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Sustainability Assessment on an Urban Scale: Context, Challenges, and Most Relevant Indicators

Maryam Salati [1,*], Luis Bragança [1,2] and Ricardo Mateus [1,2]

[1] Institute for Sustainability and Innovation in Structural Engineering (ISISE), University of Minho, 4800-058 Guimarães, Portugal; braganca@civil.uminho.pt (L.B.); ricardomateus@civil.uminho.pt (R.M.)
[2] Civil Engineering Department, School of Engineering, University of Minho, 4800-058 Guimarães, Portugal
* Correspondence: pg41160@alunos.uminho.pt

Abstract: The concept and practice of sustainability in urban planning have gained worldwide significance since the early 2000s and have become increasingly mainstream in the policymaking process. Adopting global frameworks, such as the United Nations Sustainable Development Goals and ISO standards, for sustainable communities provides an opportunity to build more sustainable, innovative, and equitable towns and cities, with regard to natural resources and biodiversity. However, attaining sustainability requires addressing many fundamental issues at various levels, and achieving the goals and objectives of sustainability poses a significant challenge for all segments of society. Several methods for assessing the sustainability of the urban environment have been established in recent years. Therefore, compiling a short and comprehensive list of indicators addressing the broad concept of urban sustainability issues has arisen as a significant challenge. This research reviews four urban sustainability assessment tools—BREEAM-C, LEED-ND, iiSBE SBTool^{PT} Urban, and iiSBE SNTool—to identify a clear set of key sustainability priorities. This study aims to highlight a more consistent list of indicators that are considered the most significant aspects and priorities within the analysed sustainability methods, allowing for a common understanding of the most important principles that must be considered in the design of sustainable urban areas and are compatible with the most recent standardization and sustainability targets. The end product of this study includes a proposal for a set of sustainability indicators to assess environmental, social, and economic issues to implement in the design of sustainable urban environments, independent of the local context.

Keywords: urban sustainability assessment tools; urban sustainability indicators; neighbourhood sustainability; SNTool; SBTool^{PT} urban; LEED-ND; BREEAM communities

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1. Introduction

Analysing how cities use natural resources and energy shows two of their most important aspects. While local authorities and urban decision makers can implement measures to reduce resource needs and environmental impacts, there is a vast number of multicriteria methods and tools to assess the sustainability of the built environment through multicriteria methods and tools (e.g., BREEAM-C (Building Research Establishment Environmental Assessment Method for Communities), CASBEE-UD (Comprehensive Assessment System for Built Environment Efficiency for Urban Development), LEED-ND (Leadership in Energy and Environmental Design for Neighborhood Development), GBI (Green Building Index) for Township) used in different countries. This has led to the development and application of urban sustainability indicators, which have gained momentum, especially since specific urban indicators were created for Agenda 2030 [1] to address social, economic and environmental issues, resulting in a large dataset of urban sustainability indicators. These emerging sustainability initiatives, which at the beginning were focused on micro-scale (building scale) developments, evolved later into macro-scale (neighborhood scale) developments. This is driven by the fact that focusing on individual buildings does not consider the impact of the building sector in a broader view of the sustainable environment [2].

Furthermore, it is widely recognized that traditional urban planning models and approaches have contributed to the present environmental problems [3]. It is evident that attaining sustainability requires addressing many fundamental issues at local, regional, and global levels, and accomplishing sustainability's goals and objectives is a huge challenge for all segments of society [4]. Therefore, achieving sustainable development is one of the most difficult challenges that humanity has ever faced.

Decision makers and policymakers need sustainability assessment systems to determine what measures they need to take to make society more sustainable. Sustainability assessment methods can assist in identifying alarming vulnerabilities in environmental degradation related to the built environment and buildings and socio-economic inadequacies of neighbourhoods. These systems are developed through the indicators, which are related to the identified criteria and harmonizing systems inherent in every assessment tool. Therefore, developing an assessment method to measure, monitor, and compare the sustainability of the neighbourhood's environment to create a common vision of the predominant environmental issues and crises in planning and development activities, is a necessary step toward sustainable development goals. However, the current profusion of building and neighbourhood sustainability assessment systems, which are based on a range of different assessment methodologies, frameworks, types, sustainability criteria, and priorities, among others, makes it impossible to compare results, leading to confusion and ambiguity [5]. This raises the issue of establishing a harmonization process to standardize indicators [6]. Some international attempts are implemented to create a uniform, consistent framework of sustainability indicators (e.g., CESBA (Common European Sustainable Built Environment assessment), and Level(s) (the Life for LCA LCC)). However, there are still numerous debated arguments for and against the need to design common indicators [4]. Earlier studies regarding this issue have paid more attention to defining urban sustainability indicators which are oriented to specific national or regional contexts [1,7], critically reviewing the sustainability assessment tools, comparing the weights assigned to the indicators [2,8–12], and discussing the standardization of common indicators [13]. Considering similar observations, comparing the outcomes of different sustainability methods is difficult because they focus on different environmental, societal, and economic criteria, as well as on different life-cycle phases of the built environment. In this context, this study aims to develop a more consistent list of indicators based on the most relevant sustainability assessment methods to support sustainable urban planning strategies. The result is presented through a proposal of a set of sustainability indicators that are based on the most important indicators of the reviewed methods and are compatible with the most recent standardization and sustainability targets. It is intended that this study establishes a better understanding of the central themes and most significant aspects and priorities to implement in the design of sustainable urban environments, independent of the local context.

The reviewed methods are BREEAM-C (Building Research Establishment Environmental Assessment Method for Communities) (2012), LEED-ND (Leadership in Energy and Environmental Design for Neighborhood Development) (2018), iiSBE SBTool^{PT} Urban (2018), and iiSBE SNTool (Sustainable Neighborhoods Tool) for a Minimum version (2020). The findings reveal minimum numbers of indicators with a high level of overlap among the selected tools to deliver the minimum, yet comprehensive, requirements for urban sustainability objectives. This is aligned with the goal of standardization and improving the consistency of existing and future assessment systems, which facilitate data comparison between projects. This also allows for a comparison between the sustainability priorities of the systems and SDGs (Sustainable Development Goals) and ISO (the International Organization for Standardization), connecting local- and global-level strategies.

1.1. Emergence of Sustainability Assessment Methods

In response to the inherent relationship between the growing environmental problems and the global economic competition of capitalist systems, the evolution of sustainability assessment methods has come a long way since its early phases [14]. These methods were developed to address the environmental challenges that evolved due to the economic consequences of the growing consumption of non-renewable resources, waste production, and pollution [15]. Agenda 2030, the first practical measure for implementing sustainable development, resulted from the 2012 UN Conference on Sustainable Development (UNCSD, or Rio + 20), which negotiated the Sustainable Development Goals (SDGs). Agenda 2030 includes 17 SDGs, which encompass 231 unique indicators, in order to build a more sustainable, safer, and more prosperous planet for all of humanity. The agenda of the Paris Climate Conference in 2015 matches the SDGs, which provide common criteria and achievable targets for reducing carbon emissions, managing climate change and natural disaster risks, and limiting global warming by at least 2 °C (UNDP). In addition, ISO focuses on a wide range of subjects in the environmental field, covering a vast range of standards, including air quality, water quality, soil quality, environmental management, renewable energy, etc. These efforts aim to reduce the built environment's carbon footprint and environmental impact, while also considering social issues, such as thermal comfort, ease, and convenience [16]. Ultimately, these principles, which were subsequently grouped into specific categories, helped to address the sustainability of a building or neighbourhood. Currently, many decision-making models are being developed to support the definition and implementation of actions targeted to improve the sustainability of the built environment in urban areas (e.g., CESBA MED, the Common European Sustainable Built Environment Assessment for Mediterranean Cities). This allows for the practical implementation of the Agenda 2030 goals. In the context of neighbourhoods, a sustainability assessment tool is a tracking system for identifying, measuring, and evaluating different neighbourhood variables to determine which features and dimensions of the concept are the most prominent in the community versus which receive less attention. In this regard, sustainability indicators can be defined as broad measures of environmental, economic, and social aspects that can track changes in urban system characteristics important for human and ecological well-being [17]. In general, indicators are primarily "data carriers", measuring entities whose identity exclusively relies on the variables and parameters with which they are associated, regardless of the context, intent, or reasoning behind their use [18]. However, numerous indicators that cover a range of areas can be used to examine a single issue [8].

1.2. Definition and Characteristics of Sustainable Neighbourhoods

A neighbourhood is a morphological and structural entity defined by a specific urban landscape, a specific social context, and different functions [19]. At the same time, neighbourhood features include various factors, such as space, form, building type, uses and activities, quality, level of maintenance, symbols, etc. CESBA MED [6] recommends defining the size of a neighbourhood as a square area of 200–800 m, which can be crossed in a 10–15 min walk and has between 200 and 1500 inhabitants. The basis of new urban areas is based on mixed-uses developments, including a variety of types of homes varying in cost, stores, schools, and workplaces; moderate- to high-density developments, aligned with the layout of local streets, including car parking and garages; convenient access to public transportation; accessibility to neighbourhood parks, and so on. These characteristics are also considered as the basis for sustainable neighbourhoods. According to Engel-Yan [20], sustainable neighbourhood design requires a well-developed understanding of the interactions between micro-level objectives and the limitative macro-scale conditions. Before planning a sustainability development scenario for urban neighbourhoods and even for planning buildings, a set of clear and measurable targets must be defined.

2. Materials and Methods

To achieve the above-stated aim, four established sustainability certification systems for urban contexts were reviewed based on the technical manual of each tool. The analysis focused on the list of sustainability categories and indicators covered by the different methods to identify the key sustainability criteria that should be considered and assessed in every urban region. In addition, the gaps and similarities in the selected assessment tools were identified.

2.1. Choosing the Assessment Tools

Several indicator sets were studied in the literature review. Four final sets were selected according to their criteria, including a clear and comprehensive basis of sustainability, recent activity, urban scale, and availability of the indicators. The chosen sets were BREEAM-C (Building Research Establishment Environmental Assessment Method for Communities) (2012) and LEED-ND (Leadership in Energy and Environmental Design for Neighbourhood Development) (2018), which are pioneer methods in building and neighbourhood sustainability assessment [21], and two other tools provided by iiSBE (the International Initiative for a Sustainable Built Environment), including SNTool and SBTool^{PT}_Urban from iiSBE Portugal. SNTool has two versions, a maximum version with a comprehensive list of 160 sustainability criteria and a minimum version with 34 criteria, the latter of which was chosen for this study.

2.2. Defining the Sustainability Categories and Redistributing Indicators

The study initially rearranged the indicators in a common framework to compare the sustainability criteria covered by the selected methods. The categories are macro sustainability indicators that gather a set of indicators that address the same sustainability priority [8]. Additionally, the indicators are a multifaceted construct that includes a label, a unit of measurement, and a description [22]. Therefore, the study categorized the most relevant indicators into 12 categories according to the sustainability criteria they covered, as presented in Table 1.

Table 1. Redistributing indicators according to sustainability categories.

