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Qualitative and Quantitative Assessment of Urban Sustainability in Social Housing Using the Casa Azul Label and SBTool Urban in Brazil

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Featured Application: This paper presents a multi-method to evaluate urban sustainability of social housing using two kinds of environmental certifications: an international and Brazilian.

Abstract: The sustainability potential of Brazilian social housing (SH) needs to be assessed, considering the impacts on the population's quality of life and urban systems. One of the main weaknesses of Casa Azul Label refers to the absence of a procedure that quantifies the measures for assessing urban sustainability. Based on the post-occupation analysis of an SH project implemented in Araraquara, São Paulo state, Brazil, evaluation of urban sustainability was developed, using a multi-method approach combining the Casa Azul Label and Sustainable Building Tool (SBTool) Urban certification tools. It was proposed to apply the calculations established in SBTool Urban according to the Casa Azul Label certification requirements, as well as insert a national benchmark as a reference for the analysis and normalizing results. These procedures made it possible to base an improvement framework on a Brazilian environmental certification system, including a quantification system to evaluate the efficiency of the applied measures regarding urban sustainability. The multi-method approach, associated with the SBTool Urban procedures, could significantly help to improve the application of a sustainable assessment system in social housing in developing countries. The high number of residential units produced in recent years could be qualitatively evaluated, improving both the construction procedures and the criteria for the urban insertion of human settlements.

Keywords: Casa Azul Label; SBTool Urban; environmental certifications; social housing

1. Introduction

Social housing (SH) production in Brazil provided by the "Minha Casa Minha Vida" program (PMCMV in Portuguese)—which can be translated freely as "My House, My Life", has been significant in the last decade. This program has been responsible for housing developments, which have similar profiles in terms of urban insertion far away from urban centers, mono functionality, socio-spatial segregation, and low quality of units. These factors help to form dispersed cities due to the increased demand for infrastructure and the lack of efficient mobility systems and services for the population [1]. These characteristics paint a picture of urban unsustainability that directly affects the population's

quality of life, causing environmental impacts of different natures in many cities covered by this state program [2].

Taking this into account, the weaknesses and impacts of these housing developments in cities need to be understood so that improvement processes can be properly structured. [3] contributes by stating that evaluating the sustainability of these urban interventions can also help to identify the main problems faced in developing countries, as well as to improve urban management processes and new proposals for inserting housing developments. Therefore, sustainability certification tools have been used to assess buildings and urban areas in order to promote more sustainable practices in civil construction and urban planning.

According to [4], tools, such as Leadership in Energy and Environmental Design (LEED) [5], Building Research Establishment Environmental Assessment Method (BREEAM) [6], Comprehensive Assessment System for Built Environment Efficiency (CASBEE) [7], Sustainable Building Tool (SBTool) [8], AQUA-HQE (Haute Qualité Environnementale) [9] and Casa Azul Label [10], are examples of the wide range of certifications available internationally. The latter two focus on Brazilian reality.

The authors [11–13] highlight that such sustainability assessment tools can reduce the environmental impacts of the life cycle and the heat island effects of a building, mitigate the damage caused by the suppression of natural areas, reduce energy and water consumption, and minimize the volume of construction and demolition waste. Regarding the social aspect, certification methodologies help to reduce construction and maintenance costs of buildings and infrastructure, increase environmental comfort and human productivity, optimize access to public transport, improve occupants' safety, providing residents with a better quality of life.

In Brazil, the Casa Azul Label is known as being responsible for housing development certification sustainability, focusing on the social sector. This certification process was created in 2010 by the state bank "Caixa Econômica Federal", which is the main operating agent of the National Social Interest Housing Fund (FNHIS in Portuguese) based on Law No. 11124 [14]. The label relates to the main issues that guide housing production in the country, evaluating projects only in the design phase. This environmental certification system does not have the capacity to quantitatively assess the measures adopted so that an enterprise can accurately achieve a high degree of sustainability.

Recently, SH production projects have not reflected the quality that a label could add to the context. In general, the certification process used by the Casa Azul Label is limited by the mechanisms adopted to assess urban conditions for implementing housing developments, as it does not properly consider the environmental weaknesses of a given region. Another issue refers to the lack of information on housing development construction and operation, as well as the restrictions to quantify the efficiency of measures to mitigate environmental impacts. These facts are crucial for the reliability of an environmental certification process.

Social housing projects are often characterized by a limited budget, and they are generally dependent on fund transfers from federal and state governments. Therefore, adopting technological innovations by contractors in more sustainable practices is considered excessively costly, which can make investments in SH unfeasible, according to [15].

Scientific research has been conducted to understand the potential of the Casa Azul label, as well as its limitations. Many research works, such as [16–20], have considered its applicability in specific situations and in a wider scope, which enables professionals to verify the limitations and potential of the certification. Reference [15] carried out a comparative study between the Casa Azul Label and LEED, BREEAM, and AQUA-HQE [9], grouping similar requirements for certifications into categories. The author showed that the Brazilian evaluation system lacks quantitative criteria that meet some sustainability categories. [16] reported that the efficiency of the Casa Azul Label process could be improved by including the evaluation of the operational phase of a housing development, in addition to the design phase. Besides, the results related by [13] about an evaluation process carried out through the internationally recognized building sustainability rating systems on different housing units built under a social housing program in Mexico highlight the need to carry out a normalization criteria

process due to the particular characteristics of each sustainable label and the complexity to carry out a comparative analysis of different criteria.

In this context, the study presented a proposal to improve the evaluation of the Casa Azul Label tool, adopting a multi-method approach to evaluate SH and using a normalization process of sustainable criteria in the occupation phase in Araraquara, São Paulo State, Brazil. In choosing the city of Araraquara as a case study, factors common to medium-sized cities were observed, such as population growth, which contributes to the formation of attractive centers of capital and opportunities, reinforcing the need to investigate urban processes in cities with this profile [19].

