needs to be considered in the assessment tools [60], as proposed by ISMAS. For the definition of the weights [24], numerical values were adopted on a gradual scale, taking as a reference some conceptual parameters used to define the points, which are presented in Table 2.

When the assigned points are added, the value is set to the correlation weights shown in Fig. 1.

To define ISMAS weights, ranging from 0.5 to 4, the geometrical progression was taken into account (Eq. (1)), characterized by a numerical sequence wherein each term, starting with the second, is equal to the previous product multiplied by a constant.

$$a_n = a_1 \cdot q^{n-1} \tag{1}$$

Thus, the weight scale (Fig. 2) aims to numerically represent the parameters and drive them gradually. As such, it was possible to demonstrate and incite the maximum value to be considered with greater emphasis.

Table 3 shows the organizational structure of IMAS. In each criterion, the user selects a possible response, i.e., a level (−1/0/1) that determines the respective reference mark. In this survey, the analysis of each material was made by the authors, is not considered to be is opinionated, and therefore presents a result independent of sample or statistical treatment.

To represent the final result, i.e., the sustainability index achieved by the material within the selected theme, ISMAS presents a qualification scale (Fig. 3) with variations that range from −1 to 1.

4. Results

All multifamily residential buildings in use were examined during the field survey, i.e., 100% of such dwellings in a previously

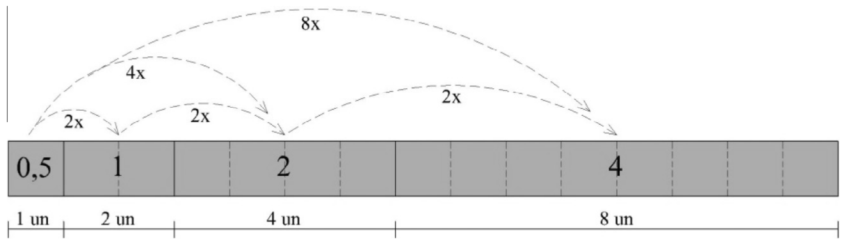


Fig. 2. Proposed geometric scale to define the weights in ISMAS [24].

Table 3
Structure of the ISMAS [24].

Criterion	Weight	Level	Reference marks
1 – It is possible to be reused, in whole or in part	1	−1	Failure to meet minimum requirements established for level 0
		0	It can be reused, but requires industrial processing
		1	It can be reused with minimal processing or directly, without processing
2 – It is renewable	4	−1	The elements that constitute the material and are from a plentiful or renewable source are present in small amounts
		0	About half of the elements of the material are renewable and abundant raw materials
		1	All material is renewable or consists of abundant raw materials
3 – Dispenses with additional materials for finishing	0.5	−1	Failure to meet minimum requirements established for level 0
		0	Needs different types of surface materials; however, this is considered just a protective material
		1	Requires no additional materials for surface finish
4 – Has recyclable elements	2	−1	Has no recycled elements in its composition
		0	Has recycled elements in its composition derived from the same material
		1	Has recycled elements in its composition derived from different materials
5 – Durability independent of maintenance	1	−1	Failure to meet minimum requirements established for level 0
		0	It has minimum design life (MDL) established by NBR 15575, and requires periodic maintenance with the use of new materials
		1	Has MDL established by NBR 15575, and maintenance occurs only with cleaning
6 – Favors dismantling aimed at reuse	0.5	−1	Failure to meet minimum requirements established for level 0
		0	It can be separated from other construction materials, but loss of material may occur because it uses binders, adhesives, and agglomerates
		1	It can be easily separated from the other materials because it uses mechanical fasteners such as moorings and screws
7 – Favors low waste generation	1	−1	Failure to meet minimum requirements established for level 0
		0	The material favors minimal waste in the construction stage
		1	Meets the requirements of level 0, including the steps of use/operation and disassembly

defined area by recording the window model used in each one, resulting in twenty-three different types of windows in 1999 buildings in use observed in the nine districts, and four types of materials used in the frame, panes, and sealing elements: aluminum, wood, PVC (Polyvinyl Chloride), and glass. It was determined that the percentages of the materials were 95% aluminum, 4% PVC, and only 1% in wood, with all window panes made of glass.

The prevalence of aluminum is related to lower cost, ease of maintenance – especially given the coastal location of the city of Vitória – durability, and suitability in relation to the volumetric design of architectural typologies. It was observed that the use of PVC is not adopted in significant amounts in the surveyed buildings, inferring that the main reason is related to the higher cost of the final product when compared to the cost of aluminum. It was also observed that some buildings, especially those built in the 1960s and 1970s, have wooden windows, a material widely used for this purpose at that time.

The sustainability index was defined for each material identified based on the results of the field survey (Table 4), also incorporating the WPC for the above reasons. Determining the level considered for each criterion was based on information provided by the manufacturers of each material.

The final analysis included the results of each criterion proposed by ISMAS, and variations were highlighted with regard to the considered specificities. In criterion 1, it was observed that the aluminum, wood, PVC, and WPC used in windows are able to be directly reused with minimal processing because they are easy to remove for replacement and/or at the end of the building's useful life. However, the glass, which is an inherently fragile material, is customarily installed with its own tape that hampers its removal and this may lead to breakage and its reuse may require industrial processing.