Categories	Indicators	Explanation (Main Issues and/or Measurements Included in the Indicators)
Urban structure and form	Use passive solar design strategies	Passive solar design strategies, natural ventilation, shading, the orientation of the buildings, urban layout to maximize solar gain, use of daylighting, shading, topography
	Use natural ventilation potential	Wind management, natural ventilation, controlling climatic conditions on a micro-scale, thermal comfort
	Smart locations and efficient urban network	Safe and secure street layouts, connectivity, and designated high-priority locations to reduce distances, facilitate circulation, and mitigate potential noise disturbance
Transportation infrastructure	Availability of public transport service	Accessibility to the alternative public transport options, quality of public transport road network, and transit facilities and amenities, use of clean, renewable energy in public transport, use of public transport for physically disabled persons, provision of safe, convenient, and comfortable transit waiting areas, and availability of public transportation in the outskirts with access to car parks
	Pedestrian path accessibility	Pedestrian safety and accessibility, shaded sidewalks, accessibility of people with disabilities to crucial buildings, walking distance to public transport
	Cycling network and facilities	Quality cycle path network, adequate provision of cyclist facilities
	Availability of on-street and indoor car parking spaces	The percentage of on-street and indoor car parking spaces in relation to the total resident and working population
Basic services availability	Availability and proximity of key local public services	A set of diversified services and consumer facilities in the local area
	Access to recreation facilities	A set of quality leisure amenities
	Availability of local food production	Access to fresh products, community food production

Table 1. *Cont.*

Categories	Indicators	Explanation (Main Issues and/or Measurements Included in the Indicators)
Energy-saving measures	Infrastructure energy efficiency	Energy efficiency in public spaces with more efficient technologies (public lighting and dynamic control systems, and other street infrastructures)
	Percentage of total end-use energy generated on-site, derived from renewable sources	Availability and access to a public or private renewable energy production
	Centralized energy management	Energy management systems, district heating, and cooling strategies
	Percentage of total primary energy consumption derived from renewable sources	Availability and access to a public or private renewable energy production
	Primary energy demand for heating, cooling, and DHW	To reduce the need for energy for heating, cooling, and DHW for residential/non-residential buildings
Water-saving measures	Efficient drinking water consumption	Water conservation practices to reduce water consumption in public spaces, reducing the production of effluents and pressure in the drainage systems, analysing the current availability of water and demands, and the predicted water demand resulting from growth and climate change, water consumption management in green spaces (e.g., water efficiency is considered in the selection of tree, shrub, and herbaceous planting specifications and any associated irrigation systems)
	Effluent management	Recharge of underground reserves, reducing the load on public drainage, effluent treatment systems, public sewage disposal, domestic effluent management, increase infiltration and minimizing water demand, on-site collection and storage opportunities
	Rainwater harvesting and water body conservation	Efficient water run-off surface to reduce run-off volume
	Centralized water management	Centralized water systems
Resource efficiency, recycling and waste measures	Resource efficiency and low impact material used in public spaces	Use of sustainable and certified materials, fast renewable materials, recycled materials, reused materials, and local or locally produced materials, and considering embodied carbon of construction materials.
	Reusing of construction and demolition waste	Reuse the construction and demolition waste, consumption of non-renewable material, qualitative and quantitative assessment of waste produced from the construction, demolition, deconstruction, or refurbishment activities
	Urban solid waste management	Selective separation of waste and implementing recovery systems
	Construction activity pollution prevention	Reduce pollution of construction activities (e.g., controlling soil erosion, waterway sedimentation, and airborne dust)
Ecosystems and landscapes	Distribution of green spaces	Percentage of green space in the site,
	Connectivity of green spaces	Connected green spaces
	Enhancement of ecological value and conservation of imperilled species	Enhance/restore biodiversity and native vegetation in the site, preserve irreplaceable agricultural resources; protect, enhance, and create wildlife corridors and habitat connectivity using appropriate native species, which are selected according to being water-efficient, conserving imperilled species and ecological communities
	Environmental management and monitoring	Monitoring the environmental quality of the site

Table 1. *Cont.*

Categories	Indicators	Explanation (Main Issues and/or Measurements Included in the Indicators)
Land use and infrastructure	Use the natural potential of land	Appropriate use of the land according to its natural potential (e.g., use of wet or steep slopes for green areas, establishing leisure areas and equipment in the areas with watercourses, and determining green spaces and green corridors in areas of high biodiversity)
	Compact neighbourhoods	Land use efficiency, increase density through the building height, development within existing cities, and towns to reduce the sprawl
	Mixed-use neighbourhoods	Diversity of uses
	Reuse of urban land	Reuse of previously built land areas, rehabilitation of contaminated lands, conservation of land with ecological or agricultural values
	Reuse of buildings and infrastructure	Adaptive reuse of buildings, optimization of technical infrastructures,
Outdoor environmental quality	Adaption for ambient air quality	Long-term ambient air quality resulting from the operation of buildings and private vehicles, the polluting substances that can be assessed in the urban air are SO_2, CO, NOx, O_3, PM10
	Heat island effect in the local area	Temperature and thermal comfort in outdoor spaces
	Ambient noise conditions	Reduction in outside noise by implementing strategies to reduce and isolate noise sources in the intervention area (e.g., sound barriers, vegetation barriers, finishing materials with high sound absorption in public spaces, use of vegetation on the building's facades to enhance the diffusion coefficient of the incident sound)
	Light pollution reduction	Avoiding light pollution of public lighting (e.g., efficient design, reduction in brightness in the sky, glare and intrusive light (inside homes), intelligent systems for automatic cutting in night shifts, and prohibited or limited use of mirrored glass and other reflective materials at the buildings, facing the outside)
Employment and economic development	Economic viability	Optimize initial costs based on the evaluation of operating and maintenance costs, regional priorities, alternative project financing strategies, quantification of the internal rate of return (IRR)
	Local economy	Local economy study of an urban project (e.g., identification of existing business areas and priority areas for the growth, main services and necessary local commerce, strategies for internal exchanges of goods and services, the attractiveness for private investment to the area, benefits attributed to investors, areas with greatest investment potential, diversity of uses in the different areas of the project, proximity to services to reduce transport needs of the inhabitants)
	Employability	Creation of jobs
Local and Cultural Identity	Access to public spaces	Access to high quality civic and public spaces
	Valuing Heritage	Strengthened the local identity, conservation of the built and natural and historical heritage of the place, promoting the integration of the project into the local context, maintenance and enhancement of the existing built and natural heritage for the public, which use can be developed by assigning new uses to them according to the needs of the present such as providing tourist routes to make the heritage known to local inhabitants and visitors, and other efforts to promote the existing built and natural heritage, etc.
	Social inclusion and integration	Provision of services, facilities, and amenities based upon the local demographic trends and priorities, enhancing skills and training opportunities beneficial to the local area, stakeholder engagement, communities' involvement in developing the strategies for the area, and promoting socially equitable and engaging neighbourhoods
	Housing provision	provision of a diversity of housing types and affordable housing, provision for social housing units

Table 1. *Cont.*

Categories	Indicators	Explanation (Main Issues and/or Measurements Included in the Indicators)
Context and vulnerabilities	Street safety	Crime prevention measures in the streets
	Flood risk assessment	The vulnerability of buildings in the local area to riverine flooding events
	Windstorm events assessment	The vulnerability of buildings in the local area to windstorm events
	Earthquake's events assessment	The vulnerability of buildings in the local area to local forest fire events
	Environmental management based on information and communication technologies (ICT)	Integrated management of the various environmental aspects from a Smart City perspective, access to a public telecommunications system
	Adapting to climate change	Changes in regional ambient summer temperatures, resiliency to the impacts of climate change

2.3. Method for Screening the Indicators

In the next step, the study performed a systematic analysis to identify the importance of the indicators of each category to select the most important indicators for the final list. This study provides a list of commonly labelled indicators for indicators with common purposes and issues. To demonstrate a proper understanding of the purpose of each indicator, the main sustainability issues of each indicator are presented in Table 1. According to the categorized indicators in Table 1, we counted the number of indicators devoted to the stated relevant issues of each method (Figures 1–16). Aside from this, the relevant indicators of ISO 37120 standards and SDGs, which have the same targets as the indicators, were considered, confirming the importance of the indicators.

In the definition of the final list of indicators, an indicator that is promoted only by one method is considered to be less important unless it is aligned with ISO 37120 standards and SDGs. The indicators, which were chosen for the final list, are provided by rationales and narrative descriptions to define their importance, and they are considered to be scientifically valid, responsive to the users' needs, based on data availability, cost-effective to collect and use, understandable for potential users, and able to support a wide range of geographical conditions. The number of credits belonging to each issue and the value of the weighted credits that belongs to the tools are not within the objectives of this study. The results and implications of this trend are developed in the following sections.

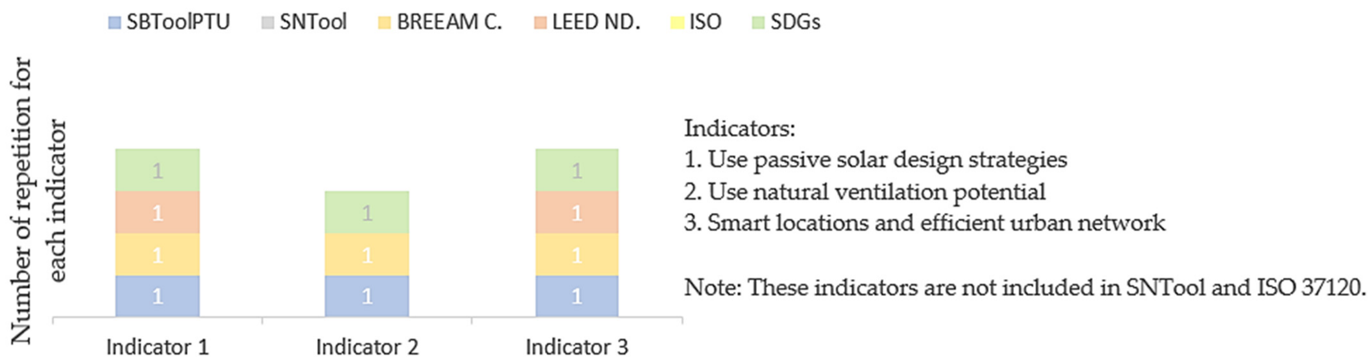

Figure 1. Frequency distribution of each indicator, relevant to the category of urban structure and form in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120 and SDGs.