This work aimed to apply a multi-method evaluation consisting of the Casa Azul Label and SBTool Urban tools with the purpose of qualitatively evaluating the urban sustainability of an SH project in Araraquara using another benchmark in São Paulo, SP. Having obtained the results, improvements could be proposed in the Casa Azul assessment system.

1.1. The Multi-Method Approach

The SBTool Urban instrument—"Sustainable Building Tool Urban"—developed by the Building Physics and Construction Technology Laboratory (LFTC-UM), Portugal, and the company Ecochoice SA, has devised a method based on the SBTool and urban community assessment. This instrument presents management and urban planning parameters, aiming to provide improvements in the quality of life in the city [3]. The method is based on the main international assessment methodologies, such as BREEAM communities and LEED for neighborhood development. SBTool Urban adopts quantitative assessment procedures, which are flexible and adaptable to the reality of the Brazilian construction market.

The evaluation structure comprises indicators grouped into categories based on the similarity of the subjects covered. The categories are grouped into three dimensions, which are environmental, economic, and social issues. The analysis process consists of adopting references to sustainable practices of real estate developments, which are called benchmarks. These benchmarks serve as a comparison model to verify obtained values by the main object of study.

The comparison between SH projects with the benchmarks aims to establish a reference that presents best practices for certain factors related to the environmental impact on society and the economy. Thus, after defining the score through comparison, the sustainability indicators undergo a normalization process in order to standardize the obtained values for the same scale, which align with international standards [13]. Thus, the standardization process establishes that values closest to 1 are considered the best assessments, while those closest to 0 are interpreted negatively. A proposal for the association of values is presented below according to the SBTool (Table 1) international methodology, followed by Equation (1) to develop the normalization calculation.

Table 1. Association of values—proposed by Sustainable Building Tool (SBTool).

Association of SBTool	Values
Unacceptable practice	−1
Acceptable practice	0
Good practice	3
Best practice (benchmark)	5

Source: Adapted from [3].

Equation (1): Normalized indicators—Formula from Diáz-Balteiro:

$$\overline{Pi} = \frac{Pi - P^*i}{Pi^* - P^*i}$$

Source [21].

where: $\overline{Pi}$ = Normalized result; Pi = Obtained Score; P^*i = Worst practice; Pi^* = Best Practice (benchmark).
Source: [3].

In the final phase, the values are aggregated from a weighted sum process for global classification that varies from E to A + according to the sustainability degree achieved by the studied SH project. The weighting table helps to define the most relevant characteristics of the SH project that influence the impact measurements identified in the region in question. By doing this, the urban conditions of the area can be reviewed to attribute a greater or lesser percentage of impact, as these are more or less significant for the evaluation of a given indicator. Finally, the results are accounted for by each indicator when calculating the weight in the project's score.

The local effect has a corrective function regarding the final result. Thus, an indicator that may present a certain natural behavior may have greater or less relevance in specific situations. This higher or lower influence is expressed by adding 5% or 10% over the final value or by subtracting those same percentages when the interpretation of the effect is small (−5%) or very small (−10%). When the effect of the indicator is considered average, no adjustment to the acquired value is considered.

Table 2 shows the sustainability gradation adopted.

Table 2. Sustainability levels—SBTool Urban.

Classification on a Qualitative Scale of Sustainability	Normalized Value
A+	>1.00
A (best practice)	0.70 < __ ≤ 1.00
B	0.40 < __ ≤ 0.70
C	0.10 < __ ≤ 0.40
D (conventional practice)	0 < __ ≤ 0.10
E	<0

Source: Adapted from [3].

As shown in Table 3, the following aspects are reviewed, to which values are assigned according to the intensity of the analyzed impacts: the extent of potential effects (A), duration of potentials (B), potential intensity (C), the primary system directly affected (D), and local effect. Weight is the result of multiplying the assigned values to the factors.

Table 3. Definition of the indicators' weights according to the characteristics of the project region.

Adjustable	Prefined Values			
Local Effect	**A—Extension of Potential Effects**	**B—Potential Time**	**C—Potential Effects Intensity**	**D—Primary System Directly Affected**
1—Very small (−10%)	Building = 1	1 to 3 years = 1	Minor = 1	Services and facilities = 1
2—Small (−5%)	Local = 2	3 to 10 years = 2	Moderate = 2	Costs and savings = 1
3—Medium (0%)	Neighborhood = 3	10 to 30 years = 3	3—Larger	Well-being, safety, and individual productivity = 2
4—Large (+5%)	Regional = 4	30 to 75 years = 4		Social and cultural issues = 2
5—Very Large (+10%)	Global = 5	>75 years = 5		Natural Resources = 3
				Non-renewable material resources = 3
				Non-renewable water resources = 3
				Ecosystem (s) = 3

Table 3. *Cont.*

Adjustable	Prefined Values			
Local Effect	**A—Extension of Potential Effects**	**B—Potential Time**	**C—Potential Effects Intensity**	**D—Primary System Directly Affected**
				Non-renewable energy resources = 4
				Local and regional atmosphere = 4
				Global Climate = 5
Weigh to be established = A × B × C × D + Local Effect				

Source: Adapted from [3].

The Casa Azul Label evaluation method consists of a set of criteria, divided into five categories, which must be attended by the SH project in order to establish conditions with low socio-environmental negative impact in the region, configuring sustainable techniques and initiatives. Globally, the project is evaluated by 53 criteria, some of which are mandatory, and others of free choice, Table 4. The criteria are grouped into 5 different categories, which are urban quality; design and comfort; energy efficiency; conservation of material resources; water management, and social practices.