In criterion 2, aluminum, PVC, and glass were given an average score for having approximately 50% of their elements from a renewable or abundant source of raw materials. In criterion 3, wood was the only material used as a surface finish and then only for protection. It received the lowest score in criterion 4 for not having recycled elements in its composition. In criterion 5, wood was the only material characterized by requiring periodic maintenance with the use of new materials. This reinforces the need for the maturation of the sustainability concept regarding wood used in construction, whose assessment, as proposed by ISMAS, goes beyond the superficial concept of renewable material.

In criterion 6, glass drew attention because of its inherent fragility, which could result in losses while being removed to be reused. In criterion 7, all of the materials were confirmed as favoring low waste generation, especially given that the materials used in the manufacture of windows have been pre-sized and prefabricated.

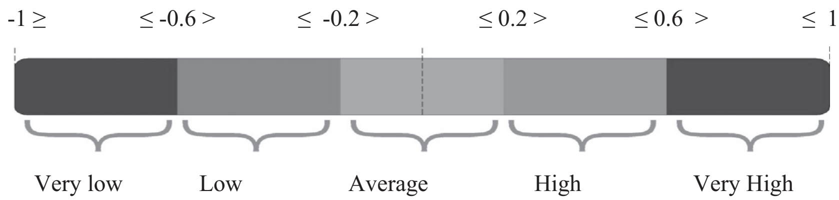


Fig. 3. Possible results of the sustainability index proposed by ISMAS.

Table 4
Sustainability index for the materials analyzed by ISMAS.

Criterion	Weight	Level obtained for each material				
		Aluminum	Wood	PVC	Glass	WPC
1 – It is possible to be reused, in whole or in part	1	1	1	1	0	1
2 – It is renewable	4	0	1	0	0	1
3 – Dispenses with the need for additional materials for finishing	0.5	1	0	1	1	1
4 – Has renewable elements	2	0	−1	0	0	1
5 – Durability is independent of maintenance	1	1	0	1	1	1
6 – Favors disassembly aimed at reuse	0.5	1	1	1	0	1
7 – Favors low waste generation	1	1	1	1	1	1
Final sustainability index		**0.4**	**0.45**	**0.4**	**0.25**	**1**
Related to savings in the use of raw materials; waste generation and management		**High**	**High**	**High**	**High**	**Very high**

Finally, there is the fact that sustainability encompasses broad and diverse concepts, making it difficult for the materials analyzed to achieve the highest levels in all the criteria. Regarding wood, although the result was below initial expectations, the undeniable potential that the timber sector plays in a sustainable development strategy should be taken into account.

As for WPC, the construction industry is currently studying the possibility of using this material in window frames and, based on the concepts adopted by ISMAS, it was the material that presented the best results in tests. It stands out as differentiators that drive getting the best sustainability index. The fact that all of the materials that make up WPC are a renewable source or composed of abundant raw materials; they do not require additional materials for surface finishing; they have recycled elements in their composition derived from other materials; maintenance occurs only with cleaning; they favor disassembly aimed at reuse (they can easily be separated from other materials because they use mechanical fastenings such as screws); and they favor low waste generation in the construction, use/operation, and disassembly stages because they are produced in pre-defined sizes for each type of use. Thus, the sustainability index for WPC indicates it as a potential material, being also considered a viable alternative due to its properties and characteristics, which enhance its use for windows.

The results also showed that, while having a goal to obtain the best score in one criterion, getting the best desired performance may not be achieved in another one. Even if one could achieve the maximum results in practice, theoretically or mathematically, it is difficult to achieve a high performance high in all criteria, because there are different priorities and constraints. Strategies recommended for achieving good performance in some aspects may conflict with other strategies. Thus, it is recommended that the designer identify and pursue the best solutions for each specific case.

5. Conclusion

The results showed that materials with different composition and properties may have the same sustainability index when measured relative to the savings in raw materials and waste generation and management, giving the designer different choices of materials for intended use.

As the main guiding element, different factors need to be considered when selecting a material based on sustainable conceptual foundations. The ISMAS instrument emphasizes only some aspects judged to be of greater importance, especially in the thematic context of this study. In this regard, it is noted that wood, when assessed under specific aspects, and not only from the standpoint of renewability, achieves lower levels of sustainability as compared to other materials, mainly because it has no recycled elements in its composition and requires constant maintenance.

Conversely, materials deemed unsustainable owing to certain aspects should also be studied to get a better idea of the criteria that drive sustainability. Within this context, the results presented by WPC stand out as a possible driving material for sustainability in construction, considering the concepts proposed by ISMAS.

Regarding ISMAS, the same criteria may be used in other parts of Brazil or even in other countries, provided the aspects considered to be most relevant in the area defined herein are the same for other locations. Eventually, there may be a need to establish constraints and adaptations according to the characteristics of each place. The results of the analysis for the same material may be different according to local conditions because issues related to the savings with raw materials and encouraging the recovery of waste may have different values in each region.

Faced with the undeniable finitude of key raw materials for construction and the need to change the way in which to exploit natural resources, the search for improvements must be accompanied by solutions that adopt traditional materials selection criteria, driven by criteria grounded in sustainable concepts.

The search for expanding sustainability assessment indicators of materials is already underway, aimed at extending precision and quantitative selection criteria, without losing sight of ISMAS's user-friendliness. The development of an instrument for use by experts is also being assessed, considering the need for complex evaluations and not necessarily linked to the design process.

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