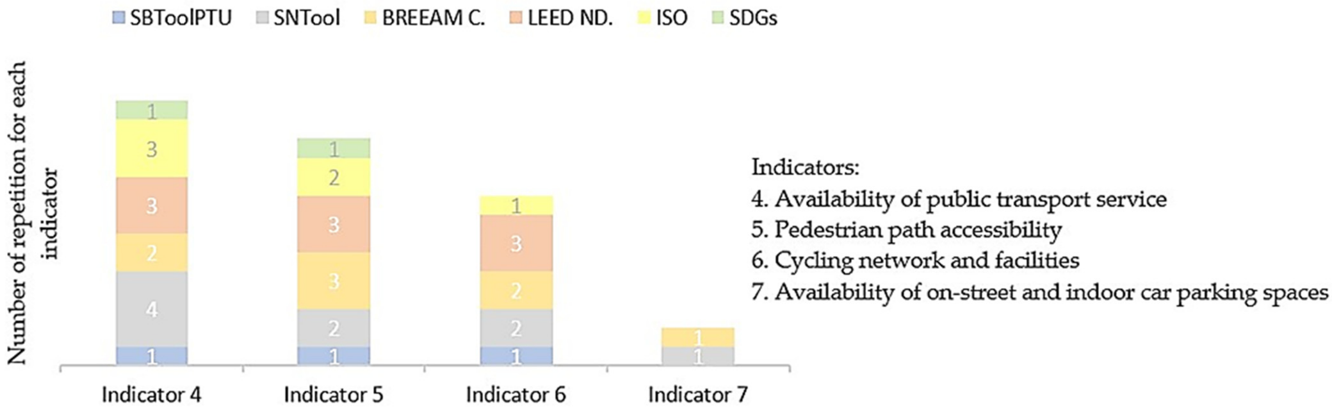

Figure 2. Frequency distribution of each indicator, relevant to the category of transportation infrastructure in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120 and SDGs.

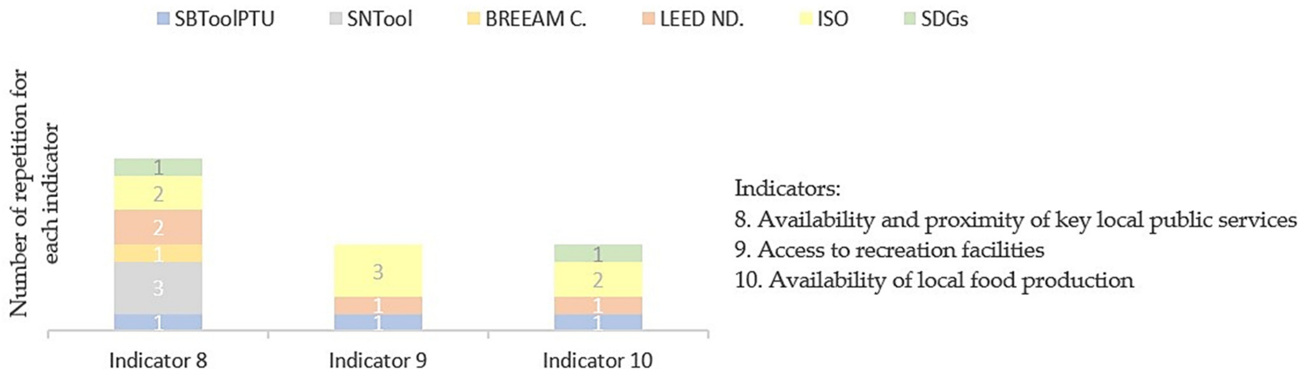

Figure 3. Frequency distribution of each indicator, relevant to the category of essential service availability in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120, and SDGs.

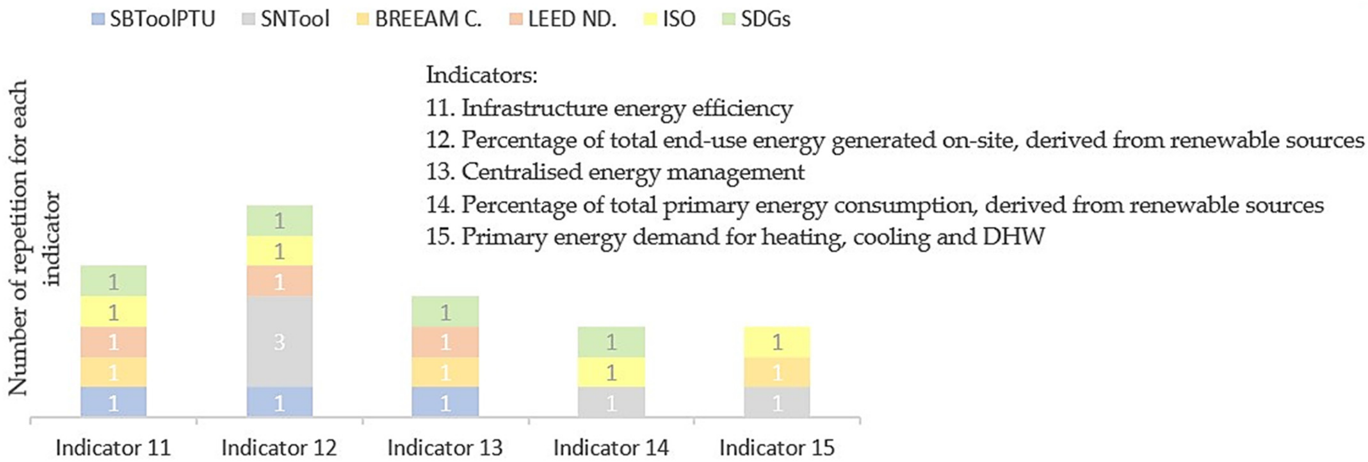

Figure 4. Frequency distribution of each indicator, relevant to the category of energy-saving measures in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120, and SDGs.

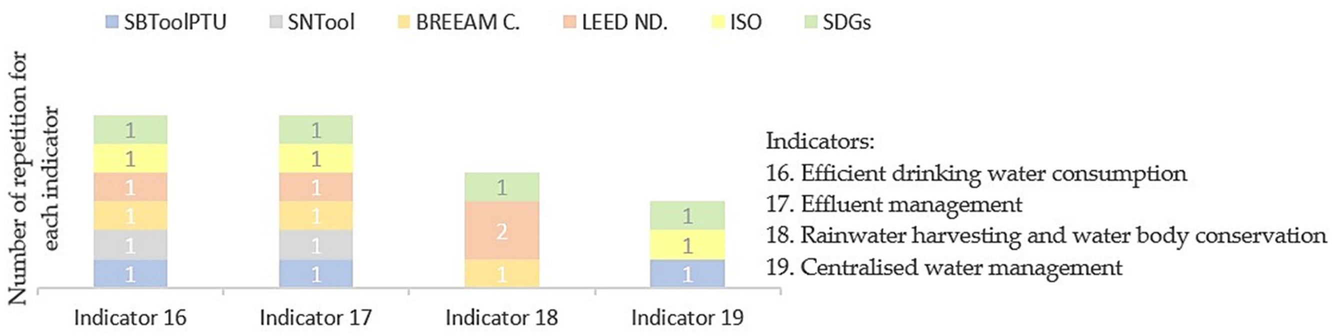

Figure 5. Frequency distribution of each indicator, relevant to the category of water-saving measures in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120, and SDGs.

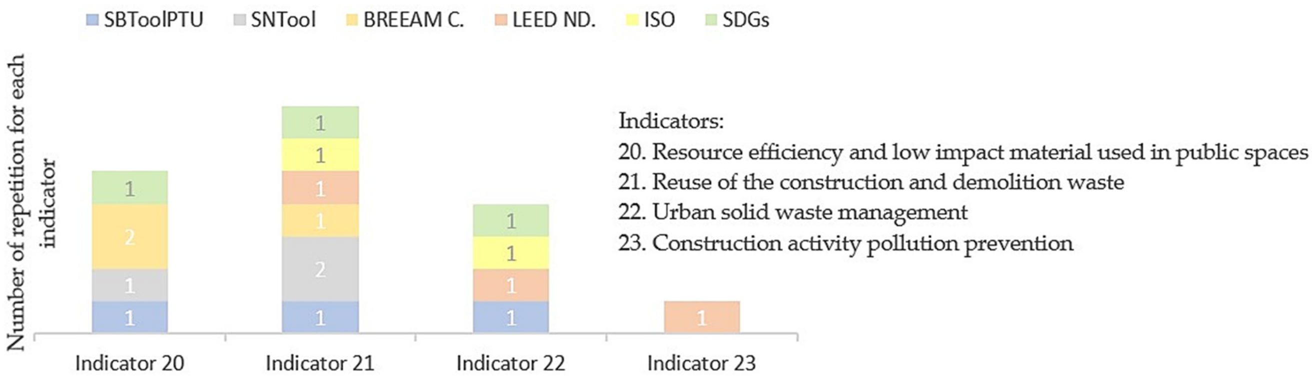

Figure 6. Frequency distribution of each indicator, relevant to the category of waste measures in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120 and SDGs.

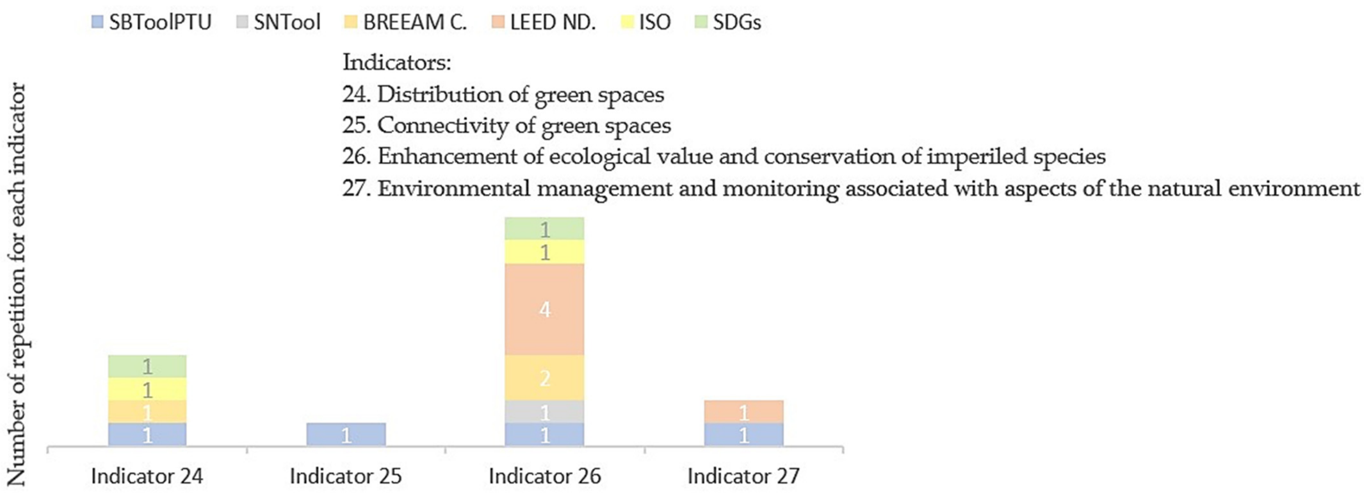

Figure 7. Frequency distribution of each indicator, relevant to the category of ecosystems and landscapes in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120, and SDGs.