Table 4. The list of requirements established for the label evaluation checklist.

1 Urban quality	1.1 Quality of neighborhood—Infrastructure (mandatory) 1.2 Quality of neighborhood—Impacts (mandatory) 1.3 Improvements in the environment 1.4 Recovery of degraded areas 1.5 Property rehabilitation
2 Design and comfort	2.1 Landscaping (mandatory) 2.2 Design flexibility 2.3 Relationship with the neighborhood 2.4 Alternative transport solution 2.5 Place of waste selective collection (mandatory) 2.6 Leisure, social, and sports equipment (mandatory) 2.7 Thermal performance—labels (mandatory) 2.8 Thermal performance—orientation to the sun and winds (mandatory) 2.9 Natural lighting in common areas 2.10 Bathroom ventilation and natural lighting 2.11 Adequacy to the physical conditions of the terrain
3 Energy efficiency	3.1 Low consumption lamps—private areas (mandatory) 3.2 Saving devices—common areas (mandatory) 3.3 Solar heating system 3.4 Gas heating system 3.5 Individualized measurement—gas (mandatory) 3.6 Efficient lifts 3.7 Efficient appliances 3.8 Alternative sources of energy
4 Conservation of material resources	4.1 Modular system coordination 4.2 Quality of materials and components (mandatory) 4.3 Industrialized components 4.4 Reusable forms and slabs struts systems (mandatory) 4.5 Construction and demolition waste management (CDW) (mandatory) 4.6 Concrete in optimized dosage 4.7 Blast furnace cement (CPIII) and Pozzolanic (CP IV) 4.8 Paving with construction and demolition waste (CDW) 4.9 Facility maintenance of the facade 4.10 Planted or certified wood use

Table 4. *Cont*

5 Water management	5.1 Individualized measurement of water consumption (mandatory) 5.2 Saving devices—discharge system (mandatory) 5.3 Saving devices—aerators 5.4 Saving devices—regular flow record 5.5 Use of rainwater 5.6 Rainwater retention 5.7 Rainwater infiltration 5.8 Permeable areas (mandatory)
6 Social practices	6.1 Education for CDW management (mandatory) 6.2 Environmental education of employees (mandatory) 6.3 Employee personal development 6.4 Professional training of employees 6.5 Inclusion of local workers 6.6 Community participation in the design of the project 6.7 Orientation to residents (mandatory) 6.8 Environmental education of residents 6.9 Training to manage the enterprise 6.10 Actions to mitigate social risks 6.11 Actions to generate employment and income

Source: Adapted from [10].

There are three possible levels of certification by the Casa Azul Label, which are:

- Bronze: Minimum compliance with mandatory criteria;
- Silver: Compliance with mandatory criteria, plus six more free choice criteria;
- Gold: Mandatory criteria, plus 12 more free choices.

It is important to highlight here some characteristics of the instruments adopted that contribute to the understanding of choosing the multi-method approach. The Casa Azul Label is aimed at the housing sector, whose assessment's focus is on SH production, on which it is evaluated using a list of attributes, several constructive issues that must be met for certification at the design stage. The main objective of the SBTool Urban, on the other hand, is to analyze the housing developments in relation to their impact on the urban space, using a more complex evaluation method that considers the particularities of the study region, in addition to having a system to assign values for measures related to sustainability that offer greater flexibility in relation to the characteristics of the region. Another issue is the possibility of SBTool Urban to evaluate projects in a post-occupation situation, going beyond the main objective of certification and promoting a technical assessment of the sustainability potential.

The association's proposal between two procedures is to confirm and complement each other's information, and one of the main advantages is to favor their improvement and improve the quality and precision of the conclusions, as recommended by [22]. According to the authors, the arguments that suggest integrating different methods are justified by the confirmation and complementarity of possible variables and criteria. The advantage lies in maximizing the amount of incorporated information, also providing better possibilities for analysis.

Thus, in addition to meeting a list of factors that aim to guide the construction and maintenance of sustainable enterprises, there is the possibility of measuring the sustainability potential qualitatively and quantitatively. These procedures can help us understand the region's weaknesses and decision-making by urban managers and entrepreneurs.

1.2. Contextualizing the Object of Study

Araraquara is a medium-sized city in São Paulo State, with an estimated population of 230,770 inhabitants in 2018. It has a high level of economic development and urban installed infrastructure, with a human development index—HDI of 0.815 [23] and an urbanization degree of 97.16% [24]. The city's location is shown below in Figure 1.

Figure 1. Araraquara and Laura Molina SH location. Source—Adapted from [20–22,25].

According to [26], this city attracts investors in the housing sector, also linked to the large offer of unoccupied lands in the urban perimeter. This profile has been common in the cities of São Paulo State, which have received significant investments in recent years by the Brazilian "My House, My Life" housing program.

Laura Molina is SH comprising detached houses with a unique typology ranging from 41 m^2 to 52 m^2 in 200 m^2 lots. The housing development is located in the Northern region of Araraquara city, characterized by the presence of water bodies, which contribute to the water supply for the whole city [27].

The region has had a significant population increase in recent years, as new housing developments have been built on the outskirts of the city with more than 3000 single-family homes as of 2010. According to [27], one of the main problems identified is silting up caused by breaking the contour lines caused by soil management in the initial practices of growing cane, soybeans, and corn. Later, this problem became worse by the opening and waterproofing of roads in housing developments. Currently, the ever-increasing process of silting up and depositing waste has restricted the operational capacity of the spring to supply the city on a yearly basis.