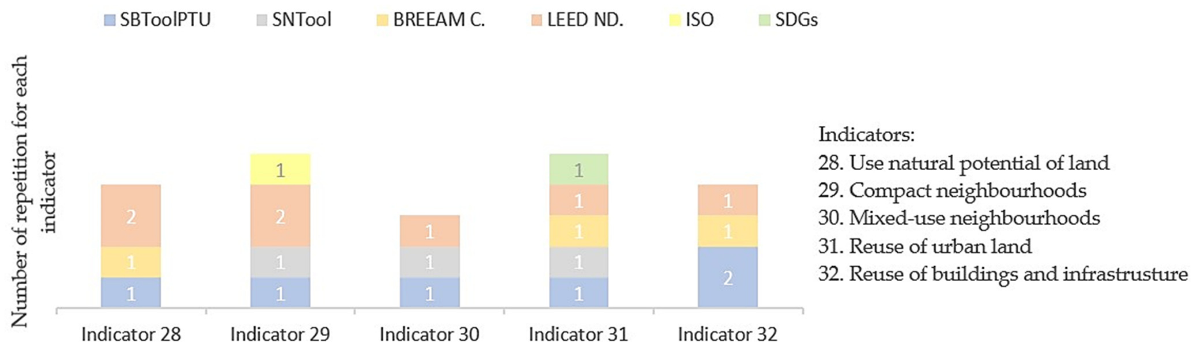

Figure 8. Frequency distribution of each indicator, relevant to the category of land use and infrastructure in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120, and SDGs.

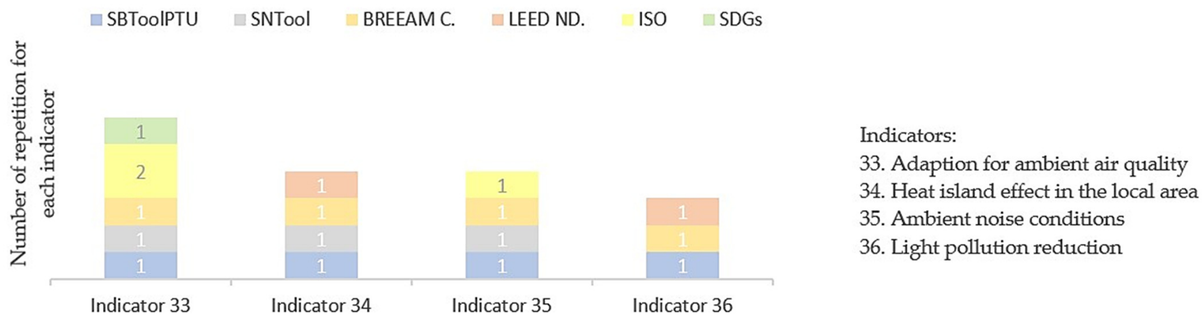

Figure 9. Frequency distribution of each indicator, relevant to the category of outdoor environmental quality in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120 and SDGs.

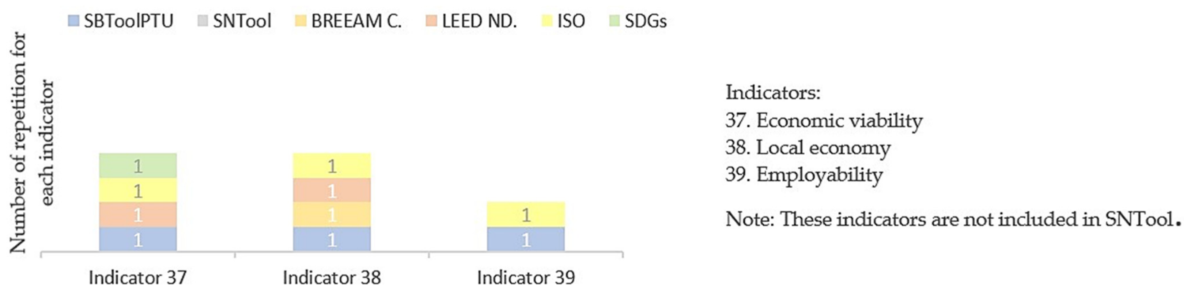

Figure 10. Frequency distribution of each indicator, relevant to the category of employment and economic development in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120, and SDGs.

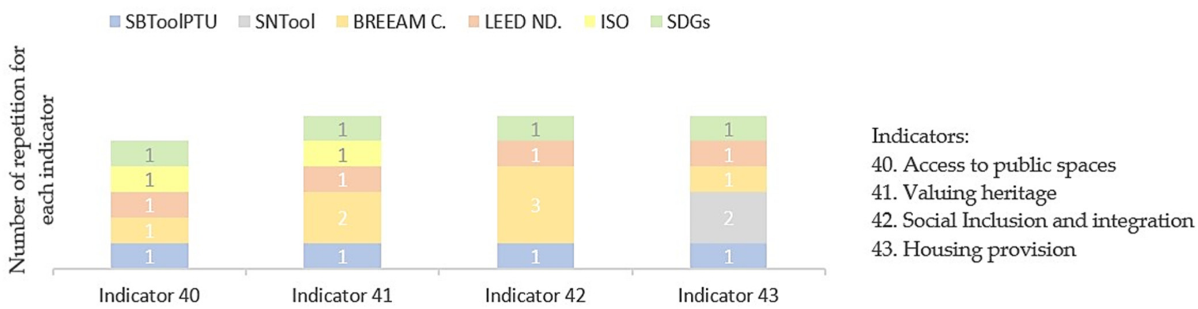

Figure 11. Frequency distribution of each indicator, relevant to the category of local and cultural identity in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120, and SDGs.

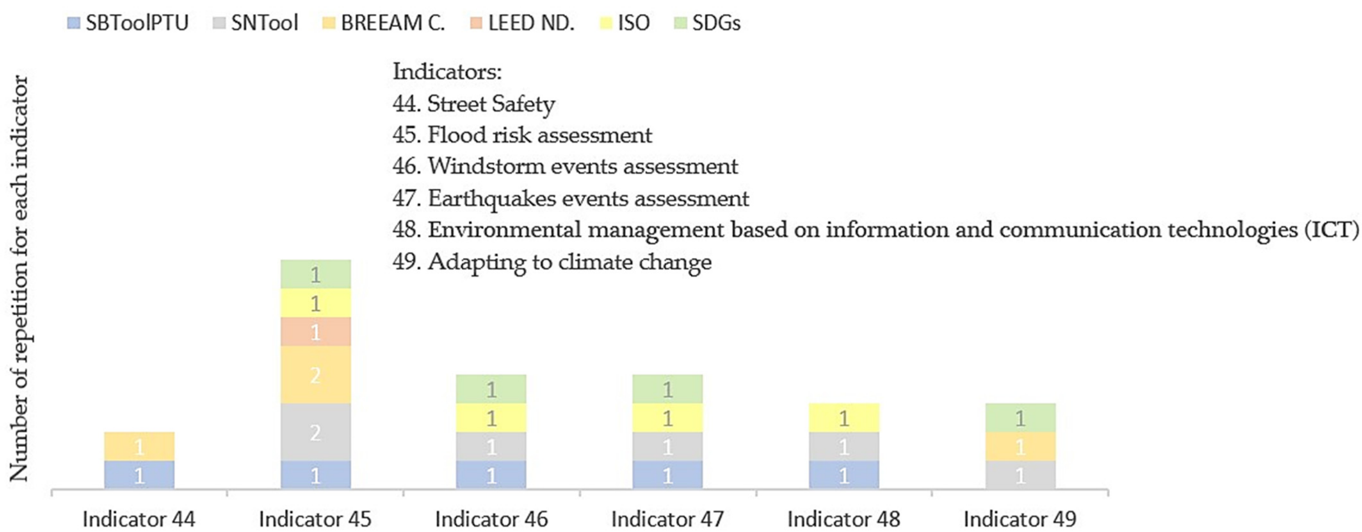

Figure 12. Frequency distribution of each indicator, relevant to the category of context and vulnerabilities in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120, and SDGs.

Figure 13. Frequency distribution of each indicator, in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120, and SDGs.

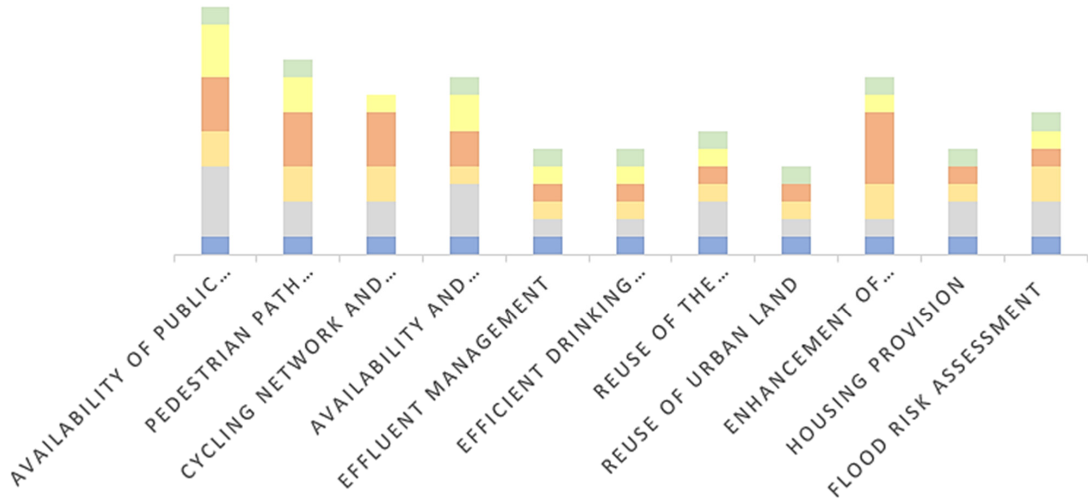

Figure 14. Frequency distribution of each indicator included in the four sustainability tools: SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), and supported by ISO 37120, and/or SDGs.

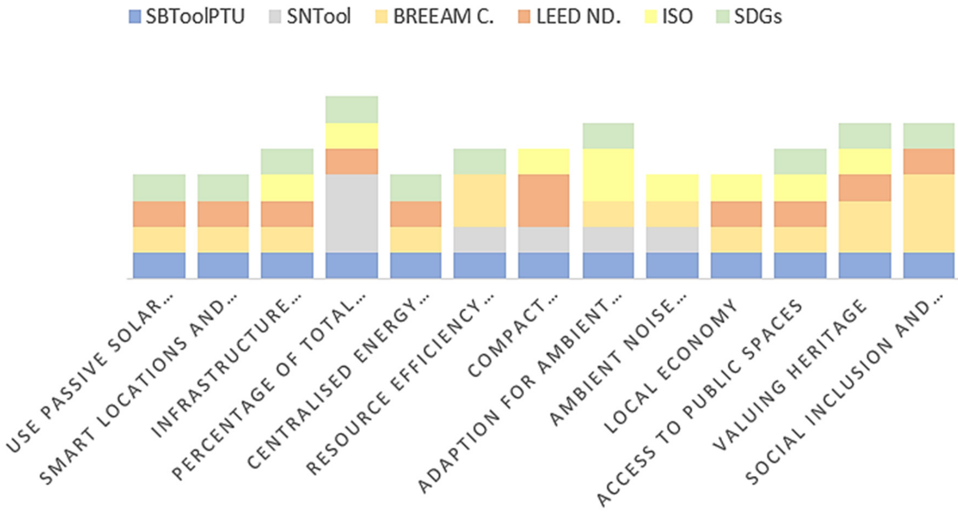

Figure 15. Frequency distribution of each indicator, which are included in the three sustainability tools: SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), and supported by ISO 37120, and/or SDGs.