In this context, the importance of analyzing the potential of the neighborhood is associated with the unsustainable characteristics of urban insertion, which have contributed to the emergence and worsening of other influential problems in the population's quality of life. Linked to inserting the subdivision in an area of environmental fragility, where agriculture was initially practiced, the overload to the water supply system; health and education services; critical conditions for urban mobility; the need to expand sewage collection, and water distribution networks are some of the problems that characterize Laura Molina as a project, which has had a significant impact on the natural and urban environment [26–29].

In Figure 2, the proximity of developments in the northern area of the city can be observed in relation to the Ribeirão das Cruzes Stream, which has caused other problems, such as silting up due to the suppression of vegetation and the dragging of construction sediments.

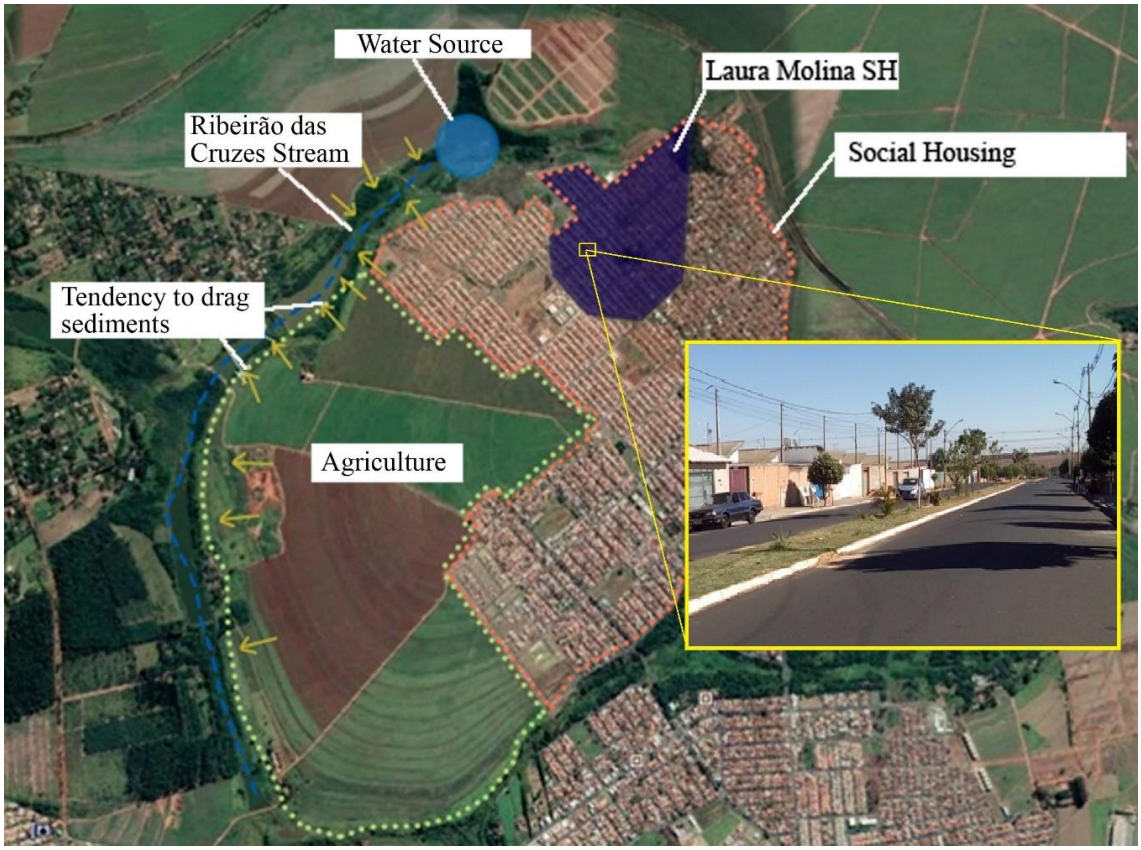

Figure 2. Araraquara north area. Source: Adapted from [25,27].

2. Materials and Methods

The study strategy was to adopt a multi-method procedure considering the combination of requirements used by the Casa Azul Label and calculation processes referenced by SBTool Urban to assess the sustainability of an SH project and normalize the results.

In addition to this, a quantitative assessment was considered to be the number of requirements met, and the more requirements met by the housing enterprise, the greater the degree of certification achieved. On the other hand, a qualitative assessment considered the quality of the verified indicators, analyzing not only their status as attended or not but also other relevant factors to the region, such as the degree of influence regarding other indicators, the cumulative effect over time, or the potential for impact.

The Paraisópolis buildings E and G [10] of social housing, located in São Paulo city, were adopted as a benchmark for analysis as it is one of the best-rated properties by the Casa Azul Label in Brazil.

The study was organized into two main steps. The first one was subdivided into two phases dedicated to analyzing the process, which included gathering information regarding the classification criteria and the characteristics of the Laura Molina social housing. The second one described the evaluation process of four categories of urban sustainability, measuring indicators with the respective analysis of results. The steps are shown as follows:

Step 1

1. Collected data about the project and other documents related to the approval and licensing process with the municipality of Araraquara, the technically responsible private companies involved in the construction period, technicians from the public sector, and other scientific research already carried out in the study area. Regarding the licensing process, public access documents were verified in general lines, such as urban design, urban infrastructure project, water, sewage and drainage system,

and constructive technical specifications, based on documents provided by the Municipal Secretariat for Urban Development of Araraquara Council [30].

2. Defined measurable requirements and understood available information, such as permeable areas, drainage plans, solid waste disposal policy, water consumption, and other information that contributed in response to the parameters of the instruments adopted. Due to the easier access to information, the analysis was developed, focusing on four categories of the Casa Azul Label: urban quality, design and comfort, energy efficiency, and water management. In total, four categories were evaluated out of a total of 21 requirements of the Casa Azul Label, 10 of which were attended by Laura Molina [10,30].