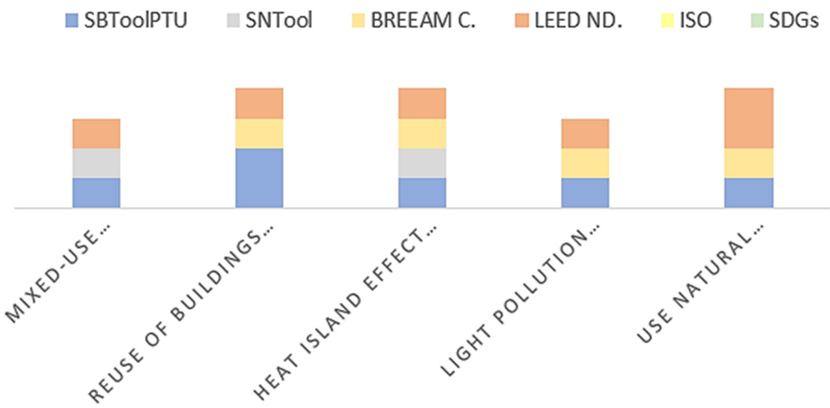

Figure 16. Frequency distribution of each indicator, which is included in three or four sustainability tools: SBTool^{PT}_Urban (2018), SNTool (2020), BREEAM Communities (2012), and LEED-ND (2018).

In the definition of the final list of indicators, an indicator that is promoted only by one method is considered to be less important unless it is aligned with ISO 37120 standards and SDGs. The indicators, which were chosen for the final list, are provided by rationales and narrative descriptions to define their importance, and they are considered to be scientifically valid, responsive to the users' needs, based on data availability, cost-effective to collect and use, understandable for potential users, and able to support a wide range of geographical conditions. The number of credits belonging to each issue and the value of the weighted credits that belongs to the tools are not within the objectives of this study. The results and implications of this trend are developed in the following sections.

3. Results and Discussion Regarding the Selected Indicators within the Potential Categories

Potential indicators were collected from BREEAM-C (2012), LEED-ND (2018), iiSBE SBTool^{PT} Urban (2018), and iiSBE SNTool-Minimum version (2020) to illustrate the essential indicators for measuring urban sustainability. After analysing 162 indicators of the selected tools, the results showed that the majority of the indicators primarily focused on 49 main sustainability criteria (Table 2). The figures presented in the following sections suggest that the indicators covered by the analysed tools give an overview regarding the most and least popular indicators among the tools and if they are linked with the urban Sustainable Development Goals and ISO standards. The study provides a narrative description for each category to provide the rationale for its significance. It also depicts the frequency of usability of the indicators through the charts, enabling the comparison of their repetition. Moreover, the study provides a brief overview of the selected indicators' objectives or criteria, described in the following sections.

Table 2. Indicators with similar issues and objectives in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018).

N	Indicators	SBTool^{PT}_U	SNTool	BREEAM-C	LEED-ND
1	Use passive solar design strategies	●		●	●
2	Use natural ventilation potential	●		●	
3	Smart locations and efficient urban network	●		●	●
4	Availability of public transport service	●	●	●	●
5	Pedestrian path accessibility	●	●	●	●
6	Cycling network and facilities	●	●	●	●
7	Availability of on-street and indoor car parking spaces		●	●	
8	Availability and proximity of key local public services	●	●	●	●
9	Access to recreation facilities	●			●
10	Availability of local food production	●			●
11	Infrastructure energy efficiency	●		●	●
12	Percentage of total end-use energy generated on-site, derived from renewable sources	●	●		●
13	Centralized energy management	●		●	●
14	Percentage of total primary energy consumption derived from renewable sources		●		
15	Primary energy demand for heating, cooling and DHW		●	●	
16	Efficient drinking water consumption	●	●	●	●
17	Effluent management	●	●	●	●

Table 2. *Cont.*

N	Indicators	SBTool^{PT}_U	SNTool	BREEAM-C	LEED-ND
18	Rainwater harvesting and water body conservation			●	●
19	Centralized water management	●			
20	Resource efficiency and low impact material used in public spaces	●	●	●	
21	Reuse of the construction and demolition waste	●	●	●	●
22	Urban solid waste management	●			●
23	Construction activity pollution prevention				●
24	Distribution of green spaces	●		●	
25	Connectivity of green spaces	●			
26	Enhancement of ecological value and conservation of imperilled species	●	●	●	●
27	Environmental management and monitoring associated with aspects of the natural environment	●			●
28	Use the natural potential of land	●		●	●
29	Compact neighbourhoods	●	●		●
30	Mixed-use neighbourhoods	●	●		●
31	Reuse of urban land	●	●	●	●
32	Reuse of buildings and infrastructure	●		●	●
33	Adaption for ambient air quality	●	●	●	
34	Heat island effect in the local area	●	●	●	●
35	Ambient noise conditions	●	●	●	
36	Light pollution reduction	●		●	●
37	Economic viability	●			●
38	Local economy	●		●	●
39	Employability	●			
40	Access to public spaces	●		●	●
41	Valuing heritage	●		●	●
42	Social inclusion and integration	●		●	●
43	Housing provision	●	●	●	●
44	Street safety	●		●	
45	Flood risk assessment	●	●	●	●
46	Windstorm events assessment	●	●		
47	Earthquake events assessment	●	●		
48	Environmental management based on information and communication technologies (ICT)	●	●		
49	Adapting to climate change		●	●	

3.1. Urban Structure and Form

The first proposed category of the environmental dimension of sustainability assessment focuses on analysing the issues related to the shape of the city and urban layouts. As shown in Figure 1, this category is frequently assessed through three indicators. Urban fabric or the relationship between the building and open spaces is proven to influence the bioclimatic potential of the outdoor environment through the orientation of paths and open spaces towards the sun and prevailing winds. On the other hand, the urban form affects the efficiency of the urban network, as it determines the ease of circulation, reduction in distances, and humanizes the scale of the streets [23]. This influences the parameters of mobility, as well as the location of pollution emission sources and traffic patterns [24]. The urban form significantly affects both direct (operational) and indirect (embodied) energy [25]. The SDGs encourage an approach that emphasizes the participation of civil society in urban planning, which is addressed in SDG 11. Furthermore, to combat the impacts of climate change, integrating climate change measures into national policies, strategies, and planning are highlighted by SDG 13. Therefore, the essential indicators for assessing the level of sustainability of the urban structure and form are:

Providing a comfortable outdoor environment: This indicator is a mix of using passive solar design strategies and natural ventilation potential indicators, covered by SBTool^{PT}_Urban (2018), BREEAM-C (2012), and LEED-ND (2018), as presented in Figure 1. This indicator focuses on analysing the buildings and street forms to control climatic conditions in outdoor areas, which, for instance, maximizes solar gain and the use of daylighting, wind management, and natural ventilation.

Smart locations and efficient urban network: This indicator focuses on street layouts, pedestrian and cycle routes, location type, connectivity, and designated high-priority locations, in order to enhance multiple hierarchies of routes on a more human scale to mitigate the potential vehicle noise disturbance and potential distance and travel time, as well as facilitating circulation. This indicator is covered by SBTool^{PT}_Urban (2018), BREEAM-C (2012), and LEED-ND (2018), as presented in Figure 1.

3.2. Transportation Infrastructure

The second proposed category of the environmental dimension of sustainability assessment focuses on analysing issues related to transportation infrastructure. Figure 2 shows that this category is promoted by all of the studied sustainability assessment methods and is addressed through four indicators. Urban mobility concerns the ease of movement of people and goods. Many cities increasingly face problems caused by transport and traffic. According to the EU commission, efficient and effective urban transport can significantly contribute to achieving objectives in a wide range of policy domains for which the EU has an established competence. However, urban mobility is broad and involves intermodal articulations, where different means of transport, alternative transport options, and efficient accessibility must be planned in an integrated way. This approach is guided by the SDGs, focusing on convenient access to public transport, according to SDG 11 and SDG 9. Moreover, ISO promoted measuring the distance of public transport systems and providing access to public transportation near living areas. Therefore, the essential indicators are described below:

Availability and access to public transport facilities (accessibility, quality): This indicator focuses on the analysis of the accessibility to the alternative transport options, quality of the public transport road network, and transit facilities to increase the quality of transport, as well as local and intermodal connections, which have the potential to reduce the use of private vehicles. This indicator is addressed by SBToolPT_Urban (2018), SNTool (2020), BREEAM-C (2012), and LEED ND (2018), and supported by SDGs and ISO 37120.

Quality of pedestrian and bicycle networks: This indicator consists of pedestrian path accessibility and cycling network and facilities indicators (Figure 2). It focuses on the analysis of cycling and walking as alternatives to using cars by providing safe and efficient pedestrian and bicycle networks. This indicator is addressed by SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), and LEED-ND (2018), and supported by SDGs and ISO 37120. The study proposed a combined form of the indicator based on how SNTool promotes it.

3.3. Basic Services Availability

This category focuses on analysing issues that contribute to the accessibility of urban public amenities and services for the daily life of inhabitants of a neighbourhood. The category is addressed by many of the studied sustainability assessment tools and is based on three indicators (Figure 3). This issue influences an inhabitant's sense of place [26]. Public sector services include parks, public squares, and recreational facilities, and private sector amenities include restaurants and cafes, retail, and other goods or service providers [27]. The provision of amenities enhances the advantages of economic prosperity and attracts people to the areas where they are located [28]. ISO 37120 and SDG 1.1.4 highlighted the importance of the neighbourhood's proximity to basic services. Additionally, for access to recreational facilities, ISO 37120 promoted the assessment of the area of public outdoor recreation spaces and the budget allocated to cultural and sporting facilities by the municipalities. Aside from these indicators, ISO allocated an indicator for assessing the urban agricultural area and the amount of locally produced food, revealing the importance of local food production. SDG 2.3.2 supports this issue by examining the average income of small-scale food producers. Therefore, the essential indicators for assessing the availability of basic services, shown in Figure 3, are described below:

Availability and proximity to public and local customer services: This indicator analyses the availability of a set of diversified public and customer services in the local area, which are vital parts of supporting sustainable and resilient rural and small-town areas [29]. It is covered by SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), and LEED-ND (2018), and supported by SDGs and ISO 37120. This factor can influence the residents' choice of walking instead of using vehicles if a wide range of retail goods and services are available within easy walking distance [30]. Some of the essential local public services that should be considered in every neighbourhood include health clinics; hospitals; childcare; social services; police, fire and ambulance stations; schools; and customer services, such as grocery stores, launderettes, pharmacies, etc.

Availability of recreational facilities: This indicator is covered by SBTool^{PT}_Urban (2018) and LEED-ND (2018) and supported by ISO 37120, which focuses on the availability of public facilities that support the needs of culture, sport, religion, and recreation of the inhabitants. This indicator encourages pedestrian or bicycle travel to promote urban vitality and the health of the inhabitants of the neighbourhoods. The main elements that are determined for assessing sustainability through this indicator include playgrounds, plazas and gardens, places of worship, community centres, sports centres and gyms, recreational and cultural centres, museums and exhibition centres, and cinemas and theatres.