Step 2

1. As the proposed classification methodology by SBTool Urban recommended, a benchmark was established, evaluated by the Casa Azul Label with the largest number of characteristics similar to the Laura Molina SH as a sustainability reference. Paraisópolis Buildings E and G, located in São Paulo, were chosen for being a result of an urban and environmental program of interventions in the Paraisópolis community, where part of the neighborhood is considered a subnormal occupation. The enterprise is formed by eight apartment blocks, two of which, Buildings E and G, certified by Casa Azul Label, which together totals 171 housing units. The blocks are composed of 4 floors that were built respecting the steep slope of the land. The area of the housing unit varies between 52 and 55 m^2 [10].

2. Compared information from the reference project (benchmark) and the case study based on the criteria set out by the Casa Azul Label. Developed analysis tables with the survey of the requirements to obtain the scores of each procedure, such as urban infrastructure, environmental impacts, improvements in the neighborhood, recuperation of degraded areas, and property rehabilitation.

Urban Quality Category

3. Made the calculations proposed by the SBTool Urban through surveys carried out in the categories of the Casa Azul Label and adopted the benchmark, followed by making the calculations for benchmark evaluation by adopting an ideal profile considering the fulfillment of all the requirements of the Casa Azul Label. The latter was proposed as a way to evaluate the reference adopted, considering its limitations identified in scientific research.

4. Evaluated by category, according to the identified requirements by the SBTool Urban tool and discursive analysis of the potential of the case study to promote sustainability. Thus, as a final result, the sustainability parameters could be verified, proposed by the Casa Azul Label together with the referenced assessment and the development of the SBTool Urban normalizing results, that is, associating two different methods for the same project and its implications.

Figure 3 shows a flowchart of the study.

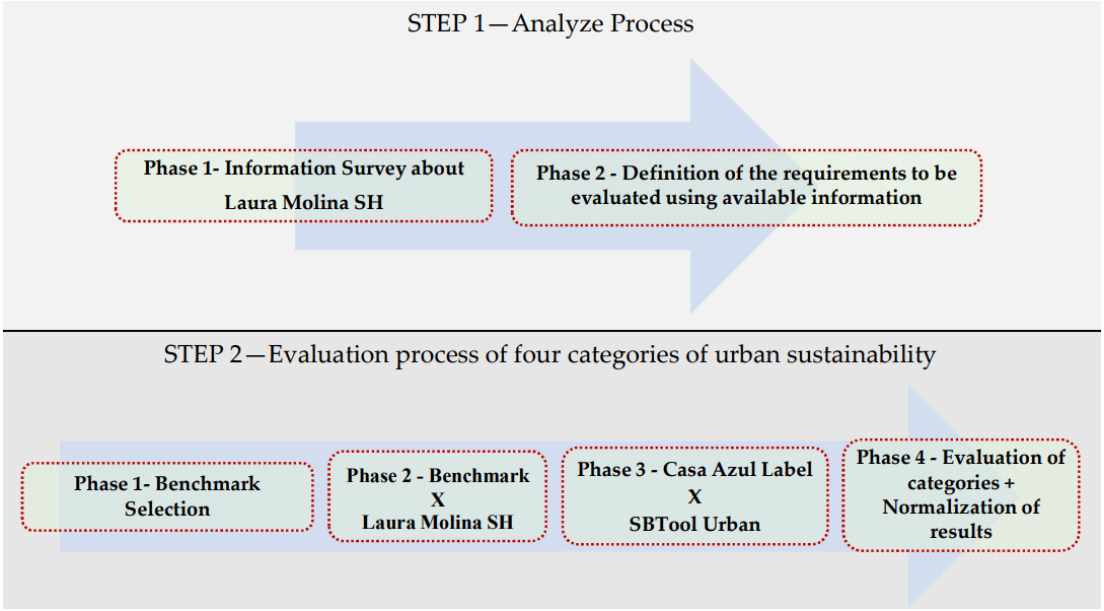

Figure 3. Flowchart of the study.

3. Results

Initially, the requirements to evaluate the four evaluated categories were selected: urban quality, design and comfort, energy efficiency, and water management. Moreover, 21 requirements of the Casa Azul Label were detected, 10 of them were attended by Laura Molina SH.

The categories of "conservation of material resources" and "social practices" were not included, respectively, due to the lack of access to information regarding the applied materials and the waste destination. Furthermore, there was no information and documentation that could prove the existence of educational programs involving workers and future residents during the construction period, as the label recommends as criteria.

The Paraisópolis Buildings E and G results, adopted as a reference, were assimilated with the highest score proposed by the SBTool methodology, while the case study, Laura Molina SH, was scored by comparing it with the presented values by the benchmark. After the score was established, and the normalization formula was applied, the weights for each category were calculated considering the influence of the indicators' impacts in the region where Laura Molina is located [10,30].

The urban quality category exemplified the adopted process in the others for which the same steps were repeated.

Step 2–Phase 2—Initially, the benchmark survey was carried out and then the case study.

The following table (Table 5) gathers information from Paraisópolis Buildings E and G and Laura Molina SH regarding the requirements of the Casa Azul Label of the urban quality category. It is possible to check through the checklist which requirements were or were not met by both projects.

Table 5. Urban quality category—the evaluation of Paraisópolis E and G × Laura Molina social housing (SH).

Evaluation Requirements and Criteria		Paraisópolis E/G—Buildings	Laura Molina SH
1.1 Quality of the neighborhood—infrastructure (MANDATORY)	Electrical network	✓	✓
	Drinking water supply network	✓	✓
	Paving	✓	✓
	Street lighting	✓	✓
	Sewerage	✓	✓
	Leisure equipment (maximum 2.5 km)	✓	X
	Drainage	✓	✓
	Public transportation	✓	✓
	Health posts (at 2.5 km maximum)	✓	✓
	Trading points	✓	✓
	Schools and kindergartens (with a maximum of 2.5 km)	✓	✓
	In general:	Met	Met
1.2 Quality of neighbourhood—Impacts (MANDATORY)	No sources of excessive noise, smell, and air pollution.	Met	Met
1.3 Neighborhood improvements	Recuperation of sidewalks, public equipment, afforestation, squares, etc.	Met	X
1.4 Recuperation of degraded areas	Recuperation of 20% or more in the area of the SH	Met	X
1.5 Property rehabilitation	Property rehabilitation/filling urban voids	X	X
Total		4	2

Step 2—Phase 3—After checking the list, the appropriate scores were assigned according to the international SBTool Urban instrument. As this was an assessment focused on the categories, the method for assigning values from the SBTool tool was adapted to the number of met requirements, similar to the Casa Azul Label.

- Unacceptable practice (<25%) = −1
- Acceptable practice (≥25% × <50%) = 0
- Good practice (≥50% × ≤75%) = 3
- Best practice (>75% × ≤100%) = 5

Results of both sets:

- Paraisópolis Building E/G = met 4 criteria (best practice) = 5
- Laura Molina SH = met 2 criteria (50%) = 3

Step 2—Phase 4—Calculation of normalization and association of values, as presented in Equation (1).

- $\overline{Pi}$ = Normalized results
- Pi = Obtained score
- P^*i = Worst practice
- Pi^* = Best practice

Normalized value: $(3 - (-1))/(5 - (-1)) = 0.66$
Weighting calculation is shown in Table 6.

Table 6. Calculation of weighting and final result (category contribution)—urban quality.

A = Extension of Potentials R: Neighborhood (3)	B = Length of Time Potential R: 10–30 Years (3)	C = Intensity of Potential Effects R: Moderate (2)	D = Primary System Directly Affected R: Well-Being, Safety, Productivity (2)	Local Effect = Small (−5%)
=A × B × C × D = 3 × 3 × 2 × 2 = 36		WEIGHT = 0.36 −5% = 34.2%	FINAL RESULTS (normalization with influence weight) = 0.66 × 34.2% = 0.225 = 0.23	

Table 7 shows a summary of the checked services and presents the service profile of Laura Molina SH.

Table 7. Profile of the evaluation of Laura Molina SH using the benchmark.

General Survey Framework—Laura Molina SH				
Categories	**Met Requirements—Benchmark**	**Met Requirements**	**Normalized Values**	**Sustainability Gradation**
Urban quality (5 requirements)	4	2	0.66	B
Design and comfort (11 requirements)	8	6	0.66	B
Energy efficiency (8 requirements)	3	0	0	D
Water management (8 requirements)	6	2	0.16	C

The values presented so far were related to the best benchmark ever evaluated by the Casa Azul Label. However, considering the identified limitations in scientific research relating to Paraisópolis Buildings E and G, the evaluation of Laura Molina's requirements and the benchmark in relation to the ideal profile established by the label has been analyzed below. First, the weighting of Paraisópolis Buildings E and G was prepared based on the service record by the Casa Azul Label certification and scientific research that studied the region of the buildings. Thus, a profile for the benchmark and that of Laura Molina SH was established in relation to an ideal profile considering the fulfillment of all the requirements of the Casa Azul Label, as shown in Table 8.

Table 8. Evaluation profile of Laura Molina SH—ideal Casa Azul Label.

General Survey—Laura Molina SH.						
Categories	**Normalized Value**	**Sustainability Gradation**	**Weighted Value**	**Benchmark Value—Normalized**	**Sustainability Gradation**	**Weighted Value**
Urban quality	0.16	C	0.06	1.00	A	0.38
Design and comfort	0.66	B	0.08	0.66	B	0.25
Energy efficiency	0	D	0	0.16	C	0.003
Water management	0.16	C	0.006	0.66	B	0.16
Partial classification of the sustainability level			0.146 (C)			0.793 (A)

The requirements observed allowed the reading of some subjects, being able to identify the degree of importance and influence of the existing impacts at Laura Molina SH. According to the identified perceptions, the results reflected the negative aspects that gave the project an unsustainability profile. They were less significant, according to the low verified influence on the composition of the final sustainability achieved value.

Table 9 shows the results of the performed calculations at Laura Molina SH using the benchmark.

Table 9. Evaluation profile of Laura Molina SH.

General Survey Framework—SBtool Urban Calculation—Laura Molina SH		
Categories	**Assigned Weights**	**Final Score**
Urban quality	34.2%	0.23
Design and comfort	12%	0.08
Energy efficiency	0%	0
Water management	3.8%	0.006
Partial classification of the sustainability level		0.32(C)

3.1. Urban Quality Category

In general, the "urban quality" category met two requirements, expressing a value of 0.66, equivalent to level B of the sustainability gradation adopted. Concerning the investigated benchmark, there was a significant difference with Paraisópolis Buildings E and G adopting a score of 1.00 (level A). Among the five established requirements by the Casa Azul Label, the studied object met two of them: "quality of the environment infrastructure" and "quality of the environment—impacts".

The requirement "quality of the neighborhood infrastructure" was considered fulfilled since the project has an electricity network, drinking water supply, public lighting, as well as some commercial outlets, schools, daycare centers, and health centers within a radius of 2.5 km [10].