Availability of local food production: The term "local food" is used for products produced and consumed within a particular narrowly defined geographical area [31], which is the domain of this indicator. This indicator is addressed by SBTool^{PT}_Urban (2018) and LEED-ND (2018) and supported by SDGs and ISO 37120. Local food production guarantees city inhabitants' access to fresh products, promotes community food production, and contributes to improving residents' nutrition, supporting the economic development of the area by supporting small farmers and reducing the harmful effects of large-scale industrialized agriculture [23]. Short food-supply chains (SFSCs), community-supported agriculture (CSA), direct farmer-to-retailer business, farmers' markets, farm shops, on-farm or digital direct sales, and box schemes are some examples of local food marketing strategies [32]. Additionally, to promote community gardens, some of the elements that need to be provided are spaces or private land for local food production, with good sun exposure and appropriate storage places.

3.4. Energy Saving Measures

This category focuses on analysing the issues related to energy-saving measures, which are addressed by the studied sustainability assessment methods through five indicators (Figure 4). Energy-saving is a matter of concern since climate change is one of the most significant challenges faced by all nations. Since the Industrial Revolution, the levels of long-lived greenhouse gases (CO_2, CH_4, N_2O) have dramatically increased [33]. This demands that the renewable energy share in the total energy generation and consumption is urgently increased [34]. In this regard, using renewable energy sources, such as geothermal, solar, wind, biomass, and biofuels, to meet the growing energy demand will help to keep the pollution of sources at a minimum and promote long-term economic growth [35]. SDG 7, which ensures access to affordable, reliable, sustainable, and modern energy for all, is related to this category, aiming to develop international collaborations and investments in energy infrastructures and clean energy technology. ISO 37120 sets the condition for calculating the total end-use energy derived from renewable sources and public street lighting electricity consumption. Moreover, infrastructure energy efficiency, to reduce the environmental harms from energy used for operating public infrastructure, attention to the municipality's installations in urban areas, specifically public street lighting, is considered an indicator by ISO 37120 and two other tools. Therefore, the essential indicators for assessing the energy-saving measures are:

Infrastructure energy efficiency: This indicator promotes a reduction in energy consumption through energy-efficient public infrastructure. This indicator is covered by SBTool^{PT}_Urban (2018), BREEAM-C (2012), and LEED-ND (2018) and supported by SDGs and ISO 37120. An example regarding the focus of the indicator is the development of street-smart lighting in Indonesia, which was promoted under the Nationally Appropriate Mitigation Action [36]. The indicator aims to cut emissions and increase energy supplies by substituting conventional street lighting with more efficient technologies and strategies in cities and urban areas.

Percentage of total end-use energy generated on-site, derived from renewable sources: This indicator addresses the energy locally produced from renewable sources in the region. It is covered by SBTool^{PT}_Urban (2018), SNTool Min (2020), and LEED-ND (2018) and supported by SDGs and ISO 37120. The availability of energy efficiency technologies and the costs of adopting these technologies, which are two aspects typically considered when developing effective energy-efficient buildings and urban communities [37], are considered in this indicator.

Centralized energy management system: The focus of this indicator is on controlling the use of energy for the timely identification of problems in the network and systems, increasing the potential of flexible loads in demand response. Additionally, district heating and cooling energy systems can be of added value to this indicator. This indicator is addressed by SBTool^{PT}_Urban (2018), BREEAM-C (2012), and LEED-ND (2018) and supported by SDGs. Energy management systems (EMS) are automation systems that collect energy measurement data from the field and make it available to users through graphics, online monitoring tools, and energy quality analysers, thus enabling the management of energy resources [38]. The Smart City project of Malaga in Spain is an example of this [39]. Some of the centralized energy management systems applications are the use of advanced smart meters to enable remote management for energy efficiency improvements, forward-looking demand management systems, employing a light-emitting diode (LED) street lighting network, and micro-nano generation and high-technology energy storage setups [40]. Additionally, this approach can be used to integrate renewable energy sources, such as solar, wind, etc.

3.5. Water-Saving Measures

The next category focuses on the analysis of issues related to water-saving measures. It is assessed through four indicators, as presented in Figure 5. Water and water resources are unlike other natural resources as they are a critical necessity for human survival. The long-term neglectful exploitation of water resources has become a critical issue due to human effects on the water cycle. Humans directly affect the water cycle by removing water from various reservoirs for agricultural, urban, and industrial purposes [41] and indirectly impact the water cycle in drainage basins through land use transformation. Additionally, climate change caused by fossil fuel combustion significantly influences the water cycle [42]. Water consumption metering in the cities can improve the performance of water distribution systems [43]. However, efficient water consumption in cities is a critical phase, leading to a conceptual framework for planning and investing in urban water infrastructures, targeted by SDG 12 for sustainable consumption and production. Furthermore, resource recovery and reuse, the efficient management of rainwater, and conservation of water bodies are issues targeted by SDG 6, which emphasizes sustainable management of water and sanitation. Effluent reuse arising from particular collection or treatment systems leads to the protection of water surfaces, groundwater, and land [44]. Additionally, ISO 37120 developed an indicator for wastewater that receives centralized treatment. Consequently, to assess the water-saving level in every neighbourhood, the following three main indicators (Figure 5) are deemed important:

Efficient drinking water consumption: This indicator promotes reducing water consumption and improving water conservation practices in a neighbourhood to reduce the production of effluents and pressure in the drainage systems. This indicator is addressed by SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), and LEED-ND (2018), and supported by SDGs and ISO 37120. The main factors that should be considered to determine the efficiency of drinking water consumption in a neighbourhood include the management of water consumption in public spaces and all buildings on the site, an analysis of the current availability of water and demands, the future predicted availability while taking climate change into account, and the expected water demand in the area as a result of growth and climate change.

Effluent management: The objectives of this indicator are to promote the recharge of underground water reserves, which are under decontamination conditions, reduce the risk of flooding, reduce the load on public drainage and effluent treatment systems, and promote the adequate design of domestic wastewater treatment systems, which are a response to the needs increased by the site. This indicator is addressed by SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), and LEED-ND (2018), and supported by SDGs and ISO 37120.

Rainwater harvesting and water body conservation: This indicator promotes the efficient use of surface water run-off and the conservation of wetlands and water bodies to preserve water quality, natural hydrology, habitats, and biodiversity. This indicator is covered by BREEAM-C (2012), and LEED ND (2018), and supported by SDGs.

3.6. Resource Efficiency, Recycling, and Waste Measures

This category focuses on analysing the issues related to resource efficiency, recycling, and waste measures. As presented in Figure 6, this category is assessed through four indicators. Worldwide consumption and production, which are driving forces of the global economy, concerns the use of the natural environment and resources in a way that continues to have harmful effects on the planet [45]. The construction sector uses many heavy non-renewable resources, including cement, concrete, steel and aluminium, which have a high carbon footprint. Therefore, the construction industry is known to have a considerable potential for improving sustainability by adopting measures, such as using renewable materials, reusing recycled and low-impact materials. This issue is emphasized by SDGs 8 and 12, having implemented multiple indicators relevant to material footprint, domestic material consumption, and hazardous waste management. Moreover, waste collection and management, promoted by SDG 11, is an essential public service for every community and is necessary for protecting public health and the environment. ISO 37120 also promotes an assessment of a city's solid waste disposal in a sanitary landfill and the amount of recycled waste. The municipal solid waste (MSW) management system can be split into three phases: collection, transportation, and waste treatment [46]. Chi and Dong [47] emphasized the collection of MSW from a life-cycle assessment point of view, particularly analysing the importance of a source-separated collection for the entire total environmental performance of an MSW system. This highlights the importance of recycled urban solid waste derived from regularly collected solid waste. Indeed, the commitment aims to prevent, reduce, recycle, and reuse waste and properly collect and discharge waste. To assess the resource efficiency and the adequacy of measures that promote waste reduction and recycling at the neighbourhood scale, three indicators were considered, as presented in Figure 6:

Resource efficiency and low-impact materials used in public spaces: Resource efficiency refers to the sustainable use of the Earth's limited resources, while minimizing environmental impacts, addressed in the Roadmap to a Resource Efficient Europe [48]. The objective of this indicator is to reduce the environmental impacts associated with the extraction, production, transportation, and use of construction materials. This indicator is addressed by SBTool^{PT}_Urban (2018), SNTool Min (2020), and BREEAM-C (2012) and supported by SDGs.

Reuse construction and demolition waste: This indicator encourages the on-site reuse of recycled aggregates to reduce the demand for raw materials and, consequently, reduce the impacts associated with their extraction, transportation, and end-of-life treatment. It is also meant to encourage the final recovery of recycled aggregates when they cannot be reused on-site and returns them to the construction material loop rather than sending them *to* landfill. The stages of demolition, renovation, and construction, the materials used and their respective origin, the used resources that can be recycled, and the characteristics of the building design, have an impact on the waste created during the project [49]. This indicator is covered by SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), and LEED-ND (2018) and supported by SDGs and ISO.

Recycled urban solid waste derived from regularly collected solid waste: This indicator promotes the selective separation of waste and the implementation of recovery systems to increase the recycling added value and the accessibility of users to the service. This indicator is covered by SBTool^{PT}_Urban (2018), LEED-ND (2018) and supported by SDGs and ISO 37120. Solid waste collected from the source of generation (primary collection), the collected waste from communal bins (secondary collection), recycled municipal solid waste, waste incineration for energy recovery, and the biological treatment of the food waste are the main criteria considered for this indicator.

3.7. Ecosystems and Landscapes

This category focuses on analysing issues related to ecosystems and landscapes and is addressed through 4 indicators (Figure 7). The intersection of biodiversity, urban environments, and people is a promising area for urban policies that aim to reconcile urbanization processes with biodiversity in urban regions for the sake of both urban residents and urban nature [50]. Urban conservation strategies are integrated into the global urban agenda. SDG 11 promotes the universal access to green and public places that are safe, inclusive, and accessible. Furthermore, SDG 15 mentions species conservation, preventing biodiversity loss, and the extinction of vulnerable species.

However, it should be considered that converting forest areas into agricultural land can cause erosion, sedimentation, floods and drought [51]. To prevent biodiversity loss, it is advocated that half of the Earth should be kept for conservation to avoid biodiversity loss [52]. Integrating this idea into the sustainable built environment is recognized as a leading path towards reaching the outcomes. For instance, one of the strategic stages in water resource management is the greening or conservation of vegetation to maintain groundwater availability in the dry season and maintain the stability of infiltration rates during the rainy season [53]. Therefore, it is evident that cities with a biodiversity-friendly environment refer to sustainable urban development and human well-being. In this regard, assessments can be brought into play to plan appropriate conservation strategies. To assess the efficiency level of the ecosystems and landscapes in every neighbourhood, two main indicators are considered significant (as shown in Figure 7):

Distribution of green spaces for public use: This indicator mixes the distribution of green spaces and connectivity of green spaces indicators. The objectives of this indicator are to promote the ecological continuity within urban areas, which contributes to improving the quality of the area, creating recreational opportunities for the population and preserving biodiversity. This indicator is covered by SBTool^{PT}_Urban (2018), *BREEAM-C (2012)* and supported by SDGs and ISO 37120.