On the other hand, the infrastructure issue was controversial as the fulfillment requirement did not consider the association with the peripheral insertion of the buildings, which incurred expenses for the public authorities for the expansion of water distribution systems, sewage, and energy networks. This situation compared the ideal of a compact city and its benefits.

In the "urban quality" category, when compared to the benchmark, Laura Molina SH presented an approximate score, with the difference of two met requirements.

The weight obtained was 34.2%, and the final score was 0.66, which initially revealed a reasonable situation since results between 0.40 and 0.70 conferred a grade B as the gradation of the SBTool Urban established.

3.2. Design and Comfort Category

The "design and comfort" category was the one that achieved the best performance with six met requirements among the eleven existing and considered. The corresponding score was 0.66, which was also the same one adopted by the benchmark when considering the ideal of full compliance with existing requirements since the difference in service between the two projects was only two requirements.

However, weights differed significantly, with Laura Molina SH admitting 12% and the benchmark 37.8%. This differentiated the exerted influence on the impact regions where they operated in and, consequently, reflected the potential of the benefits offered to users.

3.3. Energy Efficiency Category

The energy efficiency category was the only one in which the project did not meet any criteria. As it is an essential resource for the habitability of homes, the cost of which significantly impacts the economy of families, the negative impact had a great influence on the sustainability potential of the neighborhood.

Thus, the benchmark stood out with a 0.16 score (level C), and a weight of 1.9%, considering the fulfillment of the requirements "low consumption lamps"; "individualized gas measurement", and "saving devices—common area". Here, it is important to highlight the nature of relevance of these services, which were reduced to those ones with little contribution to the complex as a whole, like the requirements that could add to the option for renewable energy sources, for example, such as the requirement "alternative sources of energy". Thus, the translation of the impact in relation to the considered aspects contributes to the reading of how important these services can be for reaching more sustainable situations for the region.

3.4. Water Management Category

The water management category had two requirements met by Laura Molina, compared to six met by the benchmark among the eight existing ones. The scores achieved were 0.16 (level C) and 0.66 (level B), respectively. The weights calculated were 24% for the benchmark in question and 3.8% for Laura Molina.

Laura Molina SH attended the requirements of "rainwater retention" and "individualized measurement". It was observed that the reading of these requirements showed a lack of primary resources that could contribute to a saving water resources policy, another identified aspect referred to the stage in which this assessment was focused on. According to the parameters of the Casa Azul Label [10], the required saving devices refer to the building under occupation, with no other parameters that enable the conference during the construction site stage. Even though the criteria were demanded during the design phase, the evaluation did not expand to the construction site specifically, nor to the understanding of the conditions of water supply infrastructure in the region.

In Figure 4, the achieved values by Laura Molina SH in relation to the benchmark Paraisópolis Buildings E and G are presented, as well as the profile of the latter in relation to the ideal service adopted profile.

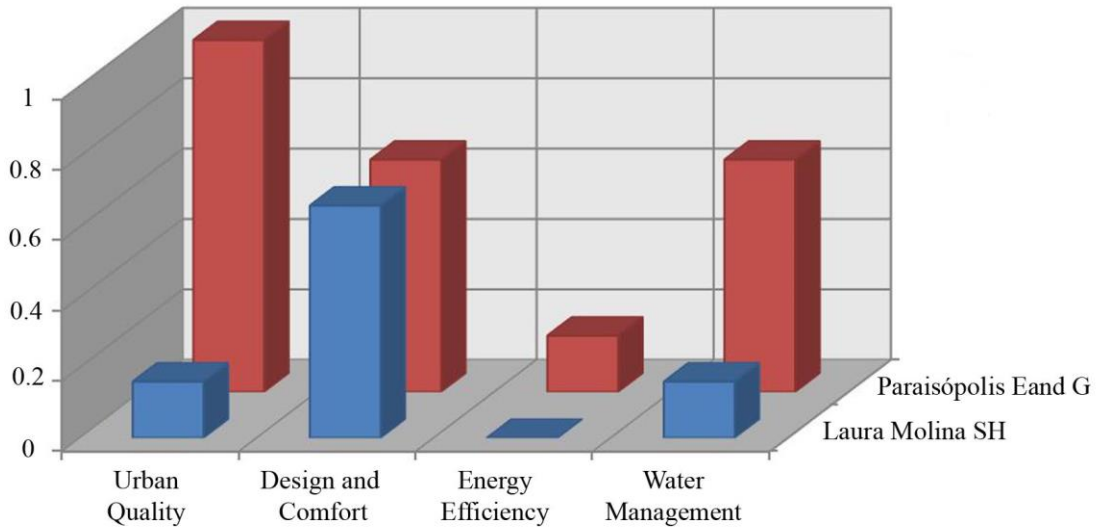

Figure 4. Partial sustainability profile of projects.

4. Discussion

According to [4,29], the certification systems aim to measure the environmental impacts of buildings and construction projects in a generic way. In some cases, these systems may also cover urban scale projects, community, and infrastructure projects. These schemes are designed to help project management make them more sustainable, providing precise criteria to assess the various aspects of a project's environmental impact and possible mitigation measures.

However, it can be observed that the application of certain tools must be in line with the normative and legal context of the place in question. Managers and consultants need to understand the social, economic, and environmental characteristics to follow the most appropriate procedures [20]. References [12,13] points out that methodologies, such as LEED, BREEAM, and SBTool, were initially developed according to the realities of their countries of origin and, then, were adapted to the circumstances of each country in which they were applied.

The studies carried out in Mexico by [13,20] indicate that housing developed by the funding program for housing solutions obtained low qualifications according to building sustainability rating systems, with deficiencies concerning materials, energy efficiency, indoor environmental quality, and management. The authors have also pointed out that Mexican sustainable social housing does not comply with other global certifications among all indicators, as much as we could detect in Brazil, mainly those that depend on urban indicators.

One of the causes pointed out in terms of the lack of investment in energy efficiency can be explained by the construction profile of social housing, usually with an insufficient budget. Reference [17] shows that among the projects certified by the Casa Azul Label, those that present a higher standard, meet the requirements of the categories urban quality, energy efficiency, and water management. Thus, it should be noted that the SH budget is often limited to obtain a higher quality in this regard.

Therefore, it is increasingly important to develop methods that are adaptable to provide reliable and comparative assessments in different locations. Often the adopted criteria by a certification label can be irrelevant for specific situations and very important for others, hence the need to create mechanisms for weighting calculations and to balance sustainability of the system according to [21].

The post-occupation research on Laura Molina SH has demonstrated the reality of a project in Araraquara, Brazil, built with a low commitment to environmental issues and adopting few measures in favor of greater sustainability. The comparison with a benchmark, well evaluated by a Brazilian system, has shown that Laura Molina SH is characterized by the low quality of the properties. It is inserted in a place far from the consolidated urbanized network, with little or no leisure equipment,

hardly any public transportation service, and the population has difficulty in accessing public services, which increases the socio-economic vulnerability of users [18,29,31].

This situation is notable in several countries in Latin America, as reported by [28,32], mainly due to the role of private capital in investment in the housing system of social interest and the land structure highly concentrated on a few landowners. These aspects have produced contestable space results, such as the increase in the periphery, the low construction quality of the habitation units, the increase in costs for maintenance and expansion of urban infrastructure, and the high environmental impacts.

Among the local aspects that are not part of the evaluation, the speculation of the real estate sector that influences the current scenario of the city stands out, which is also a deterministic point in the inadequate urban insertion Laura Molina SH. The price of land is directly associated with its potential for use and allocation of services, determining access for those who have payment conditions [33]. According to [19], a compact city, associated with the existence of sub-centers, helps to include more people having access to city services, such as transportation, leisure, and other public services, considering lower costs for managers and higher efficiency in the resources and energy consumption.

Thus, the higher prices in the central regions, together with the possibility of exploring a larger number of housing units, are decisive for the choice of implementing SH in peripheral regions, in which the price and the greater availability of contiguous area contribute to a higher profit margin for landowners and builders.

The calculation methodology applied to the Casa Azul Label evaluation process has allowed an objective reading of the degree of importance of the environmental indicators identified in Laura Molina SH, in addition to giving flexibility to the certification. [34] presents adaptability as the most important primary characteristic regarding the application of sustainability assessment methods. Thus, regarding the weights, it is possible to understand that they are associated with the reading of impacts in an equivalent manner to the degree of identified relevance in the project, with the category "water management", which is the least collaborative for the sustainability potential of the weighted neighborhood 3.8%.

The adoption of the Casa Azul Label tool directly contributes to a greater familiarity with the main Brazilian issues; however, there is a need to expand the requirements addressed so that the readings can be carried out with greater coverage and with themes that include aspects of a quality urban insertion. In an improvement process, the need for reassessment is also of great influence for the revitalization of the quality of the undertakings in a general context, both for those already certified and for those who do not have certification. Changes in policy, architectural typologies, technological construction processes, and the lifestyle of communities should be observed, for example, to improve the efforts of housing programs and others involved in providing better quality housing [35].

5. Conclusions

Considering the low sustainability potential of SH projects in developing countries, this study has attempted to show the need of applying the SBTool Urban certification based on the Brazilian criteria recommended by the Casa Azul Label to assess the urban sustainability potential of SH developments already built. By adopting the calculation system proposed by SBTool Urban, it is possible to attribute a gradation of the level of sustainability achieved by the project in a partial way, which has not been possible by the Casa Azul Label procedures until then.

It is understood that the results reflect the surveys carried out and the influence of the adopted benchmark. The requirements show the specific reality in each area addressed, in which the weighting process is responsible for translating which categories are most influential in the actual conditions of the settlement.

It is important to highlight that the classification attributed to Laura Molina SH has considered four of the six categories proposed by the Casa Azul Label due to the lack of information to analyze all possible indicators. Therefore, its real sustainability profile can be improved as companies and public

administration bodies, responsible for the implementation, have reliable information and incentive mechanisms to adopt measures to mitigate environmental, social, and economic impacts.

Another aspect to be considered refers to the refinement of calculations in situations where the number of requirements fulfills the same percentage established range. In such cases, it is common that small differences are not expressed by the calculation. A solution is to include new benchmarks so that the calculation proposal is initiated by the requirements individually and, then, the values are calculated by categories.

The multi-method approach, associated with the SBTool Urban procedures in the post-occupation phase adopted in this study, can significantly help to improve the Casa Azul Label and its application in developing countries in such a way that a large contingent of social housing built in recent years can be qualitatively evaluated, improving both the construction procedures and the criteria for the urban insertion of human settlements.

The current requirements proposed by the Casa Azul Label focus on isolated and static sustainability indicators, without covering urban insertion, the availability of resources in a given region, and the particularities of operation and maintenance of a social housing enterprise in the environmental certification process.

Therefore, the association of weighting and benchmark calculation procedures with the requirements of the Casa Azul Label is a feasible alternative for improving the sustainability classification system adapted to the Brazilian reality and the particularities of a region.

The results of the research demonstrate that it is possible to develop more flexible systems to assess the quality of SH projects in Brazil and Latin America under post-occupation conditions in places that share similar characteristics. Thus, the referenced assessment inserting the weighting calculation aims to guide an objective mapping that, in the future, can help decision-making in the process of improving both the housing unit project and the city as a whole.

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