Enhancement of ecological value and conservation of imperilled species: The objective of this indicator is to promote the protection and increase the ecological value characteristic of urban landscapes in developed and developing regions. This indicator is addressed by SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), and supported by SDGs and ISO 37120.

3.8. Land Use and Infrastructure

This category focuses on analysing the issues related to the land use and infrastructure of the neighbourhoods. As presented in Figure 8, it is assessed through five indicators. The efficient use of urban land is a predominant issue promoted by the studied sustainability assessment tools. Land is a vital yet limited resource. Therefore, managing urban lands to meet the requirements of an expanding urban population is seen as one of the key challenges in achieving an economically efficient, socially equitable, and environmentally safe society [54]. A high-density urban form preserves lands and protects the surrounding natural environment, improving the service provided for the municipality and establishing economies of scale. SDG 11.3.1 highlighted the observation of the land consumption rate to the population growth rate, and ISO 37120 has promoted assessing the built-up density. Urban densification is used in many European urban planning initiatives to encourage the development of the compact city concept, which shares resources and infrastructure to achieve a maximum efficiency while reducing the need for daily mobility [55]. Furthermore, the European Commission promotes the urban densification in the form of infill developments or the reuse of urban land as an emphasized policy that aims to encourage efficient urban structures that are economically sustainable [56]. This strategy is frequently considered against urban sprawl. The essential indicators, which are used to assess how optimized the project is regarding land use and infrastructures, are presented in Figure 8:

Use the natural potential of land: This indicator is intended to promote land use pattern optimization, which can minimise erosion, protect habitats, and ease the stress on natural water systems by conserving the natural potential of land, such as through preserving steep slopes in a natural and vegetated state [57]. However, the land use regime must be established in the territorial planning instruments, which define the appropriate land classification and qualification. This indicator is covered by SBTool^{PT}_Urban (2018), BREEAM-C (2012), and LEED-ND (2018).

Densification, and flexibility of land use: The concept for this indicator comprises the densification of existing urban infrastructures and promotes the diversity of uses. These issues are promoted through separated indicators by SNTool (2020) and BREEAM-C (2012) but developed in a combined form in SBTool^{PT}_Urban (2018). The study proposed a combined form of the indicator due to the close relationship between the two criteria. Land densification is defined as the land development that makes maximum use of the existing infrastructure rather than developing on undeveloped land, and recycling is defined as the reuse of abandoned, unused, or underutilized land for redevelopment [58]. Additionally, providing access to a range of land uses and mixed-use development will reduce transportation distances and dependence on cars, which encourages daily walking, biking, and public transportation, leading to car-free living [57].

Reuse of urban land: This indicator aims to promote the reuse of previously built land areas by enhancing the rehabilitation of contaminated lands and determining the lands that should remain undeveloped due to their ecological or agricultural values. This indicator is addressed by SBTool^{PT}_Urban (2018), SNTool (2020), BREEAM-C (2012), LEED ND (2018), and supported by SDGs.

Reuse buildings and infrastructure: The objective of this indicator is to promote the reuse or rehabilitation of existing buildings and infrastructures where possible, to extend the life cycle of buildings and conserve resources, reduce waste, and mitigate environmental harm from new building materials manufacturing and transportation. This indicator is covered by SBTool^{PT}_Urban (2018), BREEAM-C (2012), and LEED-ND (2018).

3.9. Outdoor Environmental Quality

This category focuses on analysing the issues related to outdoor environmental quality and is addressed through 4 indicators (Figure 9). The growth of cities and the expansion of built-up areas lead to many environmental issues, including the urban heat island (UHI) effect, which can potentially increase the air temperature by 2 °C to 5 °C in urban areas, as well as affecting air quality and stormwater run-off [59]. Comfortable outdoor spaces have a substantial impact on the comfort perception of the indoor environment, while natural ventilation improves the indoor air quality of buildings by reducing pollutants [60]. SDG 11.6.2 and ISO 37120 promote an assessment of air quality through yearly mean levels of fine particulate matter in metropolitan areas, in order to make cities and human settlements inclusive, safe, resilient, and sustainable. Moreover, considering the analysed methods, developing methodologies to evaluate the thermal perception and outdoor thermal comfort in cities is necessary. Another critical issue is to assess external noise, which is promoted by ISO 37120, and light pollution, which affects wildlife and people as a consequence of urban developments. This category is promoted through the following indicators:

Adaption for ambient air quality: This indicator assesses the long-term ambient air quality and associated emissions from primary energy used in building operations, street infrastructure, and private vehicles in the local area. It is covered by SBTool^{PT}_Urban (2018), SNTool (2020), BREEAM-C (2012), and supported by SDGs. Major sources of particulates are pollutants emitted from residential wood combustion and forest fires, gasoline or diesel-powered motor vehicles, coal-fired power stations and industry, and natural dust and salt [61–64]. Under the Clean Air Act, the EPA [65] establishes national air quality guidelines for PM and five other pollutants hazardous to human health and the environment. Air quality monitoring can determine PM concentrations in metropolitan areas to ensure that PM in the air is safe for people and the environment. On the other hand, the results can help to adapt the strategies, which encourage the use of clean energy in terms of transport, therefore impacting the quality of the air being breathed [23].

Heat island effect in the local area: This indicator aims to improve the comfort of inhabitants in the outdoor spaces of the site by reducing the heat island effect and thermal comfort in the local area. This indicator is addressed by SBTool^{PT}_Urban (2018), SNTool (2020), BREEAM-C (2012), and LEED-ND (2018). Urban structure, hard surfaces, urban fabric (mass and bulk), and the shortage of vegetation cover in cities are recognized as the major contributors to the artificial temperature increase in cities, commonly known as the urban heat island (UHI) effect [66]. The worst causes are dense urban areas with a high level of re-radiation between buildings with low-albedo surfaces and the absence of adequate air circulation in the urban mesh [67]. Taking advantage of the evapotranspiration from urban vegetation and water bodies, the adequate design of urban areas to promote air circulation, street shadowing using deciduous plants, and the use of cool materials with high albedo in the external surfaces of the building envelopes, green roofs, as well as permeable, light-colour, and reflective road surfaces are some mitigating strategies for the UHI effect. In this regard, the objective of this indicator is to estimate the extent of the urban heat island effect in a local area.

Ambient noise conditions: This indicator aims to assess the acoustic comfort of the site and, if necessary, promote the attenuation of on-site noise. The indicator is covered by SBTool^{PT}_Urban (2018), SNTool (2020), BREEAM-C (2012) and supported by ISO 37120. Poor urban planning and transportation systems in metropolitan areas, where most of the population live close to major roadways, produce excessive ambient noise that is annoying and disrupting to regular activities, especially at night [68]. A noise impact assessment should be carried out in every region by determining the sources and nature of existing noise in and around the urban development area.

Light pollution reduction: This indicator aims to improve the comfort of the inhabitants of urban areas and reduce the harmful effects of urbanization on wildlife. Two-thirds of the world's population live under light-polluted (LP) sky [69]. Building illumination, streetlights, skyglow, highways, security lights, vehicle lamps, and other sources of light pollution are just a few examples [70]. The indicator is addressed by SBTool^{PT}_Urban (2018), BREEAM-C (2012), and LEED-ND (2018).

3.10. Employment and Economic Development

This category focuses on analysing the issues related to employment and economic development and is promoted through three indicators (Figure 10). Economic growth is one factor that determines success in the development of a region, analysing human development achievements by several major quality-of-life indicators. This economic analysis should be focused on the local government's priorities, representing the size and influence of the development, and the surrounding area that will be affected by it [71]. SDG 8 encourages entrepreneurship and job creation, achieving full and productive employment, and decent work for all people by 2030. The first step towards entrepreneurship is to focus on the unique environmental, economic, and social features of sustainability, which are capable of promoting the local economy through the planned comprehensive strategies. Therefore, it is vital to identify the factors that influence a region's local economy in order to implement appropriate strategies. According to the results (as shown in Figure 10), the essential indicators for assessing the level of sustainability of employment and economic development of the area are structured around two sustainability indicators, including:

Economic viability (value of the initial investment cost, value of the usage costs): The objectives of this indicator are to evaluate the economic feasibility of the new urban projects, as well as the availability of housing, services, facilities, and amenities on the site. This indicator is covered by SBTool^{PT}_Urban (2018), LEED-ND (2018) and supported by SDGs and ISO 37120.

Local economy and employability (diversity of uses and local economy promotion): The objective of this indicator is to improve the local economy through developing the diversification of goods and services, increasing internal circulation and the opportunities to attract inward investment to the area, and supporting balanced communities with nearby housing and employment opportunities. This indicator is addressed by SBTool^{PT}_Urban (2018), BREEAM-C (2012), LEED-ND (2018) and supported by ISO 37120.

3.11. Local and Cultural Identity

This category focuses on analysing the local and cultural identity issues by analysing the elements of an area that contribute to its attractiveness and the sense of place and belonging, which are essential for the improved mental health and psychological well-being of its inhabitants [72]. Sense of place is often intricately linked to history, cultural identity, and social relations [73]. Moreover, according to the United Nations Committee on Economic, Social, and Cultural Rights, the right to sufficient housing should be understood as the right to live somewhere in safety, peace, and dignity [74]. In this context, SDG 11 asked governments to promote approaches to protect heritage, cultural and natural identity, as well as providing adequate housing, etc. Aside from this, ISO 37120 has promoted the assessment of access to recreational facilities, the number of cultural institutions and sporting facilities in the neighbourhoods, and the municipal budget allocated to these facilities. Moreover, SDG 4 encourages all stakeholders to acquire the knowledge and skills needed to promote sustainable development and sustainable lifestyles, human rights, gender equality, citizenship, and the appreciation of cultural diversity and culture's contribution to sustainable development. Therefore, defining the strategies that enable a monitoring of the local and cultural identity of the neighbourhoods can support decision makers in limiting the impacts. According to the findings (Figure 11), the essential indicators for assessing the local and cultural identity of an area are structured around two sustainability assessment indicators, including:

Access to public spaces: This indicator promotes the assessment of the availability and quality of existing or planned public spaces, enhances community participation, improves public health, and strengthens the local identity of the area. This indicator is addressed by

SBTool^{PT}_Urban (2018), BREEAM-C (2012), and LEED-ND (2018), and supported by SDGs and ISO 37120.

Valuing heritage: The natural and cultural heritage includes environmental and natural resources such as forests, the wilderness, scenic landscapes, rivers, lakes, and marine areas, as well as cultural resources, such as historic buildings, structures, or other human influences on the natural environment that we pass on to future generations [75]. This constitutes different assets that provide a variety of market and non-market benefits to inhabitants. Therefore, the objective of this indicator is to promote the maintenance of the built and natural historical heritage of the place. It also intends to promote public use and boost the heritage of its market and non-market benefits, which motivate a certain level of conservation or protection. This indicator is covered by SBTool^{PT}_Urban (2018), BREEAM-C (2012), and LEED-ND (2018), and supported by SDGs and ISO 37120.

Social inclusion and integration: The concept for this indicator comprises housing provision and social involvement, which aims to ensure that the development contributes to the demographic needs and priorities of the area. These issues have been promoted in separated indicators, through SNTool (2020), BREEAM-C (2012), and LEED ND (2018), but developed in a combined form, through SBTool^{PT}_Urban (2018). Therefore, this study proposes a combined form of the indicator due to the close relationship between the criteria.

3.12. Context and Vulnerabilities

This category focuses on analysing the issues related to context and vulnerabilities and is promoted through six indicators (Figure 12). Climate-related disasters have escalated in the previous three decades, revealing a new and alarming degree of damage and devastation due to current global climate change [75]. These failures have led to casualties, property destruction, and vast economic loss. Many studies have acknowledged the importance of identifying the various vulnerabilities of communities and analysing the efficiency and effectiveness of the relevant policies in urban areas to take the right step toward reducing disaster risk. In this context, SDG 13 is positioned for taking urgent action to combat climate change and its impacts. In addition to these, goal 11 has allocated an indicator for evaluating local disaster risk reduction strategies. Flood risk assessment is an indicator addressed by all the sustainability methods that this study addresses. Moreover, ISO 37120 emphasizes emergency response services and considers the assessment of natural-hazard-related deaths. Consequently, the study combined several relevant indicators, as shown in Figure 12, to make a comprehensive indicator, which is described below:

Adapting to climate change: The objective of this indicator is to ensure a resilience to known and predicted impacts of climate change. The concept for this indicator comprises the assessment of flood risks, windstorms, earthquake events, and other natural and technological risks of the area. These issues have been promoted through separated indicators, by SBTool^{PT}_Urban (2018), SNTool (2020), BREEAM-C (2012), and LEED-ND (2018). However, SNTool (2020) and BREEAM-C (2012) have a mixed format for this indicator, emphasizing flooding events. Therefore, the study proposed a composite indicator format to make it comprehensive in all of the mentioned aspects due to the close relationship between the criteria. In this regard, evidence regarding the known and predicted impacts of climate change on the project area should be provided by the local authority and statutory bodies to demonstrate how the risks will be managed, minimizing the risk of localized natural disasters and technological hazards (e.g., increased temperatures (including the heat island effect), flood risk, increased weather volatility, impacts on water resources, changes in ground conditions, etc.).

4. Discussion

BREEAM-C, LEED-ND, SBTool^{PT}_Urban, and SNTool (minimum version) are presented and compared in this research. Based on the issues that they address, the study reorganized the most relevant urban sustainability indicators into 12 categories. Indicators in the analysed methods that have different names but address similar issues and aspects are considered the same and organized under the same title (Table 2). Moreover, the charts provided for each category (Figures 1–12) show the level of popularity of each indicator among the studied methods. Additionally, this determines whether they are addressed by ISO 37120 standards for sustainable communities and the SDGs of Agenda 2030.

The final list of indicators is based on the level of the frequency of distribution for each indicator in the selected methods, ISO and SDGs. Some indicators comprehend more than one sustainability issue, while each of those issues is considered a separate indicator in some methods. The study considered several sustainability issues in one indicator in the final list, creating mixed indicators that gather all the interrelated issues. This approach aims to ease a better understanding by the design teams of the most important sustainability principles to consider in the design of sustainable urban areas.

The final list comprises 32 indicators, organized into 12 sustainability categories (Table 3). Figures 13–16 compare the frequency of the indicators between the analysed methods. The comparison shows that:

1. Eleven indicators are promoted by all of the methods and supported by ISO 37120 and/or SDGs (Figure 14). These indicators were chosen for the final list, with four of them being proposed in a mixed-mode format.
2. Thirteen indicators are promoted by at least three methods and supported by ISO 37120 and/or SDGs (Figure 15). These indicators were chosen for the final list, and three of them were proposed in a mixed-mode format.
3. Five indicators are promoted by two to three methods but are not supported by ISO 37120 and/or SDGs (Figure 16). These indicators were chosen for the final list, and one of them was proposed in a mixed-mode format.
4. Eight indicators were promoted by two tools and supported by ISO 37120 and/or SDGs. Five of these indicators were chosen for the final list, and two of them were proposed in a mixed-mode format.

Based on the shown data, the most popular indicator is the availability of public transport services (Figure 14), which is expected because efficient and effective urban transport can significantly contribute to achieving objectives in a wide range of urban sustainability domains, e.g., reducing energy consumption and GHG emissions, which are the core focus of sustainable development. The second most common factors are the availability and proximity of vital local public services and pedestrian path accessibility, which are related to connectivity, ensuring ease of movement and convenience for commuters, which also results in lower fuel consumption and GHG emissions. The next most popular indicator is the enhancement of ecological value and conservation of native species (as shown in Figure 14), which was expected because protection and enhancement of existing ecological features are advocated to minimize biodiversity loss on the planet. Furthermore, the inclusion of the indicators in the ISO and SDG lists is also regarded as an approval of the indicator's significance.

The analysis of these assessment tools reveals that, although they were developed to address different contexts, they rely on a similar list of sustainability indicators. This means that there is a common international agreement about the main categories and sustainability indicators to assess sustainability at the urban level. The findings of the analysis highlight that certain sustainability criteria have a higher importance in the reviewed urban sustainability assessment tools, while others are considered less important. For example, as shown in Figure 13, an indicator such as adapting to climate change was frequently overlooked. Additionally, the analysis showed that some of the methods emphasized aspects related to the environmental dimension of sustainability, such as transportation infrastructure, energy-saving measures, and context and vulnerabilities, while they were neglected in other aspects, such as socio-economic dimensions of sustainability.

Moreover, the way that the indicators were evaluated differs among the analysed methods. Some methods used a quantitative approach, while others used a qualitative approach or a combination of the two. An alternative approach was a mixed-methods approach, in which qualitative and quantitative indicators were combined to produce more evidence-based results. This could help to provide a more profound knowledge of the issues resulting from the sustainability assessment, which allows them to provide more impactful strategies on how to properly select appropriate planning and solutions. However, a further attempt is required to determine areas that need improvement and enhancement in sustainability assessment tools, according to the ever-changing concept of sustainability in the era of climate changes in urban development.

Table 3. Proposed indicators for urban sustainability assessment that can be applied in different contexts.

Categories	Indicators
Urban structure and form	Providing a comfortable outdoor environment
	Smart locations and efficient urban network
Transportation infrastructure	Availability and access to public transport service
	Quality of pedestrian and bicycle network
Basic services availability	Availability and proximity to public and local public services
	Availability of recreational facilities
	Availability of local food production
Energy-saving measures	Infrastructure energy efficiency
	Percentage of total end-use energy generated on-site, derived from renewable sources
	Centralized energy management
Water-saving measures	Efficient drinking water consumption
	Effluent management
	Rainwater harvesting and water body conservation
Resource efficiency, recycling and waste measures	Resource efficiency and low-impact materials used in public spaces
	Reused of the construction and demolition waste
	Recycled urban solid waste derived from regularly collected solid waste
Ecosystems and landscapes	Distribution of green spaces for public use
	Enhancement of ecological value and conservation of imperilled species
Land use and infrastructure	Use the natural potential of land
	Densification and flexibility of land use
	Reuse of urban land
	Reuse of buildings and infrastructure
Outdoor environmental quality	Adaption for ambient air quality
	Heat island effect in the local area
	Ambient noise conditions
	Light pollution reduction
Employment and economic development	Economic viability
	Local economy and employability
Local and cultural identity	Access to public spaces
	Valuing heritage
	Social inclusion and integration
Context and vulnerabilities	Adapting to climate change

5. Conclusions

To identify important themes and objectives that must be considered in any region to contribute to the attainment of the Sustainable Development Goals, this study analysed four well-known assessment tools for sustainable neighbourhoods: BREEAM-C (2012), LEED ND (2018), iiSBE SBTool^{PT} Urban (2018), and iiSBE SNTool, Minimum version (2020). The analysis investigated the indicators of the tools to identify the main issues and aspects that are important considerations for assessing the sustainability of neighbourhoods. The results provide a compact and, at the same time, comprehensive list of indicators that seeks to cover all relevant aspects of a sustainable urban environment, which is also aligned with SDGs and ISO standards for sustainable cities and communities.

From the analysis, it is possible to conclude that most of the assessment methods share a similar definition in terms of urban sustainability since they are based on a similar set of sustainability indicators. However, the indicators with similar names may address different sustainability issues, and others with different designations may address similar sustainability issues. The comparison between the different lists of indicators shows that certain issues have a high importance. In contrast, others have lower importance and, therefore, could not be the focus of the design teams. The most relevant aspects and main issues included in the indicators that aim to be assessed are urban structure and form, transportation infrastructure, basic services availability, energy-saving measures, water-saving measures, resource efficiency, recycling and waste measures, ecosystems and landscapes, land use and infrastructure, outdoor environmental quality, employment and economic development, local and cultural identity, context, and vulnerabilities. This study presents minimum numbers of indicators with a high level of overlap among the selected tools to deliver the minimum requirements for urban sustainability objectives, which is briefly demonstrated by:

- Preserving natural resources (energy, water, materials and waste, and natural habitats), using renewable resources as an alternative to non-renewable ones, and maintaining ecosystems and landscapes. These issues are the most important except for SNTool (Minimum version) and BREEAM-C;
- Urban planning strategies, in which urban structure and form, quality of the outdoor environment, land use and infrastructure, efficient connectivity and public transportation services, and quality public spaces are all advocated in the reviewed urban sustainability assessment methods, with less importance given by SNTool (Minimum Version). On the other hand, adaption to climate change, which is crucial for the sustainability of urban areas, is not given enough attention in any of the assessment tools, except for the SNTool (Minimum version) and BREEAM-C.
- Social and economic well-being cover relevant issues to improve the local economies, community involvement, and the reinforcing of cultural identity. All tools address these issues, except for the SNTool (Minimum version). Additionally, the provision of basic services has a lower importance in the SNTool (Minimum version) and BREEAM-C.

Effective indicators will help to disclose and confirm the benefits of sustainable solutions and allow for an adaptive management approach that responds to changing conditions [17]. Additionally, for the harmonization of sustainability assessment systems, it is crucial to establish a common standard, accepted at the international level, which defines the most important urban sustainability indicators to address. The present study aims to raise awareness at the level of urban sustainability and contribute to a better understanding of sustainability concepts and the most important issues and indicators to be addressed by the design teams. The findings highlight that comprehensiveness can be improved without necessarily increasing the number of indicators, particularly by ensuring that indicators cover all areas and aspects of sustainability. However, different tools have placed varying emphasis on different aspects of sustainability. The main identified flaws of the reviewed tools for urban sustainability are that some relevant sustainability issues are not covered or not comprehensively addressed in some of the methods, which hinders the practical implementation of the Sustainable Development Goals.